Drivers in the demand for the ornamental trade of discus (Genus *Symphysodon*) between international markets

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Thesis submitted for the degree of

MSc in Biodiversity Management by research

Durrell Institute of Conservation and Ecology

Research period: 30 September 2012-2014

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ACKNOWLEDGEMENTS

I would like to express my deepest gratitude to Dr. Dave L. Roberts, my supervisor, whose excellent supervision, guidance and unending support throughout the entire process of my research has been absolutely invaluable. It has been nothing less than amazing to be a part of Dave's army.

My thanks also go to my co-supervisors Ian Watson, Dr. Noreen von Cramon-Taubadel and Dr. Freya A.V. St John for their patience, encouragements and guidance at every step of the way. I am also grateful for Dr. Iain M. Fraser, Dr. Diogo Verissimo, Amy Hinsley, Chen Yu and Lee Wing Ling for all the endless technological guidance and support, as I would not be able to reach this point without all your help.

I am grateful to Wayne Ng, Kit, Forrest Teo, Jeffrey Yang, Nielson Low, Terence Chia and all the discus enthusiasts, breeders, exporters and retailers in the UK, Hong Kong, Malaysia and Singapore for introducing me into your passion for discus and to have taught me everything that I know.

Many thanks to Alex Bartlett, Sandeep Mudhar, Eve Stephenson, Julia Wan, Terence Wan, and Jessica Wan, Hannah Conduit, Lucy Smith, Alfred and Darren for all your invaluable help, assistance and never-ending support through these two years.

I would like to extend my gratitude to the organizers of Aquatics Live 2012, Aquarama 2013, British Cichlid Association, The British and International Discus Keepers Association, and the members of the Malaysian Discus Club and Singapore Discus Club for providing me the platform to conduct my work and the support for my research. My appreciation extends to the National University of Singapore for the invaluable help and assistance.

Special thanks to my family, housemates, and friends who have been keeping me sane throughout this journey. Their love and encouragement is more than I could ask for.

Lastly I would like to thank DICE for giving me the most amazing five years of university, and to be able to share the memories with an amazing family of friends.

ABSTRACT

The ornamental fish trade is a thriving industry that is especially important in conservation and poverty alleviation. To ensure and maintain a sustainable trade, research in consumer preferences and market demand is needed to obtain end-user information and derive the market-potential for trade-suitable species. Looking at the ornamental aquarist trade for genus *Symphysodon* as a case study, stated preference methods were used to investigate the importance and economic valuation of attributes in consumer choice for discus, and additionally examine the extent of consumer interest and market potential for sustainable wild-caught options. Unlabelled Choice Experiments (CE) and Card Sorting (CS) methods, in the form of picture sorts and preference ranking, were designed and conducted at international markets, with a focus in the United Kingdom and Singapore. CE Results of the international market expressed colour as the most influential attribute, followed by origin/type. Price was of minimal concern to consumers worldwide. The CS observed preferential differences in colour and particularly shape, with an overall attraction towards Blue Snakeskin and the greatest heterogeneity for Blue Diamond, Red Turquoise and Yellow Ghost varieties across groups. Heterogeneous preferences were observed between European and Far Eastern Asian markets, with both UK and Singapore expressing wild and cultivated discus interests, followed by additional markets in Hong Kong and Malaysia with strong cultivated discus interests. Hong Kong also expressed slight potential for wild discus types. Further heterogeneity between traders and different consumer groups expressed a strong preferential overlap between professionals and hobbyists within the discus industry, while significant differences were observed between the general consumers of the wider public and people with environmental employment, with further variations based on gender, age group, fishkeeping knowledge and survey type. These findings suggest that clear differences were observed between market regions, and heterogeneous consumer preferences are strong within the international market. Further research on changes in market demand over time and studies in source markets and emerging markets will be needed to review the international market potential of wild and cultivated discus varieties.

KEYWORDS:

Symphysodon. Ornamental fish trade. Market demand. Preference elicitation.

Choice experiments. Card Ranking. Latent Class Model.

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1 INTRODUCTION

The international wildlife trade is an ever-growing multi-billion dollar industry that is mainly comprised of sales and exchanges from both wild and captive produced products, including live ornamental plants and animals, as well as its parts and derivatives i.e. skins for clothing and extracts for medicinal ingredients (TRAFFIC, 2008). With global imports estimated at a value of USD 323 billion for 2009 alone, the industry has played a significant role in contributing to local incomes and foreign exchange earnings, particularly in developing countries where many species of high demand are sourced, and poverty alleviation with the provision of vast employment opportunities for sustainable livelihood options and at associated sectors of the supply chain (WWF, 1993; TRAFFIC, 2008). However, with growing wealth among populations in emerging markets worldwide, greater demand for wildlife products may potentially bring serious impacts from increased risks of overexploitation in the wild (TRAFFIC, 2008). Thus, significant attention has been placed by government bodies, non-government organizations and academics to develop ways to strengthen trade regulations, improve monitoring schemes, and apply interdisciplinary approaches in both source and consumer countries to derive effective strategies for sustainable management of harvested resources. But before effective management plans can be suggested, as trade is driven by demand, one must first attempt to understand the sources of demand to provide foreknowledge on the market situation, and find out what motivates consumer behaviour towards purchases of the traded species.

Essentially, the underlying foundation of demand is an understanding of how consumers behave (Daud, 2013). Whether they are influenced socially or culturally, all factors are taken into account and can play an important role in behaviour towards consumerism. By defining the attraction or 'motivator', we can determine how personal values, experience, cultural beliefs and exposure forge personal preferences and attitudes through behaviour (Daud, 2013). This can be done with preference elicitation techniques, which allows us to look into the mindsets behind the behaviour, and pinpoint targets that impact and define the market.

In order to achieve sustainability, obtaining market information on the traded species is a crucial stage towards effective management and regulation of wildlife trade. As supply is linked with demand, acquiring an understanding of consumer preferences and the desirability of products can provide an insight into the extent of product interest, and examine the role of social-economic factors in driving demand for traded species. This is evident in studies on the trade of shark fins, where expanding consumer purchasing power in China was found to have driven greater demand for the luxury food item and is expected to increase pressures on limited resources (Clarke et al., 2007). With the implementation of shark finning bans and increased awareness on shark conservation, the migration of the trade away from Hong Kong and into China suggests potentially greater difficulties to

manage and assess impacts on shark populations, and the need for alternative schemes and conservation education for the latter (Clarke et al., 2007).

Considering that trends in demand may change or differ geographically and temporally, obtaining an understanding on the drivers and heterogeneities of market demand is fundamental for the sustainability and conservation of traded species. Thus, as conservation funds are limited and trial and error attempts are risky in the management of species already at threat, this type of analyses will allow for an effective evaluation and assessment on the potential for different approaches in achieving sustainability.

1.1 ORNAMENTAL FISH TRADE

The ornamental fish sector relates to the trade of cold water, tropical freshwater and marine species, and is among the most widespread and global components of the international trade with carries of the largest movement of animals worldwide (Ploeg, 2007b). Although smaller in size than the wider seafood and consumption trade, it is a thriving industry with annual estimates of global exports at around 1.5 billion live ornamentals per year (Ploeg, 2007b). Compared to marine fish with a larger wild market, over 90% of freshwater ornamentals are captive bred due to earlier and longstanding efforts in breeding and domestication (Bartley, 2005).

The industry is a highly profitable business that has provided opportunities for income generation to local communities, and employment to people of related sectors internationally (Galeano, 2005). Ornamental fish is known as a high value product that takes in an average of USD1.8 million per ton (MOA, 2003). Considering that an average one-third of the retail price constitutes to an estimated USD83 million spent on air freight for transportation to importers, and the average mark-up is assumed at 125% for importers and 200% for retailers, the total retail value of global imports can be approximately USD 2.2 billion with over 90% from tropical fish (MOA, 2003; Ploeg, 2007b).

1.1.1 MARKET SITUATION

The largest export region is Asia, which is the commercial breeding hub of an immense range of fish species from all regions of the world (Ploeg, 2007b). Particularly important are countries within South East Asia, where tropical rainforests provide an important source of wild ornamental fish (Ploeg, 2007b). Malaysia is one of the largest producers in the Far East Asian market, providing an optimal environment with a suitable climate, soil and water quality for culturing tropical fish at a larger scale (MOA, 2003). This is particularly advantageous for high-value species such as the Asian Arowana (*Scleropages formosus*), with lower costs and shorter production cycles (MOA, 2003). With around 500 farms, Malaysia has the potential to become a leading supplier with more than 550 local and exotic varieties of 250 species bred for the domestic and global market. The industry produces an annual estimate of 700 million pieces, with 70% exported to over 30 countries worldwide (Mohd Ali & Yeo, 2009). Nevertheless, a significant percentage is re-exported through

Singapore, which plays an important role as the import-export hub of Asia, with global market shares of 25.4% imports and the highest at 25.4% exports of the world's volume in the past years (Table 1.1; Ploeg, 2012a). In fact, due to a large network of trade links, Singapore acts more as a transit location that is mainly involved with re-exports of imports from all surrounding countries (Ploeg, 2012a). Despite having a large farming industry in South China, little is exported from China as the production is mainly supplied to the internal market (Ploeg, 2007b). Yet, the country is a significant importer in association with Hong Kong, at a compiled market share of 16.5%, which is a dominant retail hub and major centre of ornamental fish trading in Asia (Table 1.1; Han et al., 2002; Ploeg, 2007b).

Table 1.1 Global market shares of major import and export regions for ornamental fish in 2011

Region	**Import**		**Export**	
	Country	Market share /%	Country	Market Share /%
Asia	-	T: 26.2%	-	T: 54.0%
	*Singapore	25.4	*Singapore	25.4
	*Japan	21.2	*Japan	21.1
	Hong Kong	14.7	*Thailand	14.7
	Malaysia	7.3	*Malaysia	7.3
	South Korea	5.1	Indonesia	5.1
Europe	-	T: 50.9%	-	T: 35.0%
	*United Kingdom	16.7	Spain	53.5
	*Germany	13.8	*Czech Republic	17.2
	France	10.0	Netherlands	9.6
	Belgium	9.3	UK	4.4
	Netherlands	8.9	Germany	4.3
North America	-	T: 17.9%	-	T: 3.6%
	*United States of America	85.4	-	-
Other	-	T: 5.0%	-	T: 7.4%

*Top five countries were listed with highest market shares within region. Top five countries with highest global market shares were labelled with an asterisk *.*
Note: export values for Spain is still subject to FAO review due to high inconsistencies with only emerging market observations, thus was not labelled in the global top five (Ploeg, 2013a).
Source: FAO, 2014

With Czech Republic being one of the main producers of ornamental fish in the European Union (EU), along with an emerging market in Spain, Europe has become the second largest export region in the world (Table 1.1; Ploeg, 2012a). Nevertheless, traditional consumer countries with more history in the trade seem to be more involved in importing ornamentals. This is most evident for the United Kingdom (UK), representing a major end-user market as the largest EU importer since 2003, followed by Germany and France (Table 1.1; Ploeg, 2013a). Between 2003 and 2013, the UK has experienced an increase of 7.3% in the total value of imports, with top source countries from Singapore (over 30%), Israel (estimated 15%) and Indonesia (estimated 10%) in 2013 (OATA, 2013). Similar trends can also be seen among traditional consumer countries in North America, particularly the USA which has become the largest importer of ornamental fish internationally, surpassing both Singapore and the UK since 2009 (Table 1.1; Ploeg, 2013a).

In South America, priority regions such as the Brazilian Amazon basin can be responsible for up to 85% of wild-caught ornamental fish exports to central markets in North America, Europe and even widely across Asia (Davenport, 1996; Galeano, 2005). The freshwater industry is especially important in conservation and poverty alleviation, contributing to the consolidation of protected areas with non-timber forest products (NTFPs) as economic alternatives to environmentally destructive forest practices. Successes have been evident with initiatives such as Project Piaba, which aims to foster an environmentally and socially beneficial ornamental fish trade by promoting the sustainable harvest of aquatic resources, including discus (Genus *Symphysodon*) and freshwater rays (Family Potamotrygonidae), through community based fishery management strategies (Tlusty et al., 2014). However, this constitutes to only one-tenth of global exports, as most profits are earned in Asia where a similar environment allows the culture of wild forms away from their Brazilian localities, and thus providing greater capacities for breeding new varieties (Ploeg, 2007b).

1.1.2 ISSUES WITH SUSTAINABILITY

Nevertheless, attempts to achieve a sustainable balance in practices remain a challenge. Global issues concern risks of overexploitation of harvested species, and impacts from habitat conversion and ecological change (Galeano, 2005). With problems on the spread of invasive species and novel pathogens, industries that lack regulation and effective monitoring may present severe threats to endangered and endemic species (NEAq, 2014). Currently, the import and export regulations in place include customs, animal welfare, species protection and animal health legislations on an international level. These involve the International Air Transport Association (IATA) with Live Animal Regulations (IATA-LAR) on detailed rules of packing methods for airlines; the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) with an international agreement by states to ensure that international trade does not threaten species survival, based on three Appendices with varied degrees of protection; CITES in the European Union (CITES EU) with four Annexes for species protection instead; the Office International des epizooties (OIE) with a list of extremely dangerous animal diseases that require international cooperation and measures; and the European Union with the Regulation (2005/1/EC) on animal protection during transport of animals (Ploeg, 2012b)

Trade statistics are mainly collected by the Food and Agriculture Organization of the United Nations (FAO), and also by the United Nations Commodity Trade Statistics Database. However, it is not easy to monitor trade levels, as one of the major drawbacks of the industry relates to limitations in the available statistics on absolute values of trade volumes and harvested numbers on a species level, creating traceability issues and often records of incomplete figures (Ploeg, 2007b). Data on import and exports are mainly aggregated records on the weight of boxes in which live fish are transported and the value of shipments in USD, which is largely dependent on the species and size of the fish and may vary between countries with tax inclusion or exclusion (Ploeg, 2007). With regard to wild harvests, often collectors are paid according to the numbers caught based on genus, rather than the

specific varieties of species (Göbel, 1999). Being a primary source of local income, the location of fishing hotspots and collection sites are often not reported to importers and researchers as well, thus resulting in a lack of quantitative species-specific data from the source (Göbel, 1999). In India, a lack of enforcement in existing local regulations and management of aquarium fish collections have posed major threats to wild populations of the endangered Red Lined Torpedo Barb (Raghavan et al., 2013). Currently, this species is still routinely exported as one of three major species of threatened freshwater fish that adds up to 1.5 million exports in 2013 (Raghavan et al., 2013). Moreover, studies revealed that particular species may be less suitable for the hobbyist trade than others, such as Jerdon's carp (*Hypselobarbus jerdoni*) with a low survival rate of less than 20% during domestication, and white sturgeons (*Acipenser transmontanus*) with high potential to outgrow household tanks, and increase risks of wild releases that may result in detrimental impacts to endemic species (Sureshkumar et al., 2014; Anon., conservation academic, pers. comm.).

Issues with mortality in the aquarium hobby trade are also evident in relation to handling practices and fish health challenges at all stages of the supply chain (NEAq, 2014). Massive mortalities during transport, particularly with the more sensitive wild-caught fish, may be experienced with accidents during freight handling, such as bag leakage resulting in escaping oxygen, or delayed shipments in relation to extended hours or bad and extreme weather conditions (Ploeg, 2007a). The transport of particular species such as the cardinal tetra *(Paracheirodon axelrodi)* are also considered more difficult than others, with reports observing an increase in DOAs (Dead On Arrival) from 0.15% upon collection to 0.81% at the wholesaler's facility (Ploeg, 2007a). High levels of mortality towards the end of the chain could also be a result of stress from poor tank conditions or retail environment, disease outbreaks or fungal invasion, and potentially insufficient care knowledge among end-users (Anon., exporter, pers. comm.). However, all things considered, if managed effectively, the aquarium trade is an industry that can be highly advantageous and beneficial as a 'vehicle for aquatic conservation, poverty alleviation, education and ecosystem stability' (NEAq, 2014).

Where there is a dichotomous split in the trade between demand for wild-caught and captive-bred varieties, the relationship between the two trades is particularly unique and complex for the array of costs and benefits that could involve in both sides. As one of the greatest threats to freshwater habitats originates from habitat loss, the supply of cultivated forms would provide a diversion away from wild populations and reduce pressures on natural stocks. However, as most ornamental fish is produced in aquaculture, and most likely in non-native countries, the challenges of the cultivated trade refers to the potential introduction of invasive species through escapes, disease introduction to native flora and fauna from issues with removing wastewater in aquaculture facilities, and most problematically, the removal of any incentives or reasons for locals to conserve wild stocks due to a lack of direct economic return to the source (Rosser, 2003). If there is no direct

benefit, the prioritization of fish resources are unlikely in areas where basic human needs are not met, and will reduce opportunities of income generation and alternative livelihoods away from direct destruction such as logging or gold mining (Rosser, 2003). Thus, provided that sustainable levels of harvests are possible, the equitable share of economic benefits are set up among collectors, and the selected species biology and population levels are fit for harvests i.e. high reproductive rate and population levels with wide distributions, economic benefits and livelihood options can be provided to rural fishing communities to collect wild-caught varieties and increase incentives for conservation. Yet, trade in wild-caught individuals may incur risks of stimulating the illegal trade, and most importantly may involve high numbers of DOAs or during transport and especially potential high mortalities during acclimatization to captivity, which gives rise to both welfare and sustainability concerns of harvests (Rosser, 2003). In this sense, captive-bred fish are already used to the tank environment, and may be relatively easier to keep by the everyday hobbyist than a wild type. Thus, the identification and regulation of collections of trade-suitable species are imperative to minimize such threats, while maintaining an equitable share of economic benefits among locals. Also, a balance between the two options needs to be made for each independent case, and monitoring of the trade, in relation to the unification of both wild-capture and culture programs is imperative to ensure sustainability of trade pathways and the conservation of threatened species and habitats (NEAq, 2014).

Furthermore, an understanding of variations in international demand for ornamental fish will be particularly useful in attempts to manage and ensure the conservation and sustainability of traded species, as well as fill potential gaps of market information among actors at different levels of the supply chain. By comparing fish exploitation and exports in source countries to the demand of end-users in international markets, efforts can be focused on species of interest, and targeted away from others to reduce potential overharvesting and culture of species that do not fit the demand. Understanding consumer preferences and the choice-making process will also create opportunities for a target-based approach to derive effective management schemes and minimize demand on threatened species, i.e. suggesting potential alternatives that may fit market preferences or promoting conservation by increasing environmental valuation among consumers (Best & Bornbusch, 2001). As consumer interest in the aquarium hobby industry is heavily dependent on the introduction of new varieties, identifying preferable product attributes would be beneficial for breeders to focus development efforts on, and potentially produce market viable varieties that may meet demands as an alternative as well (Livengood et al., 2004).

1.2 DISCUS

Discus (Genus *Symphysodon*) is considered among one of the top 10 Amazonian fish in greatest demand within the ornamental fish trade (Mesquita et al., 2008). Exhibiting a slow-moving and peaceful behaviour, discus are known for expressing an elegant body shape, posture and stance. Along with attractive colorations and pattern markings, discus are often associated with royalty or as a symbol of luxury, and are regarded among hobbyists as the

"King of Aquarium Fish' (Livengood et al., 2004; Au et al., 2007). With a wide range of varieties, discus fish of both wild and domestic origins have been receiving much attention and are highly sought out for among aquarium enthusiasts worldwide (Livengood et al., 2004).

1.2.1 CHARACTERISTICS

Discus fish are cichlids with unusual, laterally compressed and disc-shaped bodies that can grow up to 15-20cm in total body length and height (Livengood et al., 2004). Generally there are no sex-specific differences in colour and morphology for wild discus, but males may grow larger than females, and potentially display a thicker forehead among cultivated forms (Livengood et al., 2004; Anon., breeder, pers. comm.). Discus species have two lateral lines, and has nine melanic vertical bars from the head to the caudal peduncle (Ng, 2004). The primary colours of wild discus often range from dark brown colorations to blue and green hues (Livengood et al., 2004). In terms of secondary colour and pattern, different species and subspecies differentiate in markings and form, but are generally spotted and striated with black and yellow colorations and red pigmentation across the body (Livengood et al., 2004).

1.2.2 HABITAT AND FEEDING ECOLOGY

Wild discus are known to occur in floodplain lakes and flooded forests of the lowland Amazon River basin in Brazil, Colombia and Peru (Crampton, 2008). These include a majority located in brackish, acidic (pH below 5.0) and nutrient-poor black waters of the Rio Negro in Brazil, with high levels of dissolved humic and tannic acids from decaying organic matter, as well as typically clear, neutralized (pH 4.5 to 7.8) and nutrient-rich white waters tributaries of the western, central and eastern Amazon River (Livengood et al., 2004). Discus are also often seen in large schools of up to 400 individuals, congregated in 'galhadas' in still or slow-moving waters of preferably 26˚C to 31˚C, over either sandy or sediment-free banks with decomposing leaf litter and wood debris (Livengood et al., 2004). These habitats are suggested to be the mechanism that allows reproductive isolation, leading to colour variants within populations in the same drainage system (Livengood et al., 2004).

1.2.3 CLASSIFICATION

The common discus from the genus *Symphysodon,* is classified as a Perciforme of the family Cichlidae (Mesquita et al., 2008). To this day, there is still an ongoing dispute on the classification of wild populations at the species level (Livengood et al., 2004).

At present, discus has been widely accepted as two species with five clades or subspecies (Livengood et al., 2004; Table 1.2). Based on phylogeographic and population genetic analyses, recent studies have also classified a sixth clade for an unnamed divergent group from the Xingú and Tocantins Rivers (Farias & Hrbek, 2008).

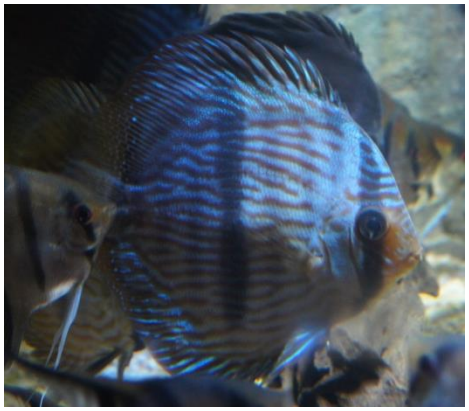
Table 1.2 Classification of Genus *Symphysodon*

Species	Name of varieties
Symphysodon discus	Heckel (*S. d. discus*)
	Abacaxi (*S. d. willischwartzi*)
Symphysodon aequifasciatus	Brown (*S. a. axelrodi)*
	Blue (*S. a. aequifasciatus*)
	Green (*S. a. haraldi*)
	(includes *Symphysodon tarzoo* variety*)*

Sixth clade excluded in the table (Livengood et al., 2004; Heijns, 2012).

Overall, species and subspecies are defined based on variations in body colour, pattern markings and the geographic localities that they originate from in the Amazonian River basin (Livengood et al., 2004). With differences in water flow, pH, dissolved oxygen and nutrients and turbility, the ecological environment of its riverine habitat seemed to have greatly influenced phenotypic variation in terms of colour between discus varieties (Livengood et al., 2004). Particular differences in the appearance of melanic bars between the two main species were observed, with *S. aequifasciatus* displaying an equal width and intensity of bars, whereas *S. discus* expressed predominantly wide and intensified colorations of bars 1, 5 and 9 (Ready et al., 2006; Figure 1.1). For *S.* discus, the group seems to exhibit primary colours ranging from beige to reddish brown, with striations across the entire exterior of the fish (Au et al., 2007). Yet, in addition to general brown colorations with secondary blue and red markings on the forehead and near the anal fin, *S. aequifasciatus* seem to have much brighter secondary colorations, including a greater coverage of blue and red stripes, and spots or reticulations (Ready et al., 2006). Among the group, Brown discus tends to vary widely in coloration, with a yellow-brown body colour, a few distinct or faint blue striations and blue-green to red dorsal and anal fins (Au et al., 2007). Blue discus has lighter-brown body colorations with blue striations on the head, dorsal and anal fins i.e. (Au et al., 2007). Whereas Green discus has a brownish-green primary colour with pale-green striations on the head, dorsal and anal fins, a black band running through the tail root, and red spotting over the anal fin and potentially the entire body (Au et al., 2007).

Figure 1.1 Wild discus



Symphysodon discus (wild)
(Source: Wan, 2013)

Nevertheless, as all species and subspecies are able to crossbreed and produce reproductively fertile offspring, discus species seem to constitute one monospecific genus or evolutionary unit (Livengood et al., 2004). Thus studies suggest that no specific species exists and that *Symphysodon* is still in the process of speciation (Farias & Hrbek, 2008). As a result, hobbyists were able to take full advantage of its ability to hybridize freely between groups, and develop multiple colour forms and artificially cultivated varieties particularly from crosses with the diverse *S. aequifasciatus* (Livengood et al., 2004).

1.2.4 GENETICS AND DOMESTICATION

Artificially cultivated varieties are selectively line-bred by private and commercial breeders to enhance desired physical characteristics. With a market that expresses continuous potential to improve and even create new strains, this has resulted in a competitive race between breeders and keepers in the past years, as well as with those who aim to reach show-quality standards and rear championship discus for international competitions. Currently, discus breeders are considered to have created close to 100 distinctive strains, marketing varieties such as Turquoise, Solid, Pigeon Blood, Golden, Snakeskin, Ghost, Snow White and Albino strains (Livengood et al., 2004).

To produce a high quality 'designer discus,' the process involves the selection of desirable heritable traits or characteristics at each generation (Livengood et al., 2004). Selection stages may begin at different times between cultivated varieties, but breeders tend to proceed with their selection as early as two months after birth, when most of the brood-stock has expressed full or complete colorations and patterning on the body (Soh, 2005). Quality control differs for each stage, where personal standards are applied for the acquisition of healthy individuals with better shape, overall consistency in colour and the distribution and type of patterning (Au et al., 2007). Fish with morphometric deformities such as kinks in the body shape, uneven gill covers as well as oddly shaped fins, eyes and irises are generally discarded and selected out (Soh, 2005; Au et al., 2007). Subsequently, individuals are cross-bred and hybridized with other variants to explore greater possibilities in the phenotypic spectrum.

As genetic variants or strains generally inherit changes in colour and pattern markings, new varieties continue to be created and introduced into the market (Livengood et al., 2004). These are usually the result of experimentation from selecting and cross-breeding with mutated fish that exhibit desirable traits for a potential new strain (Livengood et al., 2004). This is observed in the creation of the 14-bar Leopard Snakeskin, which is a hybrid between Leopard discus, obtained from a cross between Red Turquoise and Wild Red Spotted Green, and Snakeskin discus, a mutation of the Red Royal Blue (Au et al., 2007). Varieties are also 'cleaned' through crossing to accentuate colours and patterns, such as reducing melanin from the vertical bars in attempt to 'remove' the characteristic for solid varieties, and minimizing intense peppering on the body, which is a genetic side-effect with mutations such as the Pigeon Blood and Ghost varieties (Yip, 2002).

In terms of shape, numerous modern strains tend to exhibit high body forms with a taller D-body and higher finnage, potentially resultant from either forced-feeding techniques, minor spinal deformity or stabilized genes from selective breeding (Soh, 2005). With regards to the super high body form observed in 'bat discus' or 'Bulldog' varieties, the shape seems to be a result of stunted growth in relation to lordosis, the bending of the spine, and is usually accompanied with other morphological deformities such as a recessed or extremely straight forehead, shorter gill cover, double chin and distortion of the caudal or pectoral fins (Soh, 2004). On the other hand, discus with super high fin forms seem to be the latest mutation in discus shape, with excessively longer dorsal and anal fins that are stretched vertically and have taken a different and triangular form (Soh, 2005).

1.2.5 MARKET

Discus are unique in the sense that they are considered the only tropical fish that appeals to both nature enthusiasts and genetic artists worldwide (Au et al., 2007). This is evident in the international market, which is observed with a large dichotomous split in the demand for wild strains extracted from known localities, and 'fancy fish' from diverse forms of artificially-bred varieties. Breeders also have the opportunity to showcase their newly refined or developed 'fancy fish' varieties and hybridizations at national and international shows, increasing the already large and loyal international hobbyist following to an even wider audience. With bright colorations and multiple varieties, such diversity is what enhances the value of these species in the trade where they are highly regarded and priced (Ready et al., 2006). There is no particular specific market size for discus, but depending on the strain and quality, individuals can retail for an estimated USD 60-80 and potentially much higher for A-grade or show-grade discus (Livengood et al., 2004). The intensive culture of cultivated strains is most evident in the Far East region including Malaysia, Thailand, Singapore and Indonesia (Livengood et al., 2004). Wild collection still occurs in South America, with additional breeding and exportation activities in Colombia, as well as small-scale local productions in Florida (Livengood et al., 2004).

1.2.6 CONSERVATION STATUS

Despite the importance of discus in the aquarium trade and an extensive aquarium literature, quantitative data on the ecology, life history and population estimates on wild discus in particular are lacking (Crampton, 2008). Thus, discus species have not been evaluated by the IUCN. Though there has been increasing reports from fishermen on the absence of wild discus, particularly Brown discus, in traditional fishing areas, suggesting possible population declines due to over-fishing and destructive fishing methods (Livengood et al., 2004). Further efforts are needed to acquire population data as well as monitor and assess such impacts. If in threat, greater emphasis on the aquaculture for discus could be recommended to relieve pressures on the collection of wild populations for the trade (Livengood et al., 2004). Nevertheless, works between the Wildlife Conservation Society and the Piagacu Institute in the Brazilian Amazon have found the cultivation of wild discus

species possible to provide optimism and opportunity for sustainable management through community involvement (WCS, 2012). At the same time, harvests by rural communities that only occur during high water season in the Rio Negro basin continue to find minimal impacts and potential for sustainability of the local population (Daniels et al., 2015).

1.3 RESEARCH PURPOSE, AIMS AND HYPOTHESES

With potential low impacts and an international demand for both wild-caught and captive-bred individuals, the ornamental trade in discus is also particularly unique for its conservation potential as a versatile tool for sustainable management – whether by acting as a NTFP, a sustainable economic alternative to other traded but endangered species, or, if in threat, by managing overexploited wild populations through the trade of its cultured varieties. With a voluminous array of phenotypic variations and a prized reputation, the continuous evolution of cultivated varieties also provides self-sustenance of the trade by maintaining consumer interest, and instigating populous trends for keeping and breeding fish with prized features among enthusiasts. However, as discus is both data deficient in population information at the source, and particularly limited in published and accessible data on consumer demand and knowledge of its end-user markets, it may be difficult to evaluate its conservation prospects, economic potential and monitor for effective management of different sectors of the trade.

This study aims to provide an insight to investigating international demand for the ornamental trade of discus (genus *Symphysodon*), and further highlight the role of preference elicitation techniques in providing a systematic approach to obtaining market information and in the management of wildlife trade. The research proposes to:

- identify different attributes and drivers associated with market and consumer demand for discus,
- examine potential heterogeneities in consumer preferences for discus within and between end-user markets, particularly between European and Far East Asian markets with reference to the United Kingdom and Singapore,
  - *Market heterogeneity*
    H1: There is a difference in preferences for discus in European and Far East Asian markets
- explore how preferences and demand for discus change among actors at different levels of the supply chain, with an understanding on heterogeneities linked to demographic background and fishkeeping knowledge,
  - *Respondent heterogeneity*
    H2: There is a difference in preferences for discus for trade professionals and public consumers
- and evaluate strategies to obtain market information by examining how preferences may differ based on survey technique.
  - *Survey evaluation*
    H3: There is a difference in preferences for discus based on survey technique

2 METHODS

In order to implement market analyses and understand behavioural responses of individuals i.e. to the demand of a traded product, effective marketing research is much needed and can be obtained with data on preference elicitation and choice modelling. This can be done through Revealed Preference (RP) and Stated Preference (SP) methods.

2.1 INTRODUCTION TO PREFERENCE ELICITATION

RP refers to records of observed or reported actual behaviour, where respondents may be asked to discuss what has already been done, and researchers can receive results on choice consistent with the actual market (Sanko, 2001). On the other hand, SP, also known as conjoint analyses, refers to behaviour that is observed or expressed in response to hypothetical scenarios or 'experiments' designed by the researcher i.e. what would be done if the scenario did occur (Sanko, 2001). In this case, estimates of the market can be received with results from ranking, rating or choice (Sanko, 2001). However, in the marketplace, attributes often lack in strong variability and may be highly correlated with each other, resulting in difficulties to grasp the trade-off and track the inter-relationship and influences between attributes (Sanko, 2001). As SP methods collect experimental data with the provision of a stated scenario, product demand can be estimated while alleviating such issues through a clear visualization of specific attributes, and obtaining records that would allow simulated models to examine potential influences in choice yet still controlling collinearity among attributes (Sanko, 2001). Thus, SP methods are highly advantageous in obtaining estimates to interpret attribute importance and economic valuation. Nevertheless, as RP corresponds to actual behaviour and may provide further understanding into the market, preference elicitation methods can incorporate elements of both types of data in its application as well.

Such approaches can be used to conduct market studies through a variety of techniques, including choice experiments and card sorting.

Choice experiments (CE) are a form of choice-based conjoint analyses, which have become increasingly popular and widely used in marketing for social scientific research on product appeal and consumer behaviour. A rise in their use in conservation science studies can also be seen over the years, including researches on private and social valuation of wetlands (Whitten & Bennett 2001), flagship appeal and suitability for conservation (Verissimo et al., 2009), and opinions on crime sentencing related to wildlife trade (St John et al., 2012).

The discrete choice analysis approach looks at understanding choice behaviour based on the Random Utility Theory which was first proposed by Thurstone in 1927, and later expanded by McFadden in the 1970s (Louviere et al., 2010). The theory suggests that when a person is presented with choice alternatives, an unseen or 'latent' construct known as a 'utility' is given psychologically for each alternative to impact on their decision-making (Louviere et al., 2010). Such latent utilities can have systematic components that are explainable through

'attributes', which outline characteristic differences between choice alternatives such as the colour of a product, and 'covariates' which describe choice differences related to individual background, such as education levels (Louviere et al., 2010). These utilities can also be based on random components unobserved in the experiment, such as external cultural factors, which reflect variability associated from the individual rather than directly from the attributes of the given options (Hanley et al., 1998, Louviere et al., 2010).

By estimating the value of such utilities, the way choice options are assessed, particularly in relation to descriptive attributes and levels that characterizes the product, and the overall desirability and valuation of the said good can be measured between different consumer groups. This can be achieved by designing a survey with a set of questions, or 'choice sets' based on pairwise or multiple comparisons of alternatives (Louviere et al., 2010). The idea is to create a hypothetical scenario where survey respondents are consumers, and are asked to make a judgment to purchase between hypothetical products of different specifications.

Card sorting (CS) is another form of conjoint analyses, which uses participatory techniques to construct mental models of product users based on observations on attribute identification, categorization and choice behaviour (Nawaz, 2012). The method is particularly established among studies involving knowledge acquisition and comparative evaluations of usability between products, with frequent applications to research related to software development, product design and evaluation (Rugg & McGeorge, 2005; Nawaz, 2012).

Sorting techniques provide an understanding on attribute importance and general choice-making based on Kelly's Personal Construct Theory of personality and cognition (Kelly, 1955). The theory assumes that people make sense of the world by creating categorizations of attributes, which are ordered and based on a personal development of facts and internal ideas derived from a collection of positive and negative experiences (Rugg & Mc George, 2005). By looking at how different people categorize a certain concept, favourable attributes can be identified and compared among individuals, and the level of agreement and disagreement, or commonality and differences, in the categorization and order of choices can be investigated and inferred between focus groups (Rugg & Mc George, 2005).

With the advantage of being "quick, systematic and easy to use", CS has become a multidisciplinary approach with a diverse range of methodologies, and has been increasingly adapted to cater to different research purposes (Rugg & McGeorge, 2005). The basic idea behind sorting involves grouping, ordering and/or naming of either items, pictures, or cards labelled by names of an object or situation related to the studied concept (Rugg & McGeorge, 2005). Among the most common are sorting techniques in the form of an 'open sort', where users are expected to name a number of cards based on a given subject, and are required to sort the set of cards by placing them into groups or categories that they create (Tullis, 2007). This method allows preference data to be revealed directly to the surveyor without any need to access the market for preliminary research, and provides an understanding linked to how users associate or relate to their sorts on a personal level.

Other techniques are associated with the 'closed sort', where users are asked to identify and sort their cards into labelled categories provided by the surveyor (Tullis, 2007). These results are obtained from SP data, where an understanding based on preliminary research can be tested, and thought processes behind the inclusion of particular cards in different categories can be observed within the target group.

CS is also primarily effective in the acquisition of qualitative data in preference studies. Along with quantitative elements where preference data can be obtained from the ranking of choices, the exercise may also involve qualitative aspects with short interviews, conducted after each sorting task (Alsos & Dahl, 2008). This is a RP technique which provides space to investigate topics related to product opinion between consumers and external influences associated to choice. Without this stage, the information would otherwise be difficult to infer if based purely on quantitative data. In recent years, such techniques have become increasingly apparent and adapted in the social sciences, with variants developed for specific research such as the Career Interest Card Sort for vocational assessment, planning and counselling (Athansou & Hosking 1998; Butcher, 2004). Studies in community conservation also reveal its advantages in knowledge acquisition among international bodies, with preference ranking and livelihood scoring possible through picture sorts, which do not require respondents to be fluent in the surveyed language (Narayanasamy, 2009).

To investigate the heterogeneities between market regions and respondent groups, this study will focus on applying and evaluating results obtained from the two aforementioned techniques to identify the importance of particular discus attributes, and observe the changes in consumer behaviour when choosing discus.

2.2 DATA COLLECTION

Preference data was collected with the use of paper-based surveys in a questionnaire format, followed by a short exercise in an interview format. With limited information available on the trade itself, informal semi-structured interviews were also undertaken to have an extended understanding on different sectors and aspects of the trade, obtain market information that would otherwise be difficult to access by the researcher, and further investigate the external push and pull factors i.e. influential attitudes and mindsets that act behind the choice-making when purchasing discus.

Data was collected in the United Kingdom (UK) and Singapore, two of the main end-user markets and hubs for the ornamental fish trade (Anon, pers. comm. 2012). To allow a direct contact to the local fishkeeping community and professionals in the ornamental fish industry, surveys were conducted with permission at international hobby and trade shows to obtain a concentrate sample of the relevant population. These shows included Aquatics Live 2012: the UK's Largest Fishkeeping Show in London, 10^{th}-11^{th} November 2012, the 4^{th} British International and Discus Keepers Association (BIDKA) Show in Doncaster, 23^{rd} -24^{th} March 2013, and Aquarama 2013: the 12^{th} International Ornamental Fish and Accessories

Exhibition in Singapore, 30th May -2nd June 2013. Prior to data collection, the survey was piloted for review on 7th November 2012, at an ornamental fish retailer in Canterbury, UK.

The target population included visitors, exhibitors, and professionals at the shows that were over 18 years of age, and have had either experience of keeping discus or some level of knowledge about discus. Given the time frame of the shows and specific requirements for prerequisite exposures to discus, survey participants were chosen through opportunistic sampling (Newing, 2011). Informal interviews were also undertaken at the venues, but optional and only conducted if survey participants and other show exhibitors were available upon completing the main survey.

Up to three research assistants were present per day at each hobby and trade show to assist with data collection, and were assigned based on individual availability. All were academics or university students affiliated to the social sciences and conservation, and have had prior experience in conducting questionnaires. Of six assistants in total, two were contacted through the National University of Singapore, and were fluent in local Chinese dialects for assistance in Aquarama. Four were associated with the University of Kent at Canterbury, UK, of which three had attended Aquatics Live, one at the BIDKA Show, and one at Aquarama. To ensure a consistent approach of sampling and surveying, meetings and a brief training session were organized prior to the shows. This was done to allow research assistants to familiarize themselves with the survey methodology and how it was to be conducted.

In addition to the shows, informal interviews were mainly conducted during visits to local discus breeders, retailers, exporters and related professionals of the trade. These took place in Hong Kong, a specialized and competitive end-user market for discus, in December 2012 and May 2013, Malaysia, a main supplier for cultivated discus varieties, in late May 2013, and Singapore in June 2013, which is also a main exporter of ornamental fish in Asia (Anon, pers. comm. 2012). With limitations as an outsider of the trade, interviews were arranged through opportunistic and snowball sampling to reach influential contacts within the industry that would otherwise be difficult to approach (Newing, 2011). In Hong Kong, visits were based primarily at the ornamental fish retail hotspot on Tung Choi Street, and aimed at professionals that bred or sold discus in the area. Informal visits to discus contacts in Malaysia and Singapore were arranged either via the internet or from referrals by other professionals met in Hong Kong or at the shows.

For data collection in Hong Kong and Singapore, the entire survey was translated into Traditional Chinese to provide language options and convenience to survey participants. Online versions of both languages of the survey were also created to reach a wider audience in the fishkeeping community, outside of the show venues. Nevertheless, paper copies were provided as an exception during local visits, particularly to professionals who were unable to attend the trade show in Singapore, or for other reasons were unable to take the survey online. Links to the survey on SurveyGizmo were posted with permission on online forums for the British Cichlid Association and the Singapore Discus Club. Links were also distributed

to further audiences with the aid of professional contacts met at the shows and during local visits, via email and online social media platforms such as Facebook. The survey was open to the public from March 2013, and officially closed online on 1st September 2013.

For ethical reasons, all participants were asked for informed consent, whether paper-based or online, prior to undertaking the survey. This permitted the use of data for research purposes only, and provided assurance for anonymity, confidentiality of the given information and disallowance in its distribution to third parties. Participants were also given the option to receive a summary of the survey results upon completing the exercises, and were only asked for contact information if interested.

2.3 SURVEY DESIGN

The survey was comprised of three sections, and involved two different methodologies to obtain information on consumer preferences for discus.

The first section of the survey gathers basic demographic and background information of the respondents (Table 2.1). Data obtained on gender, year of birth and fishkeeping will be used to form a basic understanding on the ornamental fish community, and compliment the analyses for heterogeneities in markets and respondent class.

The second section of the survey consists of a choice experiment. This was designed to investigate how different attributes and features of a product, in this case of discus, are valued by customers (Whitten & Bennett, 2011). By obtaining information on the level of importance or influence an attribute has on the purchasing decision of a buyer, we can attempt to identify the specific preferences of a target group, understand thought processes behind the decision-making, and examine the level of variation in the demand for discus between end-users internationally.

Table 2.1 Demographic information obtained in the survey

Demographic Factor	**Description**
Gender	Male, Female
Year of Birth	Year stated
Country of Origin	Country stated
Resident Country	Current country of residence and number of years at country stated *(included for cases related to new immigrants and short-stays such as trainees in exchange or international students)*
Fishkeeping – Tropical fish	No, Previously, Yes
Fishkeeping – Discus	No, Previously, Yes If Yes, to specify the discus varieties kept
Fishkeeping Experience with discus	In years *(later included and only asked at Aquarama 2013 for general research interests)*
Class	Hobbyist, Breeder, Retailer, Wholesale Importer, Exporter, Other *(classified to personal understanding by the respondent, with more than one classification allowed)*

The third section of the survey is an adaptation of the technique of card sorting, conducted with a focus on preference ranking (Alsos & Dahl, 2008). The exercise was performed with the use of photographic images as cards, designed to further investigate preferences for particular attributes of discus based on a visual aspect, and particularly observe how purchasers categorize and associate different physical characteristics with value. This would give rise to an extended understanding on choice behaviour linked with physical attributes that were difficult to explain or to be categorized in the CE, and external 'unseen' factors including cultural influences and economic or market related reasons.

Depending on the respondent, the entire survey was estimated to take 10 to 15 minutes to complete, with an additional 15 minutes for face-to-face exercises of CS.

For paper-based surveys conducted in person with respondents, a reference sheet with a brief introduction to the aims of the research project and visual keys to both the CE and CS were provided to survey respondents. A script with instructions on the performance of both exercises was also provided as a guide to research assistants on surveying at the shows. The script clarified ways to approach a potential participant, what respondents were expected to do for each exercise, and also included preparations for scenarios involving explanations of the study methodology and research aims when asked by respondents. All sections were compulsory. However, due to the length of the survey and busy schedules at the shows, respondents may only be required to complete the CE, and were only asked to complete the CS if time allowed. In the event where participants were unable to spare the time length required or unconfident to complete the CE, the second section may be skipped to move on directly to the CS.

For surveys conducted online, a brief introduction to the study and visual keys to the survey were presented on the cover page, and instructions to both exercises were explained in short comments for each section. All sections were compulsory and were required to be complete to access the next page.

2.4 CHOICE EXPERIMENT: DESIGN AND ANALYSES

A discrete choice experiment (DCE) was designed to present choice sets based on multiple comparisons of alternatives.

The attribute space for the CE design was defined through preliminary market research on stated or revealed preferences, from secondary information on discus forums online and in books, and informal interviews with discus retailers and breeders in Hong Kong, in August 2012. General attributes of discus that were investigated include colour (specified as overall 'base colour' in the CE to minimize confusions between primary and secondary colorations), pattern, body shape, origin and price (Table 2.2). Price levels and ranges were deduced after preliminary research on online store pricelists for discus varieties sold in the UK.

The choice sets were designed using the AlgDesign package Version 1.1-7.2 on R Package version 2.15.0 (The R Project for Statistical Computing; Wheeler, 2012). With five attributes and 16 attribute levels, a full 4 x 4 x 2 x 3 x 3 factorial design with 288 combinations of the levels of each attribute was constructed. This was done by manipulating two or more of the attributes (independent variables), and including all levels of each attribute stated to create a design that ensures a statistical efficient estimation of utilities (Aizaki & Nishimura, 2008; St John et al. 2012). However, as the number of choice sets has to be limited to avoid respondent fatigue, a fractional factorial design was created to reduce the number of choice sets to the minimum needed for a near-orthogonal and statistically efficient design.

Table 2.2 Attributes and levels used in the CE

Attribute	Description with Attribute Levels
Base Colour (Col)	*Looks at the general base coloration of the discus despite primary and secondary colours, without taking into account of patterning* Blue/Green (1) – *e.g. Blue Diamond* Red/Brown (2) – *e.g. Red Turquoise* Golden (3) – *e.g. Golden Diamond* White (4) – *e.g. Ghost discus*
Pattern (Pat)	*Looks at pattern types independently* Plain (1) –*'solid' discus varieties e.g. Marlboro Red* Patterned (2) – *mosaic patterning or designs e.g. Checkerboard Turquoise* Striped (3) – *general striated discus, thick or thin striped e.g. Royal Blue* Spotted (4) – *spotted varieties e.g. Leopard Snakeskin*
Body Shape (Sha)	*Looks at shape in terms of the D-body area of the discus* Round (1) – *circular shaped* High Body (2) – *tall-bodied, oval shaped*
Origin (Typ)	*Looks at the origin or source of the discus based on bred type and environment* Wild-Caught (1) – *discus collected directly from its wild habitat* Wild Type but Cultivated (2) – *F1 to F2 tank-bred generations from wild-caught discus* Artificially Cultivated (3) – *tank-bred, cultivated varieties*
Price (Pri)	*Compares price levels on a scale to determine willingness to pay* £25.00 (1) – *equivalent to ~SG$50.00, ~HK$325.00* £50.00 (2) – *equivalent to ~SG$100.00, ~HK$650.00* £75.00 (3) – *equivalent to ~SG$150.00, ~HK$975.00*

() = coding used for CE design and analyses on statistical programs

An optimal design, or 'orthogonal array', represents the best cases on orthogonality, where zero-correlation is achieved between attributes, and level balance, where attribute levels appear an equal number of times in the CE (World Health Organization, 2012). To achieve an orthogonal array, the selected design must be at least as large as the 'saturated design', which has as many choice sets as there are parameters in the study, and the number of choice sets must be divisible by the multiples of all numbers of levels of each attribute in the study (Kuhfield, 2010). The number of parameters of a model can be defined by subtracting the total number of levels by the number of attributes, and adding 1 for the intercept of the

model (St John et al. 2010; Kuhfield, 2010). In this case the model has 12 parameters, suggesting the CE to be over a saturated design of 12 choice sets.

It is also recommended that the size should be three times the number of parameters, 36 choice sets, or at an ideal minimum of 1.5 times the parameters at 18 choice sets (Sawtooth Software Inc., 2010). As 18 tasks were still too many to allow high quality responses to be maintained throughout the survey (Mangham et al. 2008), statistical efficiencies between designs of 12 to 17 choice sets were compared to select the best alternative. A minimal of 16 choice sets, in association with the total number of levels, were found to be needed to construct a design of similar efficiency to the ideal minimum, expressing a D-error difference of 0.000576, and to achieve a near-zero correlation between attributes.

The DoE.wrapper extension package Version 0.8-7 was also incorporated to improve on the fractional design with prohibitions of non-existent or unrealistic combinations of attribute levels (Groemping, 2012). For example, certain combinations on origin and price, such as a 'wild-caught' discus at '£25.00', would be impossible to find in the market (Anon pers. comm. 2012). The filtered combinations were then randomly selected to create a design of 16 choice sets with 32 different combinations. This stage was repeated to generate 20 different versions, allowing a comparison and selection for the best design.

The final set was chosen based on level balance and design efficiency. The latter was compared by evaluating the extent of improvement on the D-error, which relates to the amount of estimated standard errors around the parameter estimates (World Health Organization, 2012). As it is inversely related to the D-efficiency, the combination of choice sets that produced the lowest D-error can be understood as showing minimum variation, and would be reflected as the most efficient design (Hensher et al. 2005; Rose & Scarpa, 2007). If the D-errors were similar, designs were compared for G-optimality, where 1.00 represents the achievement of complete orthogonality through complete minimization of the maximum prediction variance (Ibáñez & Toner, 2007; Rose & Scarpa, 2007). For any design less than the optimal size, unless it was an orthogonal array, orthogonality and level balance will be compromised due to design constraints (St John et al. 2010). Nevertheless, minimal impact was observed as the chosen CE design resulted in a D-error of 0.194, at 95.9% efficiency with an 80.5% lower bound, and a G score of optimal efficiency at 0.822.

The choice sets were then presented on the survey in an unlabelled format, where choice options were named as 'Fish A' and 'Fish B' rather than giving reference to a particular type of discus, such as 'Red Turquoise' or a 'Yellow Ghost'. For each set, respondents were asked to indicate which of the two hypothetical discus they were more likely to purchase. Three options were given: to 'Purchase A', 'Purchase B', or to indicate that they liked both discus equally by selecting to 'Purchase either' (Figure 2.1).

Figure 2.1 Example of a choice set in the CE

1. Please indicate which discus you are most likely to purchase, or if you are equally likely to purchase either.

	Fish A		**Fish B**
Base Colour	Red/Brown		Golden
Pattern	Patterned		Plain
Body Shape	Round	OR	High Body
Origin	Wild-Caught		Artificially Cultivated
Price	£75.00		£25.00
	☐	☐	☐
	Purchase A	Purchase Either	Purchase B

The choice for 'either' acts as the alternative specific constant (ASC), which was included to enhance the theoretical validity of the welfare estimates (Kontoleon & Yabe, 2003). This was to represent an equal level of preference for choice options, with no particular strong favouring based on the attributes levels presented. This option was framed this way, as opposed to traditional formats that include an opt-out for 'no preference' or 'neither', in attempt to evaluate the strength of preferences in scenarios where respondents may like all presented types of discus, and find it difficult to make a decision. This was also an attempt to display the alternative with a different choice of wording, aimed at minimizing scenarios where tendencies to select the alternative and making no valid choice were stimulated from respondent fatigue. Such scenarios tend to lead to repeated selections of choices and skipping through questions, thus impacting results.

For the CE reference sheet, the included key illustrated examples of discus that fit into different categories related to the given attributes in the choice sets (Appendix 1). This was designed in attempt to provide a clearer idea and understanding of the attribute levels. Traders in particular were also instructed to make their choices based on a judgement of what they would do when choosing to purchase between the given two types of discus, allowing room to balance and incorporate aspects of consumer interest and potential personal preference in their results.

2.4.1 DATA ANALYSIS

All survey data were collated on Microsoft Excel 2010. In order to examine the level of heterogeneity within and between respondent groups, data was analysed in association with socio-demographic variables (covariates), which were defined and categorized by demographic information obtained from surveys (Table 2.3). These include both consumer characteristics as well as measures for survey evaluation, which were numerically and dummy coded to be read into statistical packages for analyses. The received data also allowed for an additional class of respondents with environmental employment to be sorted. Despite a relatively smaller sample size, the class was included in the analyses to provide an extended evaluation of potential heterogeneities based on conservation background.

Table 2.3 Socio-economic variables used for analyses on respondent heterogeneity

Covariate (Explanatory Factor)	**Factor Levels (Sub-categories)**
Gender (gen)	Male (1), Female (2)
Year of Birth (yob)	>1990 (1), 1980 – 1989 (2), 1970 – 1979 (3), 1960 – 1969 (4), 1950 – 1959 (5), 1940 – 1949 (6), 1930 – 1939 (7), 1920 – 1929 (8)
Resident Country – United Kingdom (ruk)	Other (0), United Kingdom (1)
Resident Country – Singapore (rsin)	Other (0), Singapore (1)
Resident Country – Malaysia (rmal)	Other (0), Malaysia (1)
Resident Country – Hong Kong (rhk)	Other (0), Hong Kong (1)
Geographical Sub-Region – North Europe (uneurope)	Other (0), North Europe (1)
Geographical Sub-Region – South East Asia (useasia)	Other (0), South East Asia (1)
Geographical Sub-Region – East Asia (ueasia)	Other (0), East Asia (1)
Market Region – European (meurope)	Other (0), European (1*) – North/South/East/West Europe*
Market Region – Far Eastern (mfareast)	Other (0), Far Eastern (1) – *East/South East Asia*
Fishkeeping – Tropical Fish (ktrop)	Don't keep (0), Currently keep or previously kept (1)
Fishkeeping – Discus (kdiscus)	Don't keep (0), Currently keep or previously kept (1)
Fishkeeping Experience with Discus (kexp)	No experience (0) 0 ≤ 2 years of experience (1) 2 ≤ 5 years of experience (2) 5 ≤ 10 years of experience (3) >10 years of experience (4)
Class – Professional (cprof)	Other (0), Professionals (1) – *including Breeders, Retailers, Wholesale Importers, Exporters*
Class – Hobbyist (chobb)	Other (0), Hobbyist (1)
Class – General Interest (cgen)	Other (0), General Interest (1)
Class – Environmental-Related Employment (cenv)	Other (0), Environmental employment (1)
Survey Language	English (1), Traditional Chinese (2)
Survey Type	Paper (1), Online (2)
Survey Sections Completed	CE only (1), CE and CS (2)

() = coding used for analyses on SPSS and NLOGIT. Geographical sub-regions are categorized based on the United Nations geoscheme of macro-geographical regions and sub-regions.

Prior to further analysis, the response data was evaluated for significant results by performing a basic multinomial logistic regression (MNL) on general discus attributes on SPSS. Model interactions with each covariate were carried out individually to assess its potential significance, and the influence of factor levels in defining prospective differences

in results. If significant variances between levels were observed, this reveals the potential for in-depth analyses of possible heterogeneities between and within groups of the sample population. However, if the results were found insignificant, further analyses on heterogeneity will not be necessary as significant results are unlikely to be computed. Additionally, if most respondent groups consisted of small representations of less than 10% of the sample population, further analyses will not be recommended as results may be impacted from potential biases related to a smaller sample size.

Having identified these covariates, random utility models of discus attribute levels were generated in LIMDEP 10.0 NLOGIT 5.0 to estimate the utility of choice, and examine the extent of heterogeneous preferences within populations. This was performed using a latent class modelling (LCM) approach, which both predicts choice and promotes the understanding of systematic heterogeneity by producing a finite-mixture model, with latent segments characterized by different degrees of sensitivity to discus attributes (Boxall & Adamowicz, 2002). In LCM, such segments refer to the finite and identifiable number of groups in a population, with each representing individuals that exhibit relatively homogenous preferences, and displaying preference structures that differ substantially between groups (Birol & Villalba, 2006).

Assuming that there is a linear relationship in the parameters and variables between utility and attributes, and that the error terms (random components) are identically and normally distributed, the probability for respondents of a segment to choose any particular discus alternative (attribute level) is expressed in terms of logistic distribution (Birol & Das, 2010):

$$U_{ij/\,s} = \beta'_s X_{ij} + \varepsilon_{ij/\,s} \qquad (1)$$

where the utility U of a respondent i that belongs to latent segment s is expressed in association with the preferred discus alternative *j* of the choice set *C*. Assuming a random utility framework, the random component is expressed with β'_s as the segment-specific vector of parameters, and X_{ij} as the vector of attributes associated with discus alternative *j* and respondent i. The differences in β'_s between segments will capture heterogeneity for discus attributes across segments in a model. $\varepsilon_{ij/\,s}$ refers to the error component associated with alternative *j* and respondent i of segment *s* (Birol & Villalba, 2006).

These are known as the utility function of attributes, which were given as maximum likelihood estimations for each segment to determine the specific utilities that individuals of a group are most likely to express for a specific choice. Data was coded in NLOGIT to generate choice parameters relative to the last coded attribute level i.e. 'white' for base colour. Estimates on the likelihood of choosing the ASC, as in to purchase either option, were also generated to evaluate whether respondents of a particular segment carried specific preferences for discus, and if they were likely to make definitive decisions based on the investigated attributes.

In LCM, the likelihood of individuals belonging to a segment with similar preferences, and the potential for displaying varied interests are dependent on their social-economic and demographic characteristics (Birol & Villalba, 2006). This expresses model assumptions that consumer characteristics may affect choice indirectly through their impact on segment membership (Birol & Villalba, 2006). Thus, the model output consists of two components to account for heterogeneity within groups: utility functions that determine segment-specific preferences for particular discus attributes, and segment membership functions which estimate the relative likelihood for respondents of particular socio-demographic groups, such as hobbyists, to display such utilities and to be included in particular segments. An overview of preferences among the entire sampled population is also displayed with a basic MNL model on discus attribute levels. Overall, these results will provide an understanding of general preferences for discus, and allow an investigation on the extent and magnitude of differential preferences associated with socio-demographic effects at the individual level.

To achieve this, LCMs were conditioned with all possible combinations of two, three and four covariates, and were generated independently at two, three, four and five model segments to capture as much of the variation as possible (Lanza et al., 2007). As individuals were only classified as residents of one country, sub-region and market region at the same time, unrealistic combinations that include two or more different resident countries, or unrelated market regions, were excluded from the analysis. Once the output from models of all segments at all covariate combinations were retrieved and collated, the LCMs were filtered for statistical efficiency and model interpretability, and subsequently selected to assess for optimality (Lanza et al., 2007). Due to a large output of results, an adaptation of the approach was developed to aid the process, involving six initial filtering stages where models were either kept or filtered out based on the given criteria (Table 2.4; Lanza et al., 2007).

Table 2.4 Description of filtering stages for model selection

	Filter Stage	**Description**
1	Solvability of models	Keep models that solve at 2, 3, 4 and 5 segments
2	Segment membership 1	Make note of models with average class probabilities less than 10%
	Insignificance of segments	Keep only significant models with no more than one completely insignificant class (in terms of utility estimates)
3	Statistical efficiency - AIC	Keep models with a delta AIC of less than 100 units, between the most significant model segment and the most robust with the lowest AIC value ($p < 0.01$)
4	Covariate significance	Keep models with at least one significant segment membership estimate for each covariate across model segments
5	Standard error of utilities	Keep models with utility estimates expressing standard error values less than three non-decimal digits
6	Segment membership 2	Keep models with average class probabilities over 5%

The resultant models were then selected for best fit between sub-models of two, three, four and five latent classes. To determine the optimal number of segments, a balanced assessment of model

statistics is required to obtain the best solution of results. Comparisons were made between model segments on the log likelihood (LL) and Pseudo R-squared (R^2) values in relation to the base model. Marginal improvements in statistical efficiency between model segments were then assessed by comparing differences in the minimization of Akaike's information criterion (AIC), followed by greater penalization from the Bayesian information criterion (BIC) and modified Akaike's information criterion with 3 as a penalty factor (AIC3; Verissimo et al. 2009). Where K refers to the number of estimated parameters and N the sample size, the information criterions were calculated as:

$$\mathrm{AIC} = -2\,(\mathrm{LL} - \mathrm{K}) \tag{2}$$

$$\mathrm{BIC} = -\mathrm{LL} + [(\mathrm{K}/2) * \ln(\mathrm{N})] \tag{3}$$

$$\mathrm{AIC3} = -2\,(\mathrm{LL} + 3\mathrm{K}) \tag{4}$$

Compared to results obtained for the base model, optimal improvements in terms of efficiency were at 181.9 units for the delta AIC, 91.2 units for delta BIC, and 182.3 units for delta AIC3 at 99% significance.

Having identified the optimal model segment for each LCM group, secondary filters were also developed and applied to select the final models for the study. Models were kept if the results displayed no more than two segments with insignificant representations for all membership estimates of the conditioned socio-demographic characteristics. Filters beyond this point were based on model interpretation that could be made on respondent preferences and socio-demographic effects, which would most reflect preliminary understandings of discus preferences and observations on consumer demand.

As the CE method is consistent with utility maximization and demand theory, once the parameter estimates were obtained, the marginal value of change in implicit price of discus attributes were derived for each segment of each selected model in NLOGIT (Birol & Das, 2010). This was performed using Wald's delta method, which produces marginal welfare estimates on consumer willingness to accept (WTA) compensation for each discus attribute from:

$$WTA = -\frac{\beta_k}{\beta_y} \tag{5}$$

where β_y equates to the marginal utility of price, and β_y is the utility coefficient of discus attribute levels, derived from the LCM (Birol & Villalba, 2006).

The WTA relates to economic valuation by determining the marginal rate of substitution between payments (Birol & Das, 2010). The resultant value indicates the minimum monetary amount required for a good, or the acquisition of a less desirable product to be accepted by the individual. Thus, a significant and positive WTA would explain the extent and willingness of respondents to accept some level of price reduction or discount for the purchase of discus with less desirable characteristics. However, if the value is negative, this

indicates that the respondent does not require compensation. On the contrary, if significant, the values would equate to willingness to pay (WTP), which suggests that respondents expressed greater desirability for the product, and is willing to pay a premium for its purchase (Verissimo et al. 2009). Unlike WTP, WTA valuation is not constrained by respondent wealth as the estimate refers to how much payment is received by the respondent to accept a good (Mendes, 2004).

2.3 CARD SORTING: DESIGN AND ANALYSES

A CS variant, known as 'card-rating conjoint analyses', was performed in this section of the survey. With reference to Alsos and Dahl's (2008) technique on card ranking, the exercise was a picture sort that involved the use of photographic images of real discus fish as cards. Respondents were required to conduct the sort in the form of preference ranking, where images of a given card set were ranked in an order of preference based on different criteria.

Generally, CS methods would involve taking place in a closed setting, potentially with a group of participants, and requiring respondents to sort a large number of cards prior to the exercise (Rugg & McGeorge, 2005). Cards that are chosen from the sort are then subsequently ranked based on an order of preference (Rugg & McGeorge, 2005). These measures were encouraged to allow participants to sort and compare a larger set of cards in a more focused and spacious environment, and the collection of preferences based on an initial filter and identification of favourable attributes chosen by the participants. However, given the time needed to complete all three sections of the survey, and constraints related to a lack of survey space within the tight venues of the shows, it was deemed difficult and inefficient to base this exercise on the former methodology, and gather groups of respondents eligible for this study prior to the actual card sorting. As a result, an adaptation on the methodology was used, and the card sort was conducted individually with respondents to minimize biases during data collection.

For this study, it is imperative to incorporate investigations on the strength of preferences and the extent of potential differences on an individual level, particularly between and within demographic groups. Hence, to complete this understanding, cards were analytically chosen prior to implementation at the shows, and were given to respondents as part of a selected card set. This was to ensure that the sort included a variety of discus, which would display a more extensive range of characteristics than what could be described in the CE. This diversity would also allow observations to be made on either direction of preference, whether positive or negative, for different physical attributes of discus.

The images for the card set were derived systematically through a series of stages, involving the initial collection of images, a stage of filtering for potential inclusion, editing, followed by image analyses on colour and shape to perform the selection, and result with the final set.

2.5.1 IMAGE COLLECTION

A collection of 200 photographic images of discus were first obtained through scans of printed books from both European and Far East Asian countries, including Aqualog Special: Majestic Discus[1], Aquarium Atlas[2], Asian Discus II[3], Malaysia Discus II[4], Mini Atlas Discus II[5] and Trophy Discus[6] (labelled with superscripts for referencing of scanned images; see citations in Section 5 References). These images were selected based on the position of the fish, with a sideways profile to the camera for a better representation of its characteristics and shape. Selections were also made towards those that gave a complete capture of all features with no cutting-off of fins, and appeared to have maintained a well enough resolution and quality in the books to attempt with scanning. Each image was individually referenced to its source for use within the study.

Seventy images were then chosen from the collection based on scan quality in relation to clarity, colour and resolution. In attempt to ensure a balanced representation of different discus varieties, the selection took into account of fish from different categories based on show class, a classification commonly used among international competitions and exhibitions worldwide (Table 2.5).

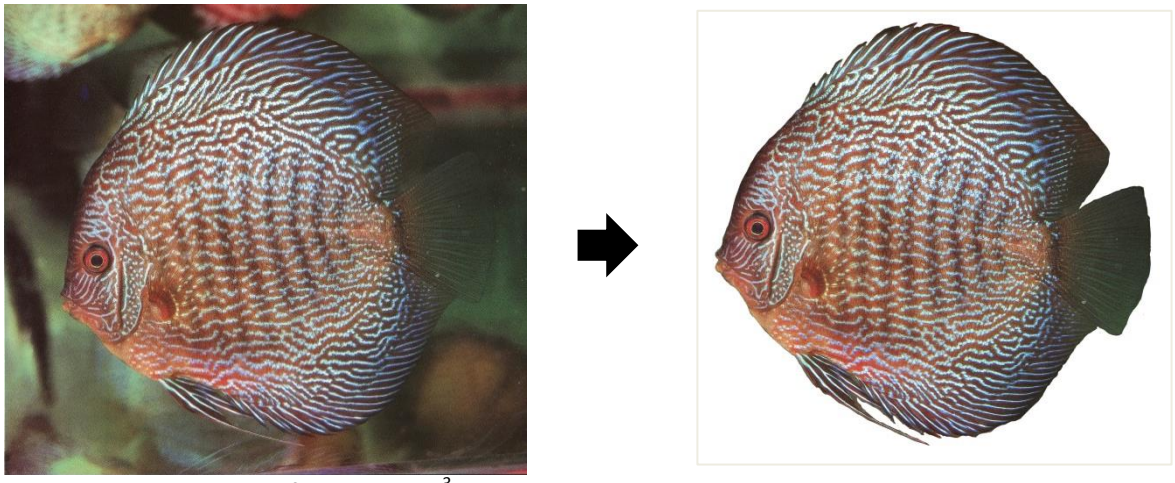
Table 2.5 Preliminary groupings of discus varieties based on show class

Show Class Categories	Discus Varieties and/or Characteristics
Wild Forms	Heckel, Wild Brown, Wild Blue, Wild Green
Solid Discus	Solid Blue/Green, Solid Red/Brown, Solid Golden
Striped Discus	Thick line striations, Thin line striations
Patterned Discus	Maze or mosaic forms, Checkerboard, Tiger striped, Ringed
Spotted Discus	Red spotted
Open Class	Albino forms, White varieties incl. Solid White, Ghost discus

Classifications with reference to Au et al. (2007).

All images were cropped from scans and consequently edited on Adobe Photoshop CS6 in its original size, preventing image distortion and further changes in resolution. Using the gridded background provided in the software, images were rotated and positioned so that the tip of the upper lip was perpendicular to the caudal peduncle at the midst of the tail. This procedure was repeated for all images to allow a standardized comparison between the selected discus. With a Wacom Bamboo Graphics Tablet, image backgrounds were carefully removed to cut out areas of ‘noise’, and produce an image of the fish on its own with a clear background. Images were then put to scale through further cropping, ensuring a gap of 3 gridded blocks at all four corners, between the farthest points of the fish and the edge of the cropped image (Figure 2.2). This was also done to minimize errors related to excessive white dominance from the background, which may impact results from colour analyses as images are saved and processed for pixel data as a jpeg file (Kryzwinski, 2014).

Figure 2.2 Example of photo editing on Adobe Photoshop



Scanned image of a Snakeskin[3] | Edited image

2.5.2 IMAGE ANALYSES

All 70 edited images were subsequently analysed using an online Image Colour Summarizer, Morphologika[2] Version 2.5 and SPSS Statistics 21 to compare differences in colour and shape between discus varieties. In doing so, sub-groups that explain the variation within the set can be identified, and visual representations of these results can be constructed to aid the final selection of images for the card sort.

Descriptive colour statistics were generated by submitting and processing images individually on Martin Krzywinski's Image Colour Summarizer (Kryzwinski, 2014). Images were set to be processed at 'extreme' precision at 300px, and data values were reported on a tab delimited text layout in the output. For each subject, the summarizer generates pixel values that defines colour by assessing levels of RGB, 'Red', 'Green' and Blue' properties, HSV with reference to 'Hue' (gradation of colour), 'Saturation' (colourfulness) and 'Value' (brightness), and LCH which looks for 'Luminance' (brightness), 'Chroma' (redness) and 'Hue' (Kryzwinski, 2014). This study focussed on pixel data generated from an assessment on RGB. For each image, these values were extracted and read into SPSS for a subsequent cluster analysis based on colour.

A Discriminant Function Analysis (DFA) followed by a Principal Component Analysis (PCA) was performed to generate factor weightings that define distinctiveness of images based on colour (Dytham, 2011). Maximum discrimination between images were then inferred by constructing a clustogram of the PCA values, allowing the identification of groupings that measure the extent of similarities within and between discus variety groups (see section 3.2.1 Preliminary Results).

Morphometric variations between the 70 images were also investigated to provide further information on differences within and between discus variety groups, and in attempt to aid the final selection. This was done using Morphologika[2], which explored this variation by

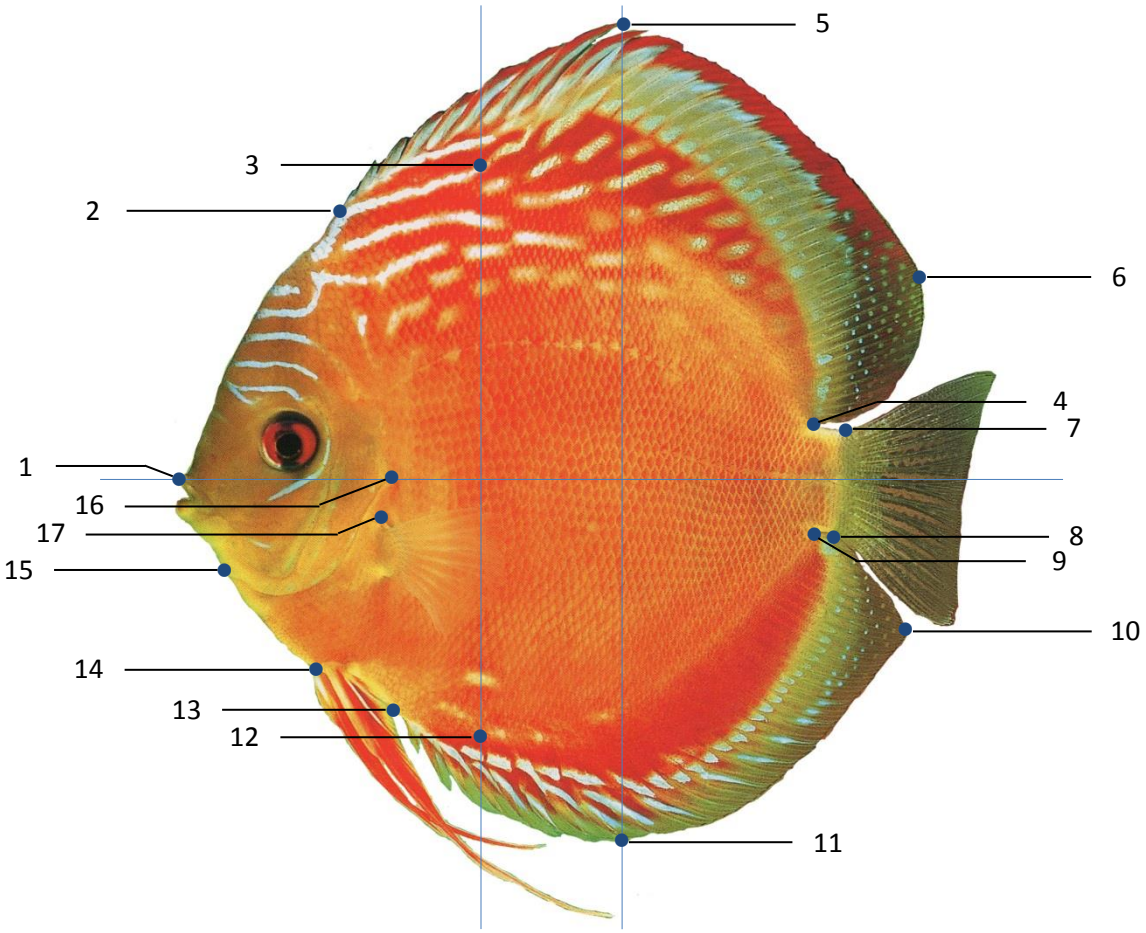
performing a PCA on the morphometric components for each image, and producing plots to observe the distribution of shape across the set of images.

In morphometric terms, the shape of a subject is described as a configuration of a set of data points known as 'landmarks' (Polly, 2012). These landmarks are located at specific positions which would define the shape of the subject, and could also be used as a universal tool to make comparisons in shape between subjects of a group, irrespective of differences in individual size (Polly, 2012). To investigate how shape differs between the selected images, 17 landmarks that represent different anatomical points of a discus were identified and used to obtain data on individual shape (Figure 2.3). For each image, all landmarks were identified by locating each point discretely on tpsDig, an extension software for Morphologika^2, allowing digitized coordinates of the landmarks to be generated for use in further shape analyses. Each position should be identified and placed with the correct landmark in the right sequence, so that coordinates are recognized as a representation of a particular anatomical point on the subject. This step is crucial in defining individual shape, as only then can a comparison be possible between images.

Since tpsDig only allows landmarks to be located for one image at a time, another extension, tpsUtil, was applied additionally to speed up the process and allow multiple images to be uploaded and marked in the same window. As a result, each image would have 17 coordinates generated, which would be grouped and coded on a text file to be read into Morphologika^2. Based on these landmarks, the software would be able to position the coordinates, capture the outline of each fish by linking the points in a specific order, and ultimately construct a wireframe that describes the shape for each discus compared.

As image size varied across the set, a procrustes analyses was performed to translate, rotate and rescale the images for further analyses in shape distribution within the sample (Polly, 2012). All images were centred, fitted and scaled to the same unit size (Polly, 2012). In doing so, a standardized set of wireframes was produced to allow comparisons to be made on discus shape. A PCA was then performed to explore the level of variation seen in morphometric characteristics between images and discus categories.

Figure 2.3 Position and order of landmarks for Morphologika[2]



Landmark Number	Description
1	Tip of upper lip, perpendicular to caudal peduncle at midst of tail
2	Pre-dorsal point of the fin at the tip of the nape
3	Highest perpendicular point of the D-body area
4	Upper insertion at the start of the caudal peduncle, end of dorsal fin
5	Highest perpendicular point on the dorsal fin
6	Tip and farthest point on the rays of the dorsal fin
7	Upper end of caudal peduncle, towards the start of the caudal fin
8	Lower end of caudal peduncle, towards the start of the caudal fin
9	Lower insertion at the start of the caudal peduncle, end of anal fin
10	Tip and farthest point on the rays of the anal fin
11	Lowest perpendicular point to Landmark 5 of the anal fin
12	Lowest perpendicular point to Landmark 3 of the D-body area
13	Pre-anal point of the fin
14	Pre-pelvic point of the fin
15	Lower point of the preopercular margin, towards the chin
16	Tip of the preopercular margin of the gill cover
17	Pre-pectoral point of the fin

Image of a Solid Red variety selectively bred from Red Turquoise, considered as a 'Chinese Alenquer' [3]

Having obtained both colour and shape data for each image, distinctiveness within and between discus categories were then observed by constructing hierarchical tree diagrams or dendrograms based on average linkage within groups. These include separate dendrograms for colour and shape on its own, and both colour and shape together. In doing so, clusters based on similarity between images can then be identified to apply the last filter and aid the final selection of images for the card sort. However, due to strong overlap and similarities in results for colour, clusters were only derived from shape analyses, with the identification of four sub-groups and one out-value (see Figure 3.5 in section 3.1.2 Preliminary Results).

2.5.3 FINAL SELECTION OF THE CARD SET

To create a valid exercise for preference ranking, previous studies recommend an estimated set of eight options to be given to participants to minimize respondent fatigue and the cognitive burden of ranking a large number of entities (Rugg & McGeorge, 2005). This was also advised to minimize potential difficulties in ranking the middle classes, which would bring choices are less obvious to the respondent than the extremes. As discus varieties appear to be highly diverse in physical characteristics, a standard size of 10 selected images was decided for inclusion in the card set.

To produce this card set, the 10 images were selected based on clusters derived from differences in shape. Two images were chosen for each of the four larger sub-groups, one among the smaller sub-group, and the last one being the out-value observed from the dendrogram (see Figure 3.5 in section 3.1.2 Preliminary Results). This ensured the inclusion of different variants of discus into the final set. Listings for each sub-group were created on an Excel spreadsheet, and a random number was assigned for each image to conduct a random selection. Images ranked with the highest value in their sub-group were chosen to be included in the set.

To ensure a balanced representation of all six categories of discus varieties, this procedure was repeated by generating a different set of random numbers, producing five different combinations of potential card sets. The final set was then chosen among groups that showed better image and scan quality than others (Figure 2.4). The selection included two wild forms, three solid discus, two striped, one patterned, one spotted and one open class.

As images were chosen based on the variety of attributes that were represented by the selected fish as well, it is noted that specific discrepancies or ‘imperfections’ in colour, pattern and shape may be related to stages of growth, subjected form of selective breeding or other factors which can only be confidently associated to the particular fish included than as a general defining attribute of the variety itself. Thus, although images are referred to by variety name, inferences made from the quantitative analyses will be focused on deriving similarities and differences between the observed features represented by the fish, and any associations to the general varieties will only be made when established with context from prior understanding.

Figure 2.4 Final set of cards used in the CS exercise

1 – Wild Green [1]

2 – Yellow Ghost [3]

3 – Golden [3]

2 – Heckel
(Cultivated Wild Type) [3]

5 – Pigeon Blood (Pearl) [3]

6 – Red Spotted Green
(Cultivated) [3]

7 – Red Turquoise
(Cultivated) [3]

8 – Blue Snakeskin [3]

9 – Solid Blue [3]

10 – Super Marlboro Red [3]

In preparation for the exercise, images of the chosen set were printed in photo quality and fitted to size to prevent stretching or distortion. Excess areas around the print and not part of the image were removed. All cards were then labelled with numbers 1 to 10 on the reverse of the photo to aid the recording of ranked data by the surveyor (Figure 2.4). These labels were not revealed to respondents, and images were unnamed to minimize biases by association. Finally, the cards were laminated to protect the images from damage when used during the exercise.

2.5.4 CONDUCTING THE CARD SORT

After respondents completed the second section of the survey, the CS exercise was conducted by providing a set of 10 cards, comprised of selected photograph images of discus (Figure 2.4). The set would have been shuffled prior to the exercise, and its current placement would show no particular relation to the numbers labelled for each card. With these cards, respondents were asked to rank the entire set based on their preferences for discus, with images placed in an order of best to worst liking. No writing or data recording was required on the respondent's part for this section of the survey.

The entire exercise was comprised of three tasks, which repeats the above procedure three times to retrieve separate data for preferences on three different attributes. These attributes, known as a 'priori', were decided based on a preliminary understanding of consumer preferences derived from previous market research in Hong Kong, in August 2012. Since the exercise was a picture sort involving images as cards, the priori were mainly defined by visual characteristics or physical attributes of discus (Rugg & McGeorge, 2005). These were base colour, pattern, and overall fish shape (including the body and fins).

As respondents progressed with the exercise and presented their order of preference, surveyors recorded their rankings on a separate datasheet (Figure 2.5). The image that was placed first in the order was recorded under 'Rank 1' on the spreadsheet, the second image under 'Rank 2' and so on. Surveyors were advised to collect the ordered set of images after each sort, and flip the images to the back to record their rankings based on the assigned label number. A reference sheet indicating the label numbers for the images were provided to research assistants for help in familiarizing with the card set, and aid the recording of data during the exercise.

After an order of images was produced, a short interview was conducted where respondents were asked to describe the reasons behind their chosen order. This was essential to obtain information that provided a qualitative insight into the respondent's thought process, allowing inferences on preferences to be made based on areas outside of what is visible or evident to the surveyor with regards to the placement of images. In this stage, respondents were asked to comment on the first and last three images of their order.

Figure 2.5 Example of datasheet used to record rank values for base colour

1. Please rank the following 10 images in the order of your preference for base colour from best to worst.

		Notes
Rank 1 _____	Rank 6 _____	_____
Rank 2 _____	Rank 7 _____	_____
Rank 3 _____	Rank 8 _____	_____
Rank 4 _____	Rank 9 _____	_____
Rank 5 _____	Rank 10 _____	_____

Image numbers were recorded based on their rank position in the ordered set. Any comments or observations were written under the section for 'Notes'.

Upon completion of each task, images were shuffled and presented to respondents in a randomized order to conduct the next card sort. For CS exercises conducted online, images were placed in different orders for each of the three tasks. The positioning of each image for each question was decided based on an assignment of random numbers using Microsoft Excel 2010, replicating the act of shuffling. Respondents then expressed their preferences interactively by drag-and-dropping images of choice in ranked order. Comments on the first and last three positions of their order were submitted by typing into a textbox placed under each task question. This step was required to proceed to the last page and reach the end of the online survey.

2.5.5 DATA ANALYSIS

All survey data was collated on Microsoft Excel and statistically analysed for differences in rank order of images on IBM SPSS Statistics 21. Heterogeneity within and between respondent groups were investigated by analysing data in association with the socio-demographic variables used to classify groups in the CE (Table 2.3).

The analysis was split into three main sections, involving boxplot representations of the distribution of rank scores, general linear models (GLM) on the significant difference between ranked means, and Spearman's rank order correlations of ranks means between and within groups.

Rank scores of images refer to numerical positions of the picture sorts based on the respondents' ordered set. A high rank score, such as 10, relates to a low rank position in the set, whereas a low rank score, such as 1, relates to a high rank position in the set. Frequency values, with relation to the occurrence of an image being ranked at a particular position, were obtained for each image to construct boxplots on SPSS. By repeating this measure for every respondent group and for each CS task individually, this provides an overview and a visual representation on the range in which images were scored between different respondent groups, with distinct reference to their particular sorts for base colour, pattern and overall fish shape.

Significant differences between respondent groups were examined by conducting multiple univariate GLMs on rank scores of each image separately, for each socio-economic variable and each individual CS task. The GLM is a generalization of the multiple linear regression model with application of ordinary least squares (OLS), which determines the form and strength of a relationship between two variables by predicting the 'effect' of the dependent response variable (y, ranked means of an image for a specific attribute) from a given value of the independent 'cause' or predictor variable (x, socio-demographics; Dytham, 2011). Parameter estimates are expressed as beta effects, which is the slope of a line of best fit that determines whether respondents of a particular group are more or less likely to place a high rank score for an image than others. This can be expressed as:

$$\mathrm{y} = \mathrm{B}_0 + \mathrm{B}_1 x + e \qquad (6)$$

where the outcome y is reflected by the a set of intercepts B_0, the set of B-effects or coefficients B_1 in association with a set of covariates x, and the error component.

The model incorporates statistical components including a one-way between subjects ANOVA, which evaluates the extent and significance of variation in mean rank scores of factor levels for each respondent group (Brace et al. 2012). However, the ANOVA carries limitations where a significant result only indicates that at least one pair of factor levels are significantly different from each other, with no specifications as to where the variation lies and from which pair (Dytham, 2011). Thus, for socio-demographic variables with three or more sub-categories, such as year of birth, if there is a significant variance in the mean rank scores of images, a Least Significant Difference (LSD) post-hoc test will be performed to identify the source of the variation within the sample. If the *p*-value is significant, this indicates that the mean difference between the listed sub-categories is statistically significant, and variance in the group can be explained from the relationship seen between these sub-categories (Dytham, 2011). As a result, models were generated correspondingly, with beta coefficients relative to the factor level that is most significantly associated with the variation explained, identifying the direction of preferences among respondent groups.

As the model (ANOVA) assumes that variances are equal and data is normally distributed within each factor, Levene's Test on the homogeneity of variances was performed for each socio-demographic variable to determine whether the results were valid for analyses and model interpretation (Dytham, 2011). If the *p*-value is less than the critical value at 0.05, this indicates a violation in homoscedasticity and that model assumptions were not met. In this case, the parametric test results will not be applicable for this variable, and a Kruskal-Wallis Test will be performed instead. This approach is the non-parametric equivalent of the ANOVA, which identifies significant differences by comparing median rank scores. As the test bears the same limitations as the ANOVA, Mann-Whitney U tests were carried out for significant results to make all possible pairwise comparisons of factor levels, and identify which levels are different from which (Dytham, 2011). The direction of group preferences were then inferred from comparisons of median rank scores between varying groups.

Subsequently, associations in the construction of rank orders for all three CS categories were evaluated by conducting a Spearman's rank-order correlation between and within respondent groups for each socio-demographic. The analysis between groups looks at comparing responses from different respondent sub-categories for each discus characteristic independently. Where 0 indicates no correlation and 1 indicates a strong and complete association, a positive and significant coefficient would suggest that similar rank orders of images were constructed, and that there is no strong difference in their preferences for discus. On the other hand, a strong negative correlation would refer to groups expressing opposing preferences and rank orders for the set.

Analyses within groups refer to the evaluation of responses between the three CS categories for each socio-economic group. In this case, a strong positive correlation would indicate similar rank orders for different CS subjects, whereas a strong negative correlation would suggest opposing rank orders for different discus characteristics.

Information received from short interviews was not subjected to qualitative analyses in this study, but will be used to assist the discussion and understanding of quantitative results from the CS.

2.4 SEMI-STRUCTURED INTERVIEWS

Additional to the CE and CS, informal interviews were conducted and qualitative data was obtained to improve background knowledge of the trade, so as to gain a broader understanding on consumer behaviour, market trends and the industry itself. All information was received to aid the interpretation of analyses and discussion of CE and CS results only. No further analysis on qualitative data was performed.

Interviews were conducted in a semi-structural format, with both open and close-ended questions. To ensure that particular topics can be discussed, if applicable, and full responses from informants were retrieved, non-directive probes or prompts were used to encourage elaborations on potential subjects of interest (Newing, 2011). These topics may include:

1. Market understanding
   Knowledge of the trade and the local industry, with reference to historic and current demands in terms of particular varieties, the supply process, and the evolution of the market.

2. Customer preferences
   Directed to professionals of the industry in terms of understanding different types of demand and general public perceptions of discus, potentially from personal experience with customers or buyers of different backgrounds.

3. Keeping discus
   Looking into the mechanics of discus keeping, the appeal among discus keepers, as well as the associated challenges in relation to particular keeping routines and issues

with disease. Opinions on the controversial use of artificial colour enhancements with feeds were also of interest.

4. Breeding discus
   Information and opinions on the selective breeding process in terms of the genetics, mutations, and selection and enhancement of particular discus characteristics. Further information on standards for quality control and grading of discus were also of interest to understand how breeders perceive discus and what is considered 'high' or 'low' quality in the industry.

5. Judging discus
   Directed towards discus judges of local or international shows, with particular interest on understanding potential differences in international judging criteria and the assessment or standards needed for a championship discus. Such information will provide a background understanding on features that are advertised and considered as the 'best' for discus among specialized keepers and enthusiasts internationally.

3 RESULTS

Excluding the pilot, a total of 584 paper surveys were conducted throughout the entire course of data collection; 440 responses for CE and 378 for CS. Of the 584 surveys, 160 were conducted at Aquatics Live, 130 at the 3rd BIDKA Show, and 241 at Aquarama. 542 surveys were completed in English, and 42 in Chinese.

224 online surveys were submitted on Survey Gizmo, with 156 in English and 69 in Chinese. As only complete records were incorporated in the analyses, 94 cases were omitted based on incompleteness of sections and repeated entries by respondents. The former relates to responses that were absent of all data points to both CE and CS sections. Repeated entries were identified based on respondent demographics and traceability data obtained from SurveyGizmo. This includes information on the IP address, user agent and GPS location of the country where the survey was accessed. As a result, 131 online surveys were eligible for analysis, involving 131 responses for CE and 91 responses for CS. Within this dataset, two responses with an incomplete CE and 36 with an incomplete CS were excluded for particular analyses of the results, allowing the evaluation of 129 complete responses for CE, and 55 for CS.

3.1 CHOICE EXPERIMENT

Of 571 total responses, 564 complete CEs of either on paper or online were included in the analyses, resulting with 9024 observations on consumer choice for discus. Five paper responses and two online were excluded due to missing data and incompleteness of the CE section.

Twenty-one multinomial logistic models with covariate interactions on the general attributes were evaluated for covariate significance, model fit and the potential for further analyses on heterogeneity between and within groups. All models were significantly predicted for all five attributes at the 99% level, with results across models accounted for a minimum 8.0% to a maximum 18.2% of the overall variance in discus choice (Table 3.1).

The distribution of classes in terms of age group, respondent class and resident countries incurred groups with representations under 10% of the sample population. Although relatively smaller representations were observed for respondents born in 1940-1949, 1939-1939 and 1920-1929, with environmental employment and from Malaysia, evident results from the remaining five major age groups, respondent classes and resident countries suggested that further analyses on heterogeneity and comparisons were possible. It was also noted that data on fishkeeping experience was only received from 116 of 564 cases, raising concerns of potential issues related to a smaller sample size that accounts for just 20.6% of all observations on discus choice. Nevertheless, as significant results were predicted with class representations over 10% for groups of all experience levels, such data was also

included for extended comparisons with the other results. Thus, all tested covariates were subjected to further analyses on NLOGIT for effects on consumer preferences at a more refined level.

Table 3.1 Model fitting information of MNL models with covariate interactions on the general attributes

MNL Model	Factor Level	Marginal Percentage	Likelihood Ratio Test			Pseudo R^2	
			Omnibus X^2	df	*p*	Cox and Snell	Nagelkerke
Gender	Male	0.734	2316.987***	11	<0.001	0.082	0.114
	Female	0.266					
Age Group	1990-1999	0.122	2353.265***	41	<0.001	0.083	0.116
	1980-1989	0.285					
	1970-1979	0.246					
	1960-1969	0.177					
	1950-1959	0.128					
	1940-1949	0.034					
	1930-1939	0.005					
	1920-1929	0.002					
M – Res Country	Other	0.592	2359.495***	11	<0.001	0.083	0.116
(i) United Kingdom	UK	0.408					
(ii) Singapore	Other	0.809	2310.736***	11	<0.001	0.082	0.114
	Singapore	0.191					
(iii) Malaysia	Other	0.961	2258.996***	11	<0.001	0.080	0.111
	Malaysia	0.039					
(iv) Hong Kong	Other	0.832	2332.597***	11	<0.001	0.083	0.068
	Hong Kong	0.168					
M – G. Sub-region	Other	0.590	2362.570***	11	<0.001	0.084	0.116
(i) North Europe	N Europe	0.410					
(ii) South East Asia	Other	0.743	2313.663***	11	<0.001	0.082	0.114
	SE Asia	0.257					
(iii)East Asia	Other	0.809	2324.428***	11	<0.001	0.082	0.114
	E Asia	0.191					
M – Market Region	Other	0.557	2378.901***	11	<0.001	0.084	0.117
(i) European	European	0.443					
(ii) Far East Asian	Other	0.546	2380.165***	11	<0.001	0.084	0.117
	Far East	0.454					
F – Tropical Fish Keepers	Don't Keep	0.202	2303.165***	11	<0.001	0.082	0.113
	Keep/Kept	0.798					
F – Discus Keepers	Don't Keep	0.488	2321.124***	11	<0.001	0.082	0.114
	Keep/Kept	0.512					
F – Fishkeeping Experience with Discus	None	0.164	781.045	26	<0.001	0.131	0.182
	0 ≤ 2 years	0.233					
	2 ≤ 5 years	0.155					
	5 ≤ 10 years	0.147					
	> 10 years	0.302					
C – Professionals	Other	0.741	2301.659***	11	<0.001	0.082	0.113
	Professional	0.259					
C – Hobbyists	Other	0.337	2267.465***	11	<0.001	0.080	0.112
	Hobbyist	0.663					
C – General Interest	Other	0.867	2367.887***	11	<0.001	0.084	0.116
	Gen Interest	0.133					
C – Environmental Employment	Other	0.920	2273.850***	11	<0.001	0.081	0.112
	Env Empl	0.080					

MNL Model	Factor Level	Marginal Percentage	Likelihood Ratio Test Omnibus X^2	df	*p*	Pseudo R^2 Cox and Snell	Nagelkerke
S – Surv. Language	English	0.869	2283.993***	11	<0.001	0.081	0.112
	Chinese	0.131					
S – Surv. Type	Paper	0.771	2447.574***	11	<0.001	0.086	0.120
	Online	0.229					
S – Surv. Completeness	CE Only	0.424	2262.961***	11	<0.001	0.080	0.111
	CE + CS	0.576					

*Models were predicted on SPSS. Significant levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

3.1.1 SUMMARY OF RESULTS

Basic discrete choice (multinomial logit) models revealed that respondents are likely to express specific preferences for discus, and are generally able to decide on their choices based on the given attributes. This was seen with estimates of a significant decrease in the odds of choosing to purchase either option by a factor of 0.866 ($p < 0.001$; Table 3.2). As a result, respondents were observed to display an overall preference towards blue/green discus for colour, striations for pattern, high bodied for shape and artificially cultivated varieties with no particular concerns for price.

Table 3.2 Discrete choice model estimates of utility functions for all CE results

Attribute Levels	MNL (ref level: 4)	MNL (ref level: 1)
ASC	-0.866*** (0.06)	-1.365*** (0.09)
Colour: Blue / Green	0.776*** (0.05)	-
Colour: Red / Brown	0.598*** (0.04)	-0.178*** (0.04)
Colour: Golden	0.460*** (0.05)	-0.317*** (0.04)
Colour: White	-	-0.776*** (0.05)
Pattern: Plain	-0.068 (0.05)	-
Pattern: Patterned	0.074 (0.05)	0.141*** (0.05)
Pattern: Striped	0.110** (0.05)	0.178*** (0.05)
Pattern: Spotted	-	0.068 (0.05)
Shape: Round	-0.112*** (0.03)	-
Shape: High Body	-	0.112*** (0.03)
Type: Wild-Caught	-0.098** (0.04)	-
Type: Wild Type but Cultivated	-0.165*** (0.05)	-0.067 (0.05)
Type: Artificially Cultivated	-	0.098** (0.04)
Price	-0.007*** (0.001)	-0.007*** (0.001)

*Pseudo R^2 = 0.084. Significance levels are indicated as * for p < 0.10, ** for p < 0.05 and *** for p < 0.01. Standard errors are quoted in parentheses by each regression coefficient.*

For every unit increase in the option of discus alternatives, respondents were estimated to respond with the highest significant increase in the odds of purchasing blue/green discus, at a factor of 0.776 relative to white discus ($p < 0.001$). Secondary interests were observed towards red/brown varieties, with a significant increase in the odds of purchase by a factor of 0.598 ($p < 0.001$), and golden varieties with an increase by a factor of 0.460 relative to white ($p < 0.001$). In other words, respondents are less likely to purchase white discus if options for other colorations are provided.

In terms of pattern, the models estimated small coefficient values of less than 0.200 across all four levels, thus indicating a similar preference and an overall slight influence of the characteristic to discus choice. Nevertheless, respondents were found more likely to acquire striped discus with estimates of the highest significant increase in the odds of purchase, by a factor of 0.110 relative to spotted varieties ($p < 0.05$) and 0.178 relative to plain varieties ($p < 0.01$). As no significant difference was observed for plain and patterned discus relative to spotted discus ($p < 0.20$ and $p < 0.20$ respectively), in the event where striped discus are unavailable to the buyer, it is suggested that respondents carried comparable preferences for such traits and are just as likely to purchase discus with plain, patterned or spotted patternation. A preference for patterned discus was also seen with a significant increase in the odds of purchase by 0.141 relative to plain discus ($p < 0.005$).

Small coefficient values of less than 0.200 were also estimated across levels on shape, thus indicating similar preferences between traits, and an overall slight influence of the characteristic to the buyer's decision-making. Nevertheless, respondents seemed to show greater interests towards high-bodied discus with a significant increase in the odds of purchasing by a factor of 0.112, relative to round discus ($p < 0.005$).

Similarly, small coefficient values of less than 0.200 were observed across levels on discus type, thus indicating similar preferences and an overall slight influence from the attribute to discus choice. Regardless, relatively stronger preferences for artificially cultivated varieties were observed with respondents expressing a significant 0.098 factor decrease in the odds of purchasing wild-caught discus ($p < 0.05$), and a significant 0.165 factor decrease in the odds of purchasing wild type but cultivated discus relative to the former type ($p < 0.005$). But in the event where artificially cultivated discus are unavailable, respondents seemed to be less concerned with no significant difference between wild caught and wild type but cultivated varieties, expressing similar levels of interest and likelihood in acquiring either type.

With regards to price, the model estimates a significantly low coefficient at 0.007 ($p < 0.001$). This suggests that respondent choice showed overall the least association with price, the attribute is of little concern to buyers, and that it carries minimal influence in the decision-making process for purchasing discus. But with a negative coefficient, it can be said that preferences may be directed slightly towards discus sold at a slightly lower price range.

3.1.2 LATENT CLASS MODELS

Of 4405 groups of models, 2630 solved and produced complete results. Among them, 64 groups passed all six stages of filtering, with eight models selected for best fit in terms of model interpretation and significant results. Due to small sample sizes, no models conditioned with responses from Malaysia were significant enough to pass through all filtering stages, and thus were excluded from the selected set. One model segmented with keeping experience was statistically significant as a group, but was deselected due to low

interpretability, with insufficient class representations and minimal significance of the particular covariate.

Due to high levels of consistency in results across the selected set, two representative models and one supporting model were chosen from the final selection; each with four covariates, and segmented with mixed information on gender, age group, fishkeeping, respondent class, market region, survey language, survey type and survey completeness (see results from other models of the selected set in Appendix B). Altogether, the results provide an overall inference and classification of groups with differential preferences for discus attributes associated with market region and respondent class, as well as an assessment for survey evaluation.

LCM 1: Market Heterogeneity – European versus Far East Asian fish keepers

The first LCM provides an insight into understanding international market demand for discus, with an overview of the similarities and differences within and between overall markets in relation to the tropical fish keeping community, and a basic evaluation on impacts from survey technique. The selected model reflected results conditioned for gender, the Far East Asian market, tropical fish keepers and survey completeness.

Comparing between model statistics, the log likelihood decreases, thus improves, and the Pseudo R-squared increases as more segments are added (Table 3.3). The greatest marginal improvement was expressed for both values between the third and fourth segment. Although the AIC was also minimized at the fourth segment, further improvement was observed towards the fifth segment, with a delta BIC value of 54.9 units ($p < 0.01$) and delta AIC3 of 104.5 units ($p < 0.01$). This change expressed an increase in model efficiency to 99% significance, and suggests that additional segmentations may not provide much further improvement than what is observed. Hence, as no segments expressed completely insignificant utility functions and large standard errors, optimal solutions for the model were found achieved at five segments.

Table 3.3 Measures of model fit from gender, the Far East Asian market, tropical fish keepers and survey completeness

Model	K	LL	AIC	BIC	AIC3	Pseudo R^2
MNL	11	-9082.287	18186.574	9117.129	18230.573	0.084
LCM 2	27	-8245.998	16545.996	8160.475	16329.996	0.168
LCM 3	43	-7973.031	16032.062	7836.827	15688.062	0.196
LCM 4	59	-7749.986	**15617.971**	7563.101	15145.971	0.218
LCM 5	75	**-7745.760**	15641.521	**7508.196**	**15041.521**	**0.219**

Note: K = number of parameters estimated. LL = model log likelihood. Models with information that were seemingly most robust were bolded for each criterion.

The five-segment LCM was significantly predicted at: $X^2 = 4336.234$, df = 75, $p < 0.001$. Results are displayed in Table 3.4, with the first panel presenting utility coefficients associated with discus attributes, and the second panel with coefficients on segment membership (Birol & Das, 2010).

Table 3.4 Five class LCM on gender, the Far East Asian market, tropical fish keepers and survey completeness

Attribute Levels	Coefficients per segment				
	1 (22.2%) Male Keepers	**2 (22.3%) Far East mix 1**	**3 (31.3%) Far East mix 2**	**4 (6.9%) Female non-keepers**	**5 (17.2%) European keepers**
	Utility Function: Discus Attributes				
ASC	0.918*** (0.20)	-2.427*** (0.21)	-1.792*** (0.15)	-9.100*** (1.54)	0.625*** (0.20)
C: Blue / Green	1.460*** (0.13)	-0.069 (0.17)	1.909*** (0.16)	2.438*** (0.72)	0.707*** (0.15)
C: Red / Brown	1.496*** (0.10)	-0.251** (0.10)	1.270*** (0.11)	1.584** (0.68)	0.632*** (0.14)
C: Golden	0.910*** (0.15)	0.142 (0.17)	1.175*** (0.15)	0.172 (0.54)	0.471*** (0.18)
C: White	-	-	-	-	-
P: Plain	0.475*** (0.14)	-0.376** (0.15)	-0.637*** (0.15)	-1.659*** (0.52)	0.046 (0.18)
P: Patterned	-0.202 (0.16)	0.101 (0.14)	0.112 (0.14)	0.092 (0.44)	0.020 (0.17)
P: Striped	0.380** (0.17)	-0.326* (0.18)	0.102 (0.17)	-4.189*** (1.12)	0.392** (0.16)
P: Spotted	-	-	-	-	-
S: Round	-0.771*** (0.09)	0.251** (0.11)	-0.007 (0.11)	-1.945*** (0.62)	-0.245*** (0.09)
S: High Body	-	-	-	-	-
T: Wild Caught	1.220*** (0.12)	-0.123 (0.11)	-0.768*** (0.14)	-1.334* (0.77)	-0.614*** (0.13)
T: Wild Type, Cultiv.	0.588*** (0.14)	-0.118 (0.22)	-0.153 (0.19)	-0.861 (0.66)	-0.761*** (0.16)
T: Artificially Cultiv.	-	-	-	-	-
Price	0.010*** (0.003)	0.005* (0.003)	-0.011*** (0.002)	-0.129*** (0.02)	-0.011*** (0.003)
	Segment Membership Function: Consumer Characteristics				
Intercept	0.945 (0.84)	0.908 (0.85)	0.517 (0.75)	-1.510 (1.17)	-
Gender	-0.740* (0.39)	-0.329 (0.38)	-0.027 (0.33)	0.893* (0.52)	-
Far East Market	-0.310 (0.37)	1.650*** (0.35)	0.755** (0.31)	0.745 (0.50)	-
Tropical Fish Keeper	0.317 (0.45)	-0.55 (0.42)	-0.304 (0.38)	-0.991** (0.48)	-
Surv. Completeness	0.016 (0.33)	-0.663* (0.34)	0.034 (0.30)	-0.166 (0.49)	-

*Significance levels are indicated as * for p < 0.10, ** for p < 0.05 and *** for p < 0.01. Standard errors are quoted in parentheses.*

The model revealed a significantly greater likelihood for Far East Asian residents to incur preferences observed in Segment 2 and Segment 3 than others. Segment 2 refers to the choices from 22.3% of respondents, which were equally likely to be expressed among both genders and people of all keeper types and fishkeeping experiences. Nevertheless, although insignificant, the negative functions suggest a potential chance for relatively greater representations of males and people who have not kept tropical fish. These may refer to non-keepers as well as keepers of other types of fish. Overall, these residents were found less likely to choose the alternative specific constant (ASC) or 'either' option, and thus more able to weigh between alternatives and make a definitive choice of purchase. Relatively greater interests were expressed towards round discus over high-bodied shapes, and relatively lesser for red/brown colorations and plain and striped patternations. However, with small utility values for all attributes, the preferences seem comparatively lesser in strength than those observed from other segments, which suggest the potential for broader interests and less particularity on purchasing specific discus varieties. This is reflected with insignificant utilities between blue/green and golden relative to white discus and patterned to spotted discus, suggesting no significant differences between attributes and similar interests with an equal likelihood to be purchased. No significant difference or influence

from discus type was also observed. On the other hand, price was significantly predicted with a near-zero value, revealing to be the least important factor among this group of Far East Asian residents, with no particular influence in their decision-making.

These results were consistent with other models on resident countries, with similar preference directions and class representations significantly expressed for a mixed group of younger to middle-aged respondents, with potentially more Hong Kong residents than others (LCM 8, Appendix B14). In this case, a slight disinterest towards wild-caught varieties was observed. Thus, it can be said that greater interests on cultivated varieties are likely to be found among the younger working demographic of the Far East Asian market, and potentially more observed in the Hong Kong market. Moreover, it is suggested that the choices of younger consumers from this sector are generally less likely to have been impacted from knowing discus type. Exact preference directions and class representations for a group of non-UK residents with potentially more males were also observed, revealing significantly lesser chance and likelihood for such preferences to be seen in the UK market (LCM 5, Appendix B5).

Preferences of Far East Asian residents from Segment 3 refer to choices reflected from 31.3% of respondents, with mixed representations on gender, and people of all experiences in tropical fish keeping with potentially slightly more non-keepers and other fish keepers. This is the largest segment in the model, revealing the highest share and type of discus preferences across respondent groups. Similar to the previous segment, Far East Asian residents were significantly more likely to make a choice between alternatives. This finds significant preferences for colour observed for all alternatives relative to white discus, suggesting strong attractions towards multiple and especially blue/green colorations, and the least towards white colorations. A general interest for discus with patterning was evident with a significant negative coefficient for plain discus, and no significant differences between all other pattern characteristics. Particular disinterest towards wild-caught discus was also seen, revealing a greater preference for cultivated varieties. Similarly, price expressed the least influence in the decision-making, but the negative coefficient is taken into account for a slight preference towards lower-priced discus. In this case, no significant difference and influences by the given shape attributes were observed.

The above preferences were highly consistent with other models on geographical sub-regions and resident countries, having exact interests and similar class representations observed among non-UK residents with potentially more non-keepers and other fish keepers who have not kept discus (LCM 5, Appendix B5), South East Asian residents which may include those from Singapore and Malaysia (LCM 6, Appendix B8), and a mixed group with some representation among Hong Kong residents (LCM 8, Appendix B14). This suggests that the observed preferences were slightly more representative of the South East Asian market than East Asia, which includes Hong Kong, and significantly least likely to be expressed in the UK market. Although such interests are equally likely to be seen in or

outside of the discus community, these interests may be more strongly observed among non-keepers and other fish keepers than those who have kept discus. Moreover, similar preference directions were observed among a mixed group of younger to middle-aged females from a smaller segment representing 11.6% of respondents (LCM 4, Appendix B2), and another small mixed group representing 9.7% of respondents, with potentially more younger to middle-aged Singapore residents than others (LCM 7, Appendix B11). No significant differences were observed on discus type for both groups, though interests are relatively more refined in the latter group, with focuses towards blue/green, gold, patterned and spotted discus that are similar to those observed among young Far East Asian residents of the previous segment. Thus, it can be said that non-keepers and other fish keepers of the younger Singapore market may exhibit greater importance on colour and pattern features, particularly that of artificially cultivated varieties. However, such choices are again found less likely to be influenced by an understanding on discus type, which suggests a general lesser impact of such labels on discus choice among the younger Far East Asian working demographic that has potentially not kept discus.

Further results from other models exhibited an extended understanding on particular sectors of the Far East Asian market, which combined preferences that were observed from both Segment 2 and Segment 3. A group with South East Asian residents that represented 28.7% of respondents, and potentially more males, expressed similar preferences for patterned and spotted discus to Segment 2, and similarly for cultivated varieties with no influences from shape in Segment 3 (LCM 6, Appendix B8). But a particular interest was observed for Golden discus with no significant differences for other colorations, suggesting specific attractions to the variety in a sector of the South East Asian market. The same similarities were observed for a group with Singapore residents that represented 40.4% of respondents with potentially slightly more of the younger working demographic, but their interests were shared for all coloured alternatives away from white discus (LCM 7, Appendix B11). Thus, it can be said that preferences for golden discus may be exhibited more strongly in males from other countries of South East Asia and the wider Far East Asian market than Singapore. Although the Singapore market showed mixed Far East Asian preferences, residents may generally carry more similar interests to Segment 3, and potentially define more of the South East Asian representatives observed.

On the other hand, European residents were significantly more likely to express preferences exhibited in Segment 5, which refers to choices from 17.2% of respondents. This was predicted as most segments of the model displayed membership coefficients for the Far East with the same sign, thus inferring a greater likelihood for an opposing representation and significant European membership. The group was also found more likely to represent females and tropical fish keepers. Overall, European keepers actually expressed greater likelihood to select the either option, suggesting a general and wide preference for multiple discus attributes. Nevertheless, a preference structure was evident where choices are potentially made in relation to specific interests towards or away from particular attributes. This

was exhibited with tendencies to choose the alternative away from white discus, towards striped discus and away from wild discus, especially cultivated wild types. A slight preference to high-bodied shapes was also seen, matching their interests for artificially cultivated features. Price was expressed with the least concern compared to other attributes, but a negative coefficient suggests slight tendencies to purchase lower-priced discus. These results were also highly consistent with other models, with exact preference directions and similar representations to female UK discus keepers (LCM 5, Appendix B5), residents outside of South East Asia (LCM 6, Appendix B8), and a mixed group of middle-aged to older discus keepers (LCM 8, Appendix B14). Thus, it can be said that the observed preferences were more representative to a sector of the UK market than other countries, particularly among female discus keepers of the mid to older working demographic.

Nevertheless, similarities were observed as both markets were equally likely to exhibit preferences expressed in Segment 1 and Segment 4. Segment 1 refers to choices from 22.2% of respondents, who were significantly more likely to be males with varied levels of keeping experiences with tropical fish. Although insignificant, it is acknowledged that there is potentially more European representation compared to the Far East, and more tropical fish keepers than others. Overall, respondents expressed broad interests and neutral preferences for discus attributes, and were more inclined to choose the ASC and purchase either option. Though a preference structure was evident, and particularly for colour, where strong significant positive coefficients for all three levels relative to white suggest a particular disinterest towards the latter. Rather than favouring a specific coloration, individuals seemed to go for either discus unless an option to purchase white discus arises, of which they would then tend to choose the alternative. A distinctive favouring towards wild varieties and especially wild-caught types were also seen, indicating substantially less for artificially cultivated varieties. Pattern preferences were observed for plain and striped discus, with no significant differences between patterned and spotted discus. Yet individuals showed greater preferences for high-bodied shapes, reflecting space for interests in modern discus varieties as well. Similarly, price seemed to carry no strong influence in the final decision, but was noted for a preference direction towards higher-priced discus.

These results were highly consistent with other models, exhibiting exact preference directions and similar class representations to a mixed group of males, with some representation of South East Asian residents (LCM 6, Appendix B8), and residents outside of Hong Kong (LCM 8, Appendix B14). As similar observations for Hong Kong were also exhibited in models for East Asia, which also expressed the largest representation of respondents from the administrative region, this suggests that such preferences are least likely to be observed in the East Asian sub-region of the Far Eastern market, and particularly less likely in Hong Kong. Similar preferences and representations were also observed for a mixed group with potential for slightly more representations of hobbyists from the European market (LCM 4, Appendix B2), a mixed group with potential for slightly more UK residents (LCM 5, Appendix B5), and another mixed group with potentially a high

representation of Singapore residents (LCM 7, Appendix B11). As the Singapore group was equally likely to purchase either or make a choice, and were only interested in plain discus as opposed to shared interest with striations for other groups, it can be said that Singapore is the main representative of the Far East Asian market in the segment, and broader interests observed with lesser for wild discus types and features than other European countries. Moreover, this indicates that the Singapore market seems to show the greatest diversity of discus preferences between the studied markets, with both strong wild and cultivated interests evident in different sectors or respondent groups. Similar results between the UK group and European hobbyists also suggest that the country exhibits a significant representation of the European market in the segment, along with respondents from other European countries that are interested in the ornamental fish hobby.

Lastly, Segment 4 classifies the smallest group, with reference to choices from 6.9% of respondents who were significant more likely to be females and to have not kept tropical fish. Although results were equally likely to be seen in both markets, potentially greater representations of residents from the Far East Asian market were observed in the segment. Overall, specific preferences were expressed with a significant favouring towards blue/green colorations, followed by red/brown relative to white colorations. Relatively stronger disinterest towards plain and especially striped discus suggests a greater preference towards spotted discus, as well as patterned discus with no significant difference with the latter. Inclinations to purchase discus with high-bodied shapes and cultivated varieties over wild-caught discus were also observed. And unlike other segments, these female non-keepers expressed significantly greater preferences to purchase discus of lower prices, reflecting the greatest concerns for price across groups. These predictions were consistent with other models, exhibiting exact preference directions and similar representations for a mixed group with relatively smaller representations from South East Asia (LCM 6, Appendix B8), and Hong Kong non-keepers of the younger working demographic (LCM 8, Appendix B11). This suggests that such preferences are most likely observed among the relatively younger East Asian and specifically Hong Kong market, among public consumers with minimal experience in keeping discus. Similar preferences expressed among non-UK residents also revealed a lesser likelihood for such concerns to be observed in the UK market.

With regards to survey evaluation, results on survey completeness revealed a slight difference with significantly more respondents who have only completed the CE to be represented in Segment 2. However, as the coefficient was of relatively low significance ($p < 0.10$) while other segments revealed small and insignificant coefficients, it can be said that the results are generally equally likely to be obtained from respondents, regardless of whether they had completed the CE only or both the CE and the CS. Moreover, as data from Far East Asian respondents were mainly collected at the trade show with no available tables or booths set up specifically for survey conduction, more CEs may be completed due to a lack of space to conduct the CS exercise, and limitations on time available by the respondent

to complete the survey. Thus, survey completeness and potential respondent fatigue expressed minimal impacts on the CE results.

The economic values for discus attributes, in terms of consumer willingness to accept compensation, were expressed in Table 3.5. Far East Asian respondents of segment 2 expressed a slight preference direction towards higher priced discus. However, most attributes expressed insignificant WTA values, with a posterior mass to both the positive and negative side of zero for all included attributes (see percentile estimates in Table 3.5). Thus, estimates cannot be confidently reported that they are not equal to zero, and represent the desirability and valuation of the given characteristics (Verissimo et al., 2009). Nevertheless, as broad interests with no significant differences for multiple attributes were observed, and price being of general least concern with a near-zero coefficient, this suggests a general heterogeneous preference for the given discus attributes, with no strong affinities to particular varieties. On the other hand, significant WTA values were generated in association with lesser desired characteristics, where respondents expressed the extent of their disinterest by the level of compensation they require to accept the purchase. This was evident for striped discus, where Far East Asian respondents anticipated for a high compensation averaged at £61.

Table 3.5 Segment specific valuation (WTA) of discus attributes associated with gender, the Far East Asian market, tropical fish keepers and survey completeness

Attribute Levels	**WTA per segment**				
	1 (22.2%) **Male Keepers**	**2 (22.3%)** **Far East mix 1**	**3 (31.3%)** **Far East mix 2**	**4 (6.9%)** **Female non-keepers**	**5 (17.2%)** **European keepers**
C: Blue / Green	-144.988*** (-227.27, -62.70)	12.885 (-55.55, 81.32)	-173.582*** (88.13, 259.03)	-18.853*** (11.36, 26.35)	-65.662*** (23.82, 107.51)
C: Red / Brown	-148.539*** (-235.20, -61.88)	46.684* (-8.37, 101.74)	-115.452*** (66.94, 163.97)	-12.247*** (3.17, 21.32)	-58.616*** (17.00, 100.23)
C: Golden	-90.415*** (-146.25, -34.58)	-26.439 (-79.33, 26.45)	-106.774*** (46.22, 167.33)	-1.328 (-6.95, 9.61)	-43.725** (1.03, 86.42)
C: White	-	-	-	-	-
P: Plain	-47.222** (-90.12, -4.33)	69.928* (-11.08, 150.94)	57.893*** (-95.86, -19.92)	12.833*** (-20.13, -5.54)	-4.259 (-27.63, 36.15)
P: Patterned	20.030 (-13.07, 53.13)	-18.839 (-79.58, 41.91)	-10.165 (-16.29, 36.62)	-0.713 (-5.96, 7.39)	-1.815 (-29.18, 32.81)
P: Striped	-37.703* (-79.34, 3.94)	60.677** (-3.58, 117.78)	-9.314 (-21.80, 40.43)	32.395*** (-41.46, -23.33)	-36.389** (0.64, 72.14)
P: Spotted	-	-	-	-	-
S: Round	76.620*** (33.48, 119.76)	-46.805 (-126.12, 32.51)	0.652 (-20.61, 40.43)	15.045*** (-21.06, -9.03)	22.750** (-44.94, -0.56)
S: High Body	-	-	-	-	-
T: Wild Caught	-121.212*** (-197.03, -45.40)	22.850 (-20.96, 66.66)	69.795*** (-115.23, -24.36)	10.314* (-21.47, 0.85)	56.976** (-101.45, -12.50)
T: Wild Type, Cultiv.	-58.386*** (-99.51, -17.26)	21.924 (-67.29, 111.13)	13.946 (-47.43, 19.53)	6.657 (-15.50, 2.19)	70.663*** (-115.53, -25.79)
T: Artificially Cultiv.	-	-	-	-	-

*Significance levels are indicated as * for p < 0.10 (note: considered insignificant for WTA), ** for p < 0.05 and *** for p < 0.01. 95% confidence intervals of the estimates are quoted in brackets.*

Although Far East Asian residents of Segment 3 carried slight preferences for lower priced discus, low concerns for price were expressed with individuals prepared to pay high premium values for discus with desired characteristics. Results revealed the highest WTP across groups. Colour seemed to be the most important factor, as individuals expressed a willingness to pay over £100 for desired purchases, with the highest averaged at £174 for blue/green colorations. On the other hand, respondents were still willing to accept purchases of the less preferred wild-caught and plain discus if a minimum 30% reduction was offered relative to their highest offer, with WTA averaging at £70 and £58 respectively.

Female European tropical fish keepers of Segment 5 also expressed slight preferences for lower prices. However, individuals seemed less inclined to pay premium values comparable to that of Far East Asian residents from Segment 3. Although colour was also of highest interest, along with striped varieties, these keepers were only prepared to pay a maximum of £66 for desired discus. Instead, relatively large compensations were expected for purchases of undesirable types, with a minimum 30% reduction for round discus, averaged at £23, and up to 115% required for cultivated wild types, averaging at £71, relative to their highest offer.

Male keepers from Segment 1, with significant representations of UK and Singapore residents, were observed with a slight preference for higher-priced discus. Thus, similar to Far East Asian residents of Segment 3, individuals seemed prepared and more willing to pay a high premium for discus with desired characteristics. The highest WTP was expressed for red/brown and blue/green colorations, averaging at £149 and £145 respectively, followed by similarly high values for wild-caught discus as well as golden colorations at over £90. Though weaker in preference than other characteristics, respondents still expressed a desire to acquire cultivated wild types and plain discus, with relatively lower WTPs averaged at £58 and £47 respectively. The group also expressed a willingness to accept purchases for lesser preferred discus, yet a greater compensation than observed for Segment 3 was expected, with a minimum 50% reduction required for round discus relative to their highest offer, averaging at a WTA of £77.

Female non-keepers and keepers of other fish from Segment 4, with significant representations of Hong Kong residents, reflected the strongest preferences for lower prices in the model. This suggests that individuals tend to be less inclined to pay premium values for discus than other groups in general. Hence, despite having an interest in blue/green and red/brown colorations, individuals only considered purchases of discus if the price met their maximum expenditure, averaging at £19 which is the lowest among others. Although small WTA values were observed for lesser desired discus, in relation to their highest offer, the group actually expressed the strongest disinterest and the highest requirement to accept the purchase, with anticipations for an average £32 or 170% reduction for the least desired striped discus.

LCM 2: Respondent heterogeneity – Traders versus consumers

The second LCM provides an insight to understanding the potential heterogeneities that exist across the discus industry and within the discus community, between traders from the source to users at the end of the supply chain. Overall inferences were made on the preferential divide between professionals of the industry and public consumers, as well as a secondary evaluation on impacts from survey technique. The selected model reflected results conditioned for professionals, respondents with general interest, survey language and survey type.

In terms of model fit, Table 3.6 displayed improvements to the log likelihood and Pseudo R-squared as more segments are added. Marginal improvement continues for both values to five segments, indicating the presence of multiple segments within the sample. All three criterion values were minimized at five segments as well, with a smaller change between four and five segments at a delta AIC of 46.4 units ($p < 0.01$), delta BIC of 89.9 units ($p < 0.01$) and delta AIC3 of 174.4 units ($p < 0.01$). Such change expressed an increase in efficiency to 99% significance, which suggests that adding an additional segment beyond the fifth may not be gaining much improvement (Boxall & Adamowicz, 2002). Hence, as no classes expressed completely insignificant utility functions and large standard errors, the model was found optimal and most statistically efficient at five segments.

Table 3.6 Measures of model fit for professionals, respondents with general interest, survey language and survey type

Model	K	LL	AIC	BIC	AIC3	Pseudo R^2
MNL	11	-9082.287	18186.574	9117.129	18230.573	0.084
LCM 2	27	-8259.982	16619.963	8174.458	16357.963	0.167
LCM 3	43	-7995.986	16077.972	7859.782	15733.972	0.193
LCM 4	59	-7761.687	15641.373	7574.803	15169.373	0.217
LCM 5	75	**-7722.470**	**15594.940**	**7484.905**	**14994.940**	**0.221**

Note: K = number of parameters estimated. LL = model log likelihood. Models with information that were most statistically efficient were bolded for each criterion.

The five-segment LCM was significantly predicted at: $X^2 = 4382.815$, df = 75, $p < 0.001$.

Results revealed that professionals of the industry were significantly more likely to exhibit preferences observed in Segment 5 than others (Table 3.7). This refers to 9.8% of respondents, and following an assessment of membership coefficients across segments for each covariate, the group also reflected some representation of respondents with general interest or basic knowledge of discus, and with more Chinese survey data, more respondents of Chinese descent. This group was observed to have more neutral preferences across discus attributes with significantly greater tendencies to choose the ASC and purchase either. Apart from some tendencies to acquire red/brown and golden discus relative to white, the overall lesser significance of colour utilities as well as insignificant and low values of pattern suggest similar preferences between alternatives, expressing no strong affinities to varieties and thus being relatively less influenced by colour and pattern in

their decision-making. Although preferences among Chinese professionals and respondents of general interest for shape are leaned towards high-bodied discus, the trend is less significant or strong compared to other groups, suggesting potential room for round discus. These professionals and general public members were also seen to show significantly little influence from price, thus revealing to be the least important factor with minimal relation to their selected choices. However, the utility functions suggest the existence of some level of preference structure. This was identified with a particular interest towards artificially cultivated varieties and away from wild discus. With a significantly lower coefficient for wild-caught discus as well, in the occasion where artificially cultivated options are unavailable, Chinese professionals and the basic consumer with general interest are predicted to choose the cultivated wild type over wild-caught discus.

Table 3.7 Five class LCM on professionals, respondents with general interest, survey language and survey type

Attribute Levels	**Coefficients per segment**				
	1 (20.6%) Specialist background	**2 (17.8%) Public mix**	**3 (45.1%) Public (non-professionals)**	**4 (6.8%) Online public mix**	**5 (9.8%) Chinese professionals**
	Utility Function: Discus Attributes				
ASC	0.982***(0.23)	-0.436** (0.11)	-2.811***(0.16)	-13.861**(5.90)	0.960***(0.35)
C: Blue / Green	1.507***(0.14)	0.964***(0.10)	0.877*** (0.09)	3.430** (1.53)	0.558 (0.37)
C: Red / Brown	1.508***(0.11)	0.596***(0.14)	0.438*** (0.05)	2.362** (1.14)	0.625* (0.33)
C: Golden	1.116***(0.18)	0.272* (0.15)	0.700*** (0.12)	-0.381 (1.04)	0.607* (0.31)
C: White	-	-	-	-	-
P: Plain	0.549***(0.14)	-0.101 (0.16)	-0.501***(0.11)	-2.719** (1.16)	-0.019 (0.37)
P: Patterned	-0.134 (0.16)	0.117 (0.12)	0.019 (0.10)	-0.363 (0.57)	-0.207 (0.35)
P: Striped	0.196 (0.20)	0.350*** (0.08)	-0.235* (0.14)	-7.098* (3.94)	0.343 (0.33)
P: Spotted	-	-	-	-	-
S: Round	-0.625***(0.11)	-0.273***(0.12)	0.104 (0.08)	-3.519 (2.21)	-0.297* (0.18)
S: High Body	-	-	-	-	-
T: Wild Caught	1.235***(0.11)	-0.199 (0.14)	-0.342***(0.08)	-2.416 (1.60)	-1.557***(0.39)
T: Wild Type, Cultiv.	0.690***(0.16)	-0.471***(0.003)	0.015 (0.16)	-1.730 (1.39)	-0.752** (0.34)
T: Artificially Cultiv.	-	-	-	-	-
Price	0.012***(0.003)	-0.010***(0.18)	-0.004* (0.002)	-0.184***(0.07)	-0.014***(0.01)
	Segment Membership Function: Consumer Characteristics				
Intercept	2.953***(1.04)	3.008*** (0.99)	2.650***(0.82)	-1.510 (1.36)	-
Professional	-0.511 (0.47)	-35.602 (2.05 E12)	-1.080** (0.43)	-2.043 (1.37)	-
General Interest	-2.751* (1.43)	-0.503 (0.64)	-0.441 (0.55)	0.182 (0.65)	-
Survey Language	-1.148* (0.63)	-0.883 (0.61)	-0.374 (0.45)	-0.926 (0.74)	-
Survey Type	-0.474 (0.59)	-0.505 (0.56)	-0.191 (0.49)	1.759** (0.71)	-

*Significance levels are indicated as * for p < 0.10, ** for p < 0.05 and *** for p < 0.01. Standard errors are quoted in parentheses.*

These results were consistent with other models on market regions, with similar preferences and class representations to a group of males of the middle-aged to older demographic, with mixed market backgrounds and people that are least likely to be hobbyists (LCM 4, Appendix B2). In this case, the group exhibited no specific preferences and similar interests for the given colour and shape attributes. Thus it can be inferred that

Chinese professionals who are males of the older working demographic are generally more likely to carry broader interests for discus attributes and express similar interests to most colour and pattern types. Moreover, it is suggested that similarities with broad interests among some members of the general public may potentially be more related to a basic or lesser knowledge to discus and the hobby, thus leading to weaker preferences and less specificities on the acquiration of particular attributes, resulting in a higher tendency to purchase either.

Although multiple respondent classes were equally likely to be represented in Segment 1, the group expressed preferences from 20.6% of respondents who were significantly least likely to carry only general interests, and thus more likely to have some level of specialist background with greater knowledge or experience in discus. Though insignificant, the membership coefficient for professionals also indicates a small representation, which suggests that the preferences were observed among some professionals, but potentially more evident among hobbyists and/ or respondents with environmental employment. Overall, these specialists were found to express broader and more neutral preferences for discus attributes, with significantly greater likelihood in choosing to purchase either of the given options. This is analogous to results observed among Chinese professionals from Segment 1, suggesting the presence of more heterogeneous preferences, with no specific interest to particular varieties among professionals alike. Nevertheless, similar to observations seen among male keepers from the UK and Singapore in Segment 1 of LCM 1, a preference structure was evident in the results (Table 3.4). Consistent trends were reflected with interests to choose the alternative away from white discus, towards high-bodied discus and towards wild varieties, especially wild-caught discus. However, a particular favouring towards plain discus was observed with no significant inclinations to choose discus with patterning, whether uniquely patterned, striped or spotted. Price was also found to be of least concern among this group of professionals and specialized hobbyists, and expressed minimal influences to choices, but a slight tendency to purchase higher-priced discus was noted.

Consistent results were also observed in other models, with similar preferences and class representations to a group of respondents of mixed market regions, with potentially more hobbyists and slightly more European residents (LCM 4, Appendix B2), and residents outside of Hong Kong with some environmentally employed (LCM 8, Appendix B14). Both cases expressed slightly stronger interests for red/brown colorations and a shared interest for pattern, with greater preferences for striped discus. Thus, it can be said that hobbyists are likely to be the most represented class in the group, with potentially stronger wild interests observed among European specialists and respondents that are environmentally employed.

In comparison, professionals were significantly least likely to exhibit preferences observed in Segment 3. This represents the largest group with reference to choices from 45.1% of respondents, who were more likely to be members of the general public with no

professional involvement in the industry, with an equal likelihood for mixed class representations. Though insignificant, respondents with general interest to discus and fishkeeping seem to be less represented in the group than other consumers, thus suggesting more inclusion from hobbyists and/ or people that are environmentally employed. Overall, this group is significantly more likely to make a choice between alternatives and carry deciding preferences between discus attributes. Similar to specialized hobbyists from Segment 1, a relative disinterest towards white discus was observed, with choices favouring towards the alternatives, but more so for blue/green and golden instead of red/brown. However, opposing interests for pattern were seen with attractions towards patterned and spotted discus, with no significant differences, and a lesser likelihood to acquire striped and plain discus. A smaller coefficient for plain varieties also suggests a greater preference for discus with patterning in general. In addition, the group expressed a particular disinterest towards wild-caught discus, suggesting an overall preference for cultivated varieties among most hobbyists and/ or the environmental employed. With no significant difference observed for shape and price being significant at a near-zero value, it can be said that both attributes showed minimal influence on the final choice. These results were particularly consistent with similar preference directions and class representations to Far East Asian, most likely Singapore, non-keepers and/ or other fish keepers of Segment 3 from LCM 1 (Table 3.4). Apart from an additional interest for striped and thus a stronger preference for discus with patterning, it can be said that the group is likely to be consumers from the general Far East Asian public with no keeping experience in discus.

Although respondents of mixed classes were also equally likely to be included in Segment 2, professionals had a substantially low representation with a highly negative coefficient and a large standard error for heterogeneous preferences among the few, which was likely an impact from the relatively small sample size. Thus, this group would be more representative of public members outside of the industry as well. These refer to the choices of 17.8% of respondents, which had potentially more hobbyists and/ or the environmentally employed than those with only general interest to discus. Overall, these respondents were found less likely to choose the ASC, and thus more likely to make a choice between alternatives. In this case, even with observations of a similar pattern to choose the alternative away from white discus, a strong favouring towards blue/green colorations and secondary interests to red/brown were evident, with potentially only slight interests to purchase golden when the former varieties are unavailable. But unlike the hobbyists and environmentally employed respondents from the previous segment, this group carried opposing preferences, particularly towards striations with no significant differences between other pattern characteristics, along with a positive influence from attractions to high-bodied shapes instead of round. This matches their preferences for artificially cultivated varieties and reflecting lesser for wild types, though having no significances with wild-caught varieties suggest an interest for the latter as well. Similarly, price was not an important factor in the decision-making, but if all other attributes were already considered, a slightly lower price may be preferred.

The above results were found to show similar preference directions and representations to European discus keepers, particularly UK residents with potentially more females of the middle-aged to older working demographic (Table 3.4). However, the former was more likely to select the ASC and expressed much broader interests for discus. This was reflected with slightly greater interests for golden colorations, in which, with shared preferences with other colours, acts potentially more as an alternative away from the much lesser desired white discus, as well as a stronger disinterest to wild varieties in general. As exact preferences to the aforementioned was observed among a slightly larger group of residents outside South East Asia with an equal likelihood to be expressed among males and females (LCM 6, Appendix B8), and another with stronger significances of older discus keepers in other models (LCM 8, Appendix B14), a slightly different gender representation with more males than the group observed for LCM 1 was suggested. At the same time, strong wild interests were only observed for Segment 1 of LCM 1, with mostly male keepers of mixed market regions, and a greater UK membership among the European representatives (Table 3.4). Thus, it can be inferred that older UK and possibly other European discus keepers of both genders are more likely to represent this segment in general, and male hobbyists and environmentally employed respondents of this group may potentially carry more definitive choices and stronger wild interests for discus than females.

Lastly, preferences for the general consumer was potentially most similar to those expressed in Segment 4, which represents the smallest group of only 6.8% of respondents in the model. Despite an equal likelihood for mixed classes, a potential for slightly more public members that carry only general interests or basic knowledge for discus was observed, along with much lesser professionals, as well as some hobbyists and/ or environmentally employed of possibly a less specialist and more general background in ornamental fish keeping. The group expressed existing preferences for the given attributes, with greater tendencies to make a choice between alternatives. These referred to significant interests for blue/green followed by red/brown discus relative to other colorations, and a strong favouring to spotted and uniquely patterned varieties with significantly lesser interests in plain and especially striped patternations. Options with lower prices were also significantly more likely to be chosen by this group, thus expressing a greater importance for colour, pattern and particularly price in the decision-making over consumer types of other respondent classes, or actors of other positions in the supply chain. In addition, unlike most other groups, no significant results were observed for both shape and type, suggesting no particular influence and a lesser importance in the knowledge of both attributes to discus choices made by the general consumer, with only basic knowledge on discus.

These results were most similar to female respondents of mixed market regions who have not kept tropical fish in Segment 4 of LCM 1 (Table 3.4). Slight discrepancies were reflected by a much stronger and distinct interest for high-bodied shapes, and a particular disinterest for wild-caught varieties. Thus, it can be said that female non-keepers and/ or keepers with no experience in tropical fish seem to show stronger considerations for type and shape, but

are generally more likely to represent and express similar preferences for cultivated discus features observed for the general consumer of the above segment.

With regards to survey evaluation, most segments showed an equal likelihood for both survey languages to be included. However, apart from Chinese professionals in Segment 5, all groups expressed a potentially larger representation of English surveys, with significantly more for UK and Singapore specialist hobbyists and professionals from Segment 1. As the survey was mainly conducted in English, with provisions of Chinese translations available when preferred by respondents, and UK and Singapore residents were generally completing the survey in English, their native or most spoken language, more English results were expected from the data collection. Thus, it can be concluded that survey language showed minimal to no influence in choices, and CE results were unlikely to be impacted by errors related to translation.

Most segments showed an equal likelihood for both survey types to be included as well, but online surveys were found significantly more likely to be completed among respondents of general interest with mixed market regions from Segment 4, and Chinese professionals of Segment 5. However, both online groups were relatively small, and other segments with more respondents per group expressed potentially larger paper representations. As the surveys were mostly conducted face-to-face and at the trade show, these observations seem to be related to the different sample sizes between survey types, with the collection of paper results much greater than that of online. Additionally, online surveys received an overall highest frequency of results from Far East Asian respondents, at 58% relative to only 25% European, and the greatest representation within the market for Hong Kong respondents, at a high 78% relative to only 16% between Singapore and Malaysia. As online surveying was the main medium for data collection in Hong Kong and especially among professionals, which includes those met in Malaysia and Singapore outside of the show venue as well, it can be said that much more specific consumer groups and preferences were observed for online results. Moreover, as the results were reflective of general understandings of the market, field observations and consistent to those observed for other analyses of market heterogeneities between respondent groups, it is also suggested that such discrepancies are mainly resultant of greater representations of particular respondent classes and market regions which are related to the data collection, and thus show minimal impacts to the overall understanding of CE results.

These inferences were reflected in a selected model for the Singapore market as well, with reference to a larger but significant group of online respondents of mixed market regions, involving potentially a large Singapore membership of the younger working demographic, and another relatively smaller group of middle aged to older residents outside Singapore, with potentially more online results included. (LCM 7, Appendix B11). This suggests that online results were overall reflecting observations from all age groups and both the Far East Asian and European market. However, although the former group displayed preferences similar to Segment 4, differences with mixed interests to other groups of larger segments

were found, reflecting the nearest overlap to those observed among a larger group of younger females with mixed market regions (LCM 4, Appendix B2). Unlike any other segments observed, the latter group carried mostly insignificant and heterogeneous preferences for discus instead, suggesting a concentrate mix of preferences from different respondent groups. Thus, as both groups in this case had different class representations for online surveys and were split based on Singapore membership, which is very specific for a small sample size on both the survey type and the interested market in general, it can be said that the former group may have included most of the Singapore representatives among online surveys, but both groups incurred a mix of results from different market regions and multiple respondent groups. Furthermore, despite the supposed differences, preferences observed for both online groups expressed minimal impacts when incorporated for general analyses of the Far East Asian market and respondent heterogeneity, showing highly consistent results to field observations and across models. Hence, it can be concluded that the slight differences between paper and online results are potentially only observed when placed in comparison, and are more likely associated to impacts from different sample sizes, and having more concentrated samples of mixed respondent background among online surveys rather than external errors related to survey technique. Most importantly, the compilation of results from both survey types was found to have expressed minimal impacts to CE results and overall inferences made on discus choice.

The economic values of discus attributes were observed in Table 3.8. Chinese professionals of Segment 5 expressed slight preferences for lower-priced discus. Although insignificant values were determined for most discus varieties, the group expressed great undesirability to purchase wild-caught discus with expectations of a substantially high reduction in price, averaged at a minimum of £109 for a possible acceptance of its purchase. This reflects the highest level of compensation observed between respondent groups.

Hobbyists with specialist background and potentially environmental employment reflected a slight preference for higher priced discus in Segment 1. Similar to those observed among UK and Singapore discus keepers of LCM 1, these individuals were the only group to have expressed an overall greater willingness to pay high premium values for their desired attributes (Table 3.4). The highest offers were placed towards the much preferred blue/green and red/brown colorations as well as golden and wild-caught discus, with WTP averaging over £90 and up to £125 for their most desired colorations. Though less significant and desirable than the aforementioned characteristics, specialists were still willing to pay a relatively lower premium for purchases of plain and cultivated wild types, averaging £45 and £57 respectively. However, the line seemed to be drawn for discus with less desirable round shapes, where purchases were only considered only requests for a minimum 40% reduction relative to their highest offer, averaging at £51, were met.

Table 3.8 Segment specific valuation (WTA) of discus attributes associated with professionals, respondents with general interest, survey language and survey type

Attribute Levels	WTA per segment				
	1 (20.6%) Specialist background	**2 (17.8%) Public Mix**	**3 (45.1%) Public (non-professionals)**	**4 (6.8%) Online public mix**	**5 (9.8%) Chinese professionals**
C: Blue / Green	-124.434*** (-184.53, -64.33)	-96.299*** (43.08, 149.52)	-214.614* (-39.82, 469.05)	-18.686*** (12.88, 24.49)	-38.910 (-8.24, 86.06)
C: Red / Brown	-124.555*** (-191.95, -57.16)	-59.524*** (23.63, 64.33)	-107.188* (-0.93, 215.30)	-12.872*** (5.85, 19.90)	-43.562 (-8.74, 95.86)
C: Golden	-92.140*** (-137.46, -46.81)	-27.119 (-5.27, 59.51)	171.308 (-46.04, 388.66)	2.075 (-12.05, 7.90)	-42.334 (-11.43, 96.10)
C: White	-	-	-	-	-
P: Plain	-45.308** (-80.84, -9.77)	10.068 (-41.03, 20.89)	122.641 (-272.59, 27.31)	14.812*** (-20.09, -9.54)	1.320 (-51.45, 48.81)
P: Patterned	11.039 (-14.48, 36.56)	-11.716 (-20.90, 44.34)	-4.552 (-44.21, 53.32)	1.979 (-7.42, 3.46)	14.427 (-64.48, 35.63)
P: Striped	-16.223 (-51.58, -19.14)	-34.930** (4.53, 65.33)	57.548 (-169.08, 53.98)	38.672*** (-53.67, -23.68)	-23.907 (-23.19, 71.01)
P: Spotted	-	-	-	-	-
S: Round	51.613*** (25.59, 77.63)	27.211*** (-47.56, -6.86)	-25.488 (-6.28, 57.25)	19.175*** (-29.38, -8.97)	20.674 (-51.17, 9.82)
S: High Body	-	-	-	-	-
T: Wild Caught	-102.046*** (-161.35, -42.74)	19.852 (-49.46, 9.76)	83.616 (-186.72, 19.48)	13.165** (-23.57, -2.76)	108.547** (-206.55, -10.55)
T: Wild Type, Cultiv.	-57.023*** (-91.75, -22.30)	47.022*** (-82.41, -11.63)	-3.555 (-71.98, 79.09)	9.248** (-18.52, -0.33)	52.390* (-109.01, 4.23)
T: Artificially Cultiv.	-	-	-	-	-

*Significance levels are indicated as * for p < 0.10 (note: considered insignificant for WTA), ** for p < 0.05 and *** for p < 0.01. 95% confidence intervals of the estimates are quoted in brackets.*

On the other hand, hobbyists and environmentally employed individuals from the general public were observed to express a slight preference direction towards lower priced discus in Segment 2. In this case, the group found blue/green colorations most desirable. Hence, similar trends to those observed for specialized hobbyists, the group showed particularly greater willingness to pay up to a high £95 for desired purchases. However, this was only specific to the former variety, as general hobbyists seemed much less prepared to pay comparable prices for their secondary interests on red/brown and striped discus, averaging offers at relatively lower prices of £60 and £35 respectively. Consumers also exhibited expectations for compensation with less-desired purchases of round and particularly cultivated wild types, where considerations were only made when a minimum 29% reduction or respective average of £27 and £47, relative to their highest offer, was given.

Public members with no professional relation to the industry exhibited a preference direction towards lower priced discus in Segment 3. This group saw the Wald procedure calculating high positive WTA values for the preferred blue/green and red/brown discus, suggesting willingness to pay for desired discus as well. However, as all WTA values were

found insignificant, estimates were unable to be confidently reported to represent the valuation of discus characteristics.

Lastly, the general consumer of Segment 4, with only basic interest and minimal knowledge in keeping discus, expressed slight but stronger preference direction towards lower-priced discus than other groups. These respondents expressed the lowest WTP even for desired discus, with the highest being an average £19 for blue/green colorations, followed by red/brown discus at an average £13. Nevertheless, the focus on colour reflects the presence of a simple but main influence in discus choice among individuals outside of the current discus community, which differs to other respondent classes by exhibiting a less complex decision-making process than others. Moreover, despite having low value WTPs, the general consumer indicated the strongest undesirability to accept purchases for less preferred attributes relative to other respondent classes. These were mostly related to wild discus features, with the most significant being their anticipations for a relative 200% reduction in of striped patternations, averaged at £39, followed by a 100% reduction for round shapes and a lesser 68% compensation for wild-caught varieties.

LCM 3: Respondent heterogeneity: The public divide

This model is included as support for the analyses of respondent heterogeneity for LCM 2. These results provide an extended understanding on the overall divide of discus preferences within the general public, which may be representative of people both outside and inside the current discus community, with a specific focus on highlighting potential differences between the general consumer and those of the conservation community. The selected model reflected results conditioned for age group, discus keepers, respondents with general interest and respondents with environmental employment.

Looking at Table 3.9, the log likelihood and Pseudo R-squared for the model improves and respectively levels off up to four segments, where the AIC is minimized with significant change from the third segment at a delta AIC of 308.4 units ($p < 0.05$). However, marginal improvement continues as further change with a delta BIC of 47.7 units ($p < 0.01$) and a delta AIC3 of 90.0 units ($p < 0.01$) are observed towards the fifth segment. With no completely insignificant segments and only one coefficient with a large standard error in the results, the model was found optimal at five segments with greater statistical efficiency.

Table 3.9 Measures of model fit for age group, discus keepers, respondents with general interest and with environmental employment

Model	K	LL	AIC	BIC	AIC3	Pseudo R^2
MNL	11	-9082.287	18186.574	9117.129	18230.573	0.084
LCM 2	27	-8259.061	16572.122	8173.538	16356.122	0.167
LCM 3	43	-7987.175	16060.350	7850.971	15716.350	0.194
LCM 4	59	**-7797.983**	**15713.967**	7611.099	15241.967	**0.213**
LCM 5	75	-7800.969	15751.938	**7563.405**	**15151.938**	0.213

Note: K = number of parameters estimated. LL = model log likelihood. Models with information that were most statistically efficient were bolded for each criterion.

The five-segment LCM was significantly predicted at: X^2 = 4225.816, df = 75, p < 0.001. Despite having shown less covariate significance for discus keepers than others, the model passed all other filter stages and displayed high interpretability of results with consistent information to other models (Table 3.10). Thus, the model was selected for inclusion in the final set, allowing inferences to be made on a public and conservation perspective for respondent heterogeneity.

Table 3.10 Five class LCM on age group, discus keepers, respondents with general interest and with environmental employment

Attribute Levels	**Coefficients per segment**				
	1 (33.1%) Specialist background	**2 (33.5%) Young working demographic**	**3 (10.7%) Environmentally employed**	**4 (5.4%) Working age with general interest**	**5 (17.3%) Older Keepers**
	Utility Function: Discus Attributes				
ASC	0.302** (0.15)	-2.525*** (0.16)	-3.262*** (0.33)	-7.671*** (1.58)	0.629*** (0.20)
C: Blue / Green	1.450*** (0.10)	0.505*** (0.10)	2.106*** (0.36)	2.117*** (0.76)	0.729*** (0.15)
C: Red / Brown	1.287*** (0.08)	0.157** (0.07)	1.386*** (0.23)	1.303* (0.78)	0.665*** (0.14)
C: Golden	0.920*** (0.12)	0.476*** (0.13)	1.278*** (0.31)	0.163 (0.61)	0.489*** (0.17)
C: White	-	-	-	-	-
P: Plain	0.298*** (0.11)	-0.568*** (0.12)	-0.425 (0.32)	-1.354** (0.60)	0.041 (0.18)
P: Patterned	-0.142 (0.12)	-0.052 (0.12)	0.862** (0.35)	0.202 (0.50)	0.025 (0.17)
P: Striped	0.202 (0.14)	-0.354** (0.15)	0.493* (0.29)	-3.408*** (1.12)	0.403** (0.17)
P: Spotted	-	-	-	-	-
S: Round	-0.567*** (0.07)	0.163** (0.08)	0.077 (0.26)	-1.458** (0.67)	-0.225** (0.09)
S: High Body	-	-	-	-	-
T: Wild Caught	0.775*** (0.09)	-0.394*** (0.09)	-0.991*** (0.22)	-1.085 (1.00)	-0.576*** (0.12)
T: Wild Type, Cultiv.	0.453*** (0.12)	-0.138 (0.17)	-0.415 (0.39)	-0.495 (0.77)	-0.779*** (0.16)
T: Artificially Cultiv.	-	-	-	-	-
Price	0.007*** (0.002)	0.001 (0.003)	-0.039*** (0.01)	-0.118*** (0.02)	-0.011*** (0.003)
	Segment Membership Function: Consumer Characteristics				
Intercept	0.906* (0.47)	1.817*** (0.46)	-0.140 (0.68)	0.292 (0.67)	-
Age Group	-0.044 (0.12)	-0.321*** (0.12)	0.020 (0.18)	-0.584*** (0.21)	-
Discus Keepers	-0.071 (0.31)	-0.016 (0.33)	-10.915 (309.41)	-0.357 (0.65)	-
General Interest	-1.513** (0.63)	-0.580 (0.47)	0.773 (0.52)	1.329** (0.64)	-
Env. Employment	0.436 (0.59)	-14.640 (3.15E4)	1.385** (0.68)	-1.068 (1.29)	-

*Significance levels are indicated as * for p < 0.10, ** for p < 0.05 and *** for p < 0.01. Standard errors are quoted in parentheses.*

Results displayed great overlap and consistency to the representative models. The most significant were inferences from Segment 1, where exact preference directions for wild varieties and cultivated features among UK and Singapore specialists were observed (Table 3.4; Table 3.7). These refer to the choices of 33.1% of respondents, which were of all age groups, with potentially higher representations of people with environmental employment than in most other segments. As the general consumer was significantly least likely to exhibit such broad and wild interests, this suggests that the group was indeed more likely to be referring to respondents with specialist background. However, such preferences were not distinctive to discus keepers, as the represented were equally likely to have had experience in keeping discus, in other fish species, or perhaps none at all for ornamental

fishkeeping in general. Thus, it can be said that a preferential overlap exists for specialist consumers and professionals that are both within and outside the current discus community, and in particular sectors across international markets.

However, a preferential divide within the conservation community was observed, where most respondents with environmentally related employment were found significantly more likely to exhibit the preferences from Segment 3 instead. These refer to the choices from 10.7% of respondents with mixed age groups, and potentially large representations of public respondents with general interest. Although the observations are again equally likely to be found in people with mixed experiences in discus keeping, a substantially low membership coefficient suggests the least representation of discus keepers in the group. This indicates that respondents within the conservation community were most likely to be outside of the discus community, with only experience in either the keeping of other fish species or none for ornamental fish at all. A high standard error on keeper membership also suggests heterogeneous preferences among other fish keepers and non-keepers, potentially impacted from mixed or overlapping interests to fish keepers or specialists in Segment 1, and non-keepers with general public interests to discus from other segments. This is reflected in the preferences, where environmentally employed respondents expressed a mix of interests to both respondent classes.

Overall, individuals made definitive choices from the given attributes. Consistent across respondent classes, colour was found to be of greatest importance with a particularly strong attraction to blue/green discus, though a general trend in choosing alternatives away from highly undesired white colorations was observed. Individuals also expressed great interests on patterned and the more traditional striped discus. But unlike few of the environmentally employed in Segment 1, most of the conservation community expressed a distinct disinterest on purchases of wild-caught varieties, and a general affinity towards cultivated types. No significant difference was observed for shape. Price was also expressed as of least concern in the decision-making process, though individuals showed a slight favour towards lower prices, with preferential strengths closer to those observed for the general consumer of the wider public than other respondent groups (as seen in Segment 4 of LCM 2, Table 3.7). Nevertheless, as respondents were found less likely to be consumers of discus, it is taken into account that the preferences and expectations observed may reveal discrepancies to those of end-users that fuel most of the demand for the current discus market.

These discrepancies were most observed in comparison to the general consumer, where significant preferences of respondents with only general interests and no specialist knowledge for discus were expressed in Segment 4. The results were found to be both consistent and more specific than those observed for the respondent class in Segment 4 of LCM 2, supporting inferences and indicating a more specific display of preferences from the general consumer. These refer to the choices from only 5.4% of respondents, who were most likely of the younger to middle-aged core working demographic, applicable to groups

>1990 to 1960-1969, and of mixed backgrounds, with potentially small representations of discus keepers and only slight among the environmentally employed. Overall, individuals seemed more likely to make a decision and carry specific preferences for discus. Similar to the environmentally employed, young public members expressed a significant favouring towards blue/green colorations and slightly stronger preferences for lower prices. However, no significant differences for type were observed. Instead, the group expressed a particularly strong interest in high-bodied shapes and opposing preferences for spotted and patterned options, with particular disinterests in plain and striped discus, as well as a secondary interest for red/brown colorations. This reveals a relatively greater consideration of different discus characteristics and specific interests for particular physical features among the younger general consumer, as opposed to influences that are mainly originated from coloration and origin or type by the environmentally employed.

In addition to respondent class, further differences between consumers of the general public seem to be defined by age group. As well as those observed with general interest in Segment 4, individuals of the younger to core working demographic were also significantly likely to express preferences exhibited in Segment 2. In this case, this refers to 33.5% of respondents from multiple classes, and a mix of both fish keepers and non-keepers with varied experiences in discus. In comparison, the group seems less represented by public respondents with general interest and the least by the conservation community, which suggests potentially more hobbyists and/ or some traders. Overall, results displayed existing preferences for the given attributes, with similar pattern preferences for spotted and patterned discus across the core working demographic. But unlike those with only general discus interest, hobbyists and potentially traders seem to show broader interests, with small coefficients and lesser strength in discus preferences than the former. Nevertheless, an attraction towards blue/green and golden discus was observed, with secondary interests to red/brown colorations and round shapes relative to white and high-bodied. A general liking towards cultivated varieties was also reflected with a lesser interest in wild-caught, showing greater considerations for discus type in the discus choice. Price on the other hand was insignificant instead, which suggests an overall lesser importance in price among hobbyists and/ or traders than general consumers from the same demographic. However, consistent results, with similar preference directions and class representations, to public members with no professional relation to the industry in Segment 3 of LCM 2 (Table 3.7) suggest that such observations are potentially more evident among hobbyists than professionals.

On the other hand, consumers of the middle-aged to older working demographic, applicable to groups 1950-1959 to 1920-29 were most likely to incur preferences observed in Segment 5. This refers to 17.3% of respondents from mixed classes and different keeping backgrounds, with potentially more discus keepers than others. Broader interests for discus attributes were observed with a higher likelihood of respondents to purchase either than making a definitive choice. Nevertheless, an evident preference structure was observed,

with individuals showing tendencies to select colour alternatives, particularly blue/green, over white. A slight favouring towards high-bodied shapes was also observed, which matches the strong interests for artificially cultivated varieties among older discus keepers. However, individuals revealed greater disinterest towards cultivated wild types instead, thus revealing room for slight wild-caught interests when artificially cultivated options are excluded. This matches their specific attractions towards striped discus, which includes both modern and the more traditional varieties, and a liking to red/brown colorations as well. Although price was still of least importance to their decision-making, if all attributes were considered, older discus keepers were likely to express a slight preference direction towards lower-prices. These results are highly consistent with exact preference directions and similar class representations to European keepers of LCM 1 (Table 3.4), which suggests that such preferences may be more evident in the European market than the Far East.

The economic values of discus attributes were observed in Table 3.11. Similar, to observations from previous models, specialists and some with environmental employment seemed to prefer purchases of higher-priced discus. Thus, individuals were seen to be willing to pay a high premium for discus with more desirable characteristics; the highest being for blue/green colorations averaging at £221, followed by red/brown, golden, and wild-caught discus with WTP over an average £100. Though less important than other attributes, desires to acquire cultivated wild types were also observed with a relatively lower WTP at £69. However, as individuals were willing to pay premium values for desired characteristics, a high compensation was required to accept purchases of undesired traits such as round shapes, with an average WTA of £86, which relates to a minimum 39% reduction relative to their highest offer.

In comparison, most of the conservation community represented in Segment 3 expressed a preference for slightly lower priced alternatives. Thus, despite an observed interest for particular colour and pattern characteristics, respondents with environmental employment seem to be less prepared to pay premium values comparable to specialists of Segment 1. Regardless, individuals were willing to make higher offers than the general consumer, averaging up to £54 for acquiring the highly desired blue/green discus. In contrast, individuals were only willing to accept purchases of undesirable wild-caught varieties when an average discount of £26 is offered. Although the value may seem smaller, the group actually requested for a relatively higher reduction, at 50% of their higher offer, compared to other environmentally employed individuals who are willing to settle transactions at higher prices.

Younger respondents with only general discus interest from Segment 4 seemed to show significantly greater preferences for lower-priced discus than other segments. This was reflected in the results, which saw individuals being less prepared to pay premium values even for preferred discus. Overall, the general consumer seemed only willing to pay up to £18 for their most desired blue/green colorations. This suggests that their interests to

purchase discus may generally be lesser in strength compared to other groups, who are more willing to pay higher values for their desired attributes. Nevertheless, respondents expressed minimal intentions to accept purchases of less preferred attributes such as striped discus, with substantial levels of compensation required for its consideration. This refers to an average £29 discount, which is relative to a minimum 160% reduction to their highest offer.

Table 3.11 Segment specific valuation (WTA) of discus attributes associated with age group, discus keepers, respondents with general interest and with environmental employment

	WTA per segment				
Attribute Levels	**1 (33.1%) Specialist background**	**2 (33.5%) Younger respondents**	**3 (10.7%) Environmentally employed**	**4 (5.4%) Young with general interest**	**5 (17.3%) Older Keepers**
C: Blue / Green	-221.139*** (-369.56, -72.72)	-463.804 (-2470.00, 1542.40)	-54.367*** (32.20, 76.53)	-17.971*** (8.98, 26.96)	-65.619*** (24.66, 106.58)
C: Red / Brown	-196.289*** (-336.48, -56.10)	-143.819 (-838.92, 551.28)	-35.798*** (26.17, 45.43)	-11.057* (-0.57, 22.68)	-59.884*** (19.43, 100.34)
C: Golden	-140.252*** (-234.08, -46.42)	-437.454 (-2295.45, 1420.54)	-33.002*** (14.32, 51.68)	-1.380 (-8.71, 11.47)	-43.971** (3.29, 84.65)
C: White	-	-	-	-	-
P: Plain	-45.411* (-94.62, 3.80)	521.812 (-1780.44, 2824.06)	10.980 (-27.40, 5.44)	11.490** (-20.78, -2.20)	-3.653 (-27.70, 35.01)
P: Patterned	21.620 (-17.45, 60.69)	47.571 (-222.39, 317.53)	-22.257** (4.43, 40.09)	-1.714 (-6.58, 10.01)	-2.216 (-27.85, 32.28)
P: Striped	-30.872 (-79.77, 18.03)	325.127 (-1015.05, 1665.30)	-12.727* (-2.15, 27.60)	28.913*** (-39.80, -18.06)	-36.279** (0.73, 71.83)
P: Spotted	-	-	-	-	-
S: Round	86.378*** (29.26, 143.50)	-149.759 (-909.90, 610.39)	-2.000 (-10.67, 14.67)	12.372*** (-25.75, 7.33)	20.244** (-40.17, -0.32)
S: High Body	-	-	-	-	-
T: Wild Caught	-118.178** (-210.89, -25.47)	362.118 (-1244.60, 1968.83)	25.583*** (-40.13, -11.03)	9.210 (-16.44, 8.04)	51.824** (-91.40, -12.25)
T: Wild Type, Cultiv.	-69.036** (-123.58, -14.49)	126.571 (-597.80, 850.94)	10.707 (-30.52, 9.11)	4.204 (-75.60, -54.64)	70.100*** (-112.83, -27.37)
T: Artificially Cultiv.	-	-	-	-	-

*Significance levels are indicated as * for p < 0.10 (note: considered insignificant for WTA), ** for p < 0.05 and *** for p < 0.01. 95% confidence intervals of the estimates are quoted in brackets.*

With regards to the younger and core working age demographic from Segment 2, no significant WTA values were observed for the included attributes, thus indicating heterogeneous preferences within the group. However, significant results were determined for older generations of the working demographic and European discus keepers from Segment 5, which expressed slight tendencies to purchase discus of lower prices. As such, individuals seemed less prepared to pay a high premium relative to specialists from Segment 1, but are still willing to pay more than public respondents and the environmentally employed from Segments 3 and 4. The highest value was for the purchase of the most desired blue/green discus at £66. Regardless, similar to the general consumer, a high compensation was also requested for undesirable purchases, particularly for cultivated wild types with acceptance only by an average £70 or relative 100% reduction in price.

3.2 CARD SORTING

Of 469 total responses, 430 complete card sorts from both paper and online versions were included in the analyses. Three paper responses and 36 online were excluded due to missing data and incompleteness of the CS section.

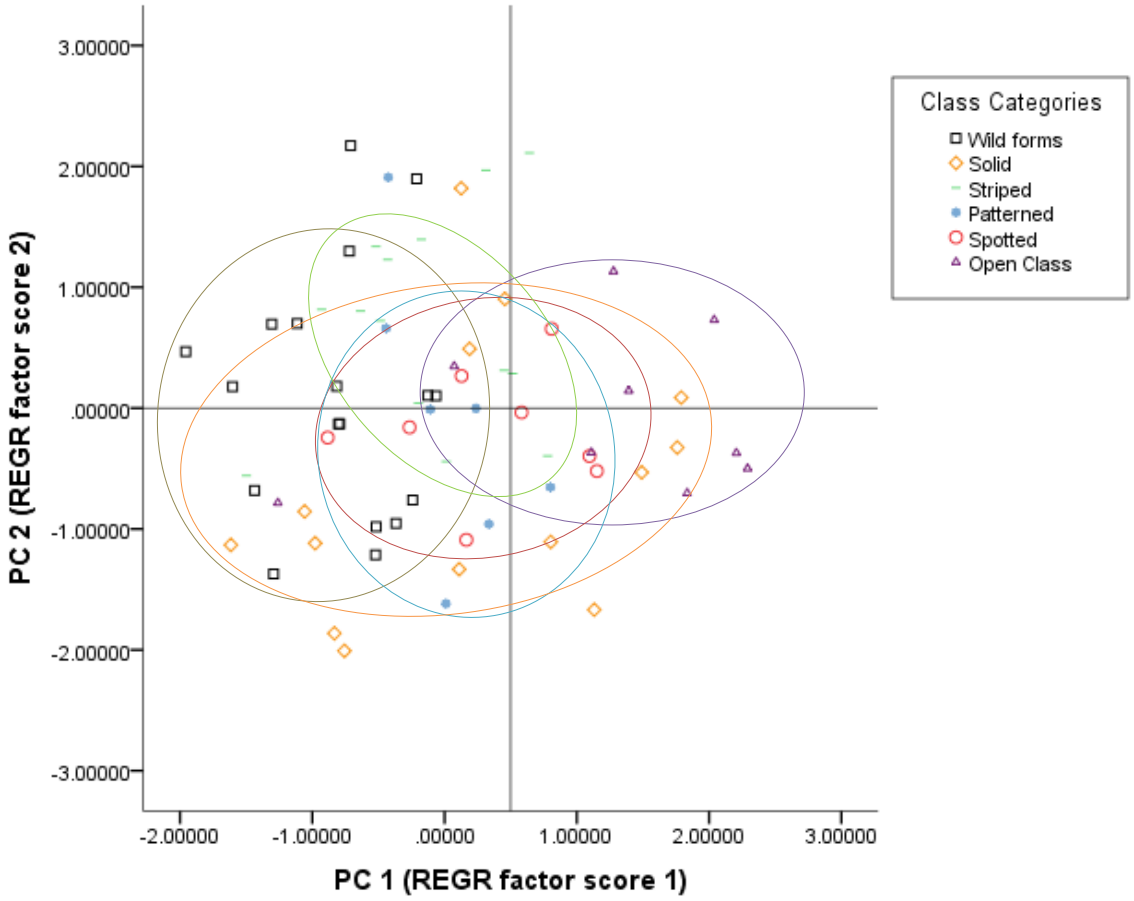
3.2.1 PRELIMINARY RESULTS

Before surveys were conducted, preliminary results on colour and shape of 70 images of discus were obtained to aid the selection of the final card set.

Results from the PCA on discus colour indicated that the first principal component explained 22.2% of the variation, and a cumulative explanation of 90.7% on colour variance between images by the 20th principal component (Appendix C1). As the first and second principal axes (PC 1 and PC 2) expressed the highest set of eigen values, and were the most informative in explaining differences in shape, the axes were plotted against each other to identify particular images that contribute most to the differences seen among the groups (Figure 3.1; Dytham, 2011).

The scatterplot suggested that images were generally similar to each other based on colour, with no distinctive clusters visible based on class categories (Figure 3.1). Images of different categories tend to overlap, especially in terms of results observed from PC 2, suggesting high degrees of homogeneity between variety groups. This indicates a potential for images to be classified as one general group instead of having clear divisions of subgroups, thus making the selection for CS images based on colour data difficult. However, images of the same class category were seen to be clustered in proximity to each other, indicating strong similarities in colour among discus of the same variety group. This is particularly evident among spotted discus, which may have exhibited similar levels of redness due to the shared red-coloured spotting within the group. Regardless, variation is evident for results related to PC 1, where strong differences can be observed among images located at the extremes of the principal axis (x-axis) than others. This suggested that heterogeneity exists for colour to a certain degree, but further analyses may be needed for a better understanding of this variation.

Figure 3.1 Scatterplot of PCA on discus colour between PC 1 and PC 2

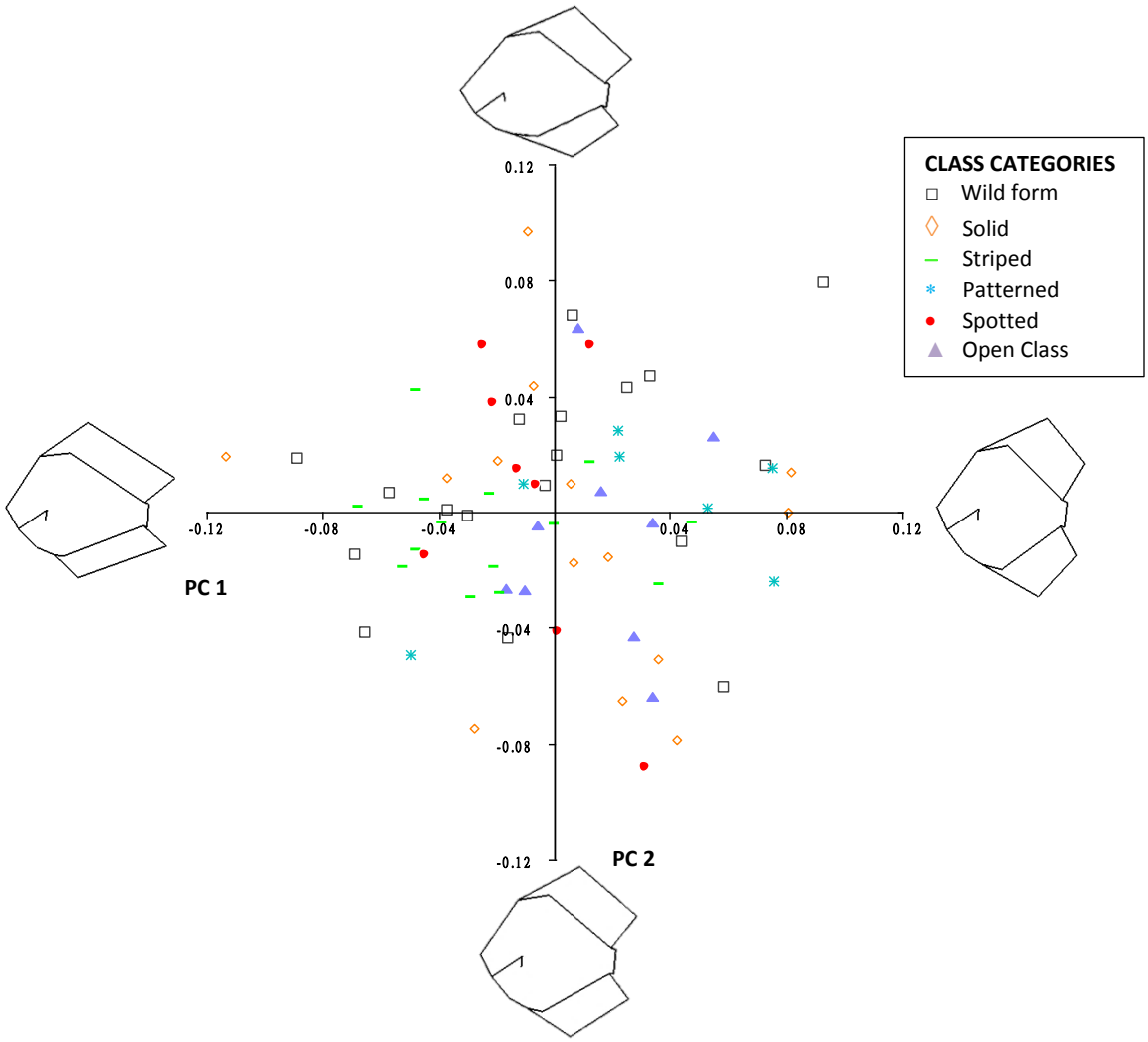


On the other hand, results from the PCA on discus shape indicated that the first principal component explained the highest amount of variance at 25.0%, and a cumulative account on 90.6% of the variance explained by the 10th principal component (Appendix C2). As each principal axis explains less of the variation than the last, scatterplots for PC 1, PC 2 and PC 3, where the highest eigen values were recorded, were constructed to locate clusters and any outliers that hold stronger and more distinctive characteristics than other images (Dytham, 2011).

The PCA between principal components 1 and 2 showed no distinctive clustering of images based on shape, thus indicating that levels of similarity exist between images in relation to morphology (Figure 3.2). As cultivated varieties tend to be selectively bred for particular shape, this could explain the general overlap seen among images with fish that generally display a similar shape. However, strong levels of variation were seen among images both within and between discus categories. Regardless of their category, images were seen scattered individually across the graph in both principal axes, suggesting that variations in shape may be related to very specific differences of features between images. This can be observed by comparing shapes of discus for each principal axes at extreme levels of variation. PC 1 seemed to have explained most of the variation based on length and width of the body, and the length of the dorsal and anal fins. Images that scored closer to -0.12

displayed tendencies of a longer body length with a compressed body shape, and slightly longer finnage in relation to its body. Whereas, images near 0.12 appeared to be squished in terms of overall fish length and stretched up for height, displayed a tall and more higher bodied shape, and with wider and shorter fins. PC 2 seemed to have translated most of the variation based on the shape of the D-body, with images that scored closer to 0.12 being more compressed in body shape, while others that scored closer to -0.12 displayed a more high bodied shape.

Figure 3.2 Scatterplot of PCA on discus morphometrics between PC 1 and PC 2

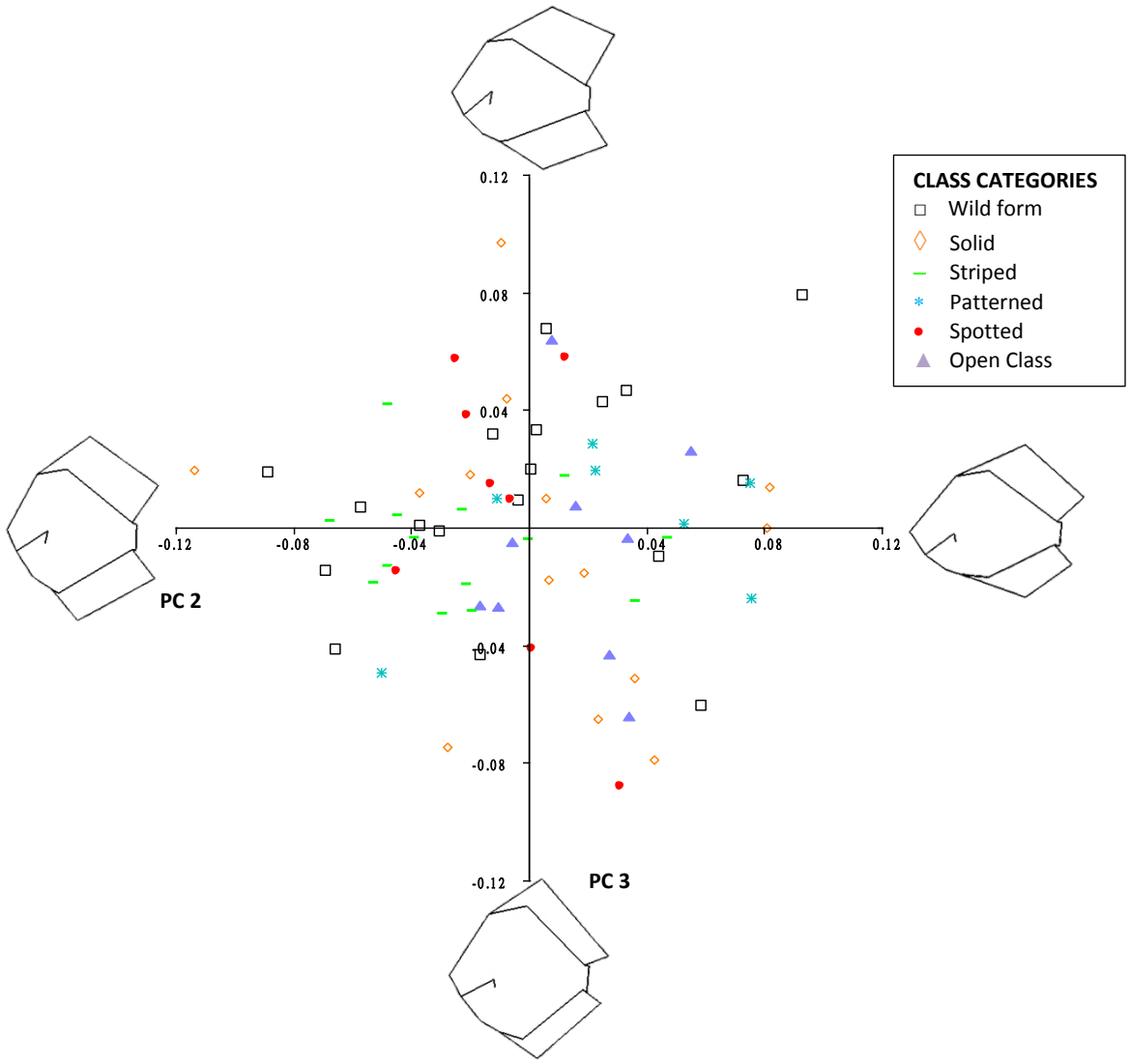


All wireframes were produced on Morphologika[2], and presented on the graph to illustrate the variance explained from each principal axis.

The second plot between principal components 2 and 3 displayed similar results to the first plot, where an overall similarity in shape was evident among images within the entire sample (Figure 3.3). Images of different variety groups displayed strong levels of overlap with each other, suggesting a degree of homogeneity present between images. However, as no specific clusters based on class category, apart from striped discus, were visible in the plot, this suggests that any level of variations in shape would have little to do with the variety groups that the images were categorized in. However, specific differences and

variation in shape could be observed as images were scattered in all areas and near extreme regions of the graph. Looking at each principal axes individually, PC 2 seemed to represent the variation based on the frontal area of the fish and the height of the body, whereas PC 3 explained differences in the overall D-body shape and size of fins. For images scored near -0.12 of PC 2, observed tendencies towards a shortened length in the frontal region or head of the fish and a higher body shape was evident. In contrast, images that scored closer to 0.12 were more compressed in body shape, had fins that were pushed further to the rear, and had a longer and sharper 'snout' than others. In terms of images scored near -0.12 for PC 3, an overall round and larger body shape could be observed, with much shorter fins and a tall overall shape. However, images with scores closer to 0.12 had a more compressed body shape with much larger-sized, longer and angular fins.

Figure 3.3 Scatterplot of PCA on discus morphometrics between PC 2 and PC 3



All wireframes were produced on Morphologika[2], and presented on the graph to illustrate the variance explained from each principal axis.

From these results, it can be inferred that an overall similarity in shape was present among the set, but specific variations in particular morphometric components were evident between images, with no definitive association with class categories or discus varieties. In terms of the final selection, the image analyses for shape revealed the presence of an evident structure of variation between images, suggesting that there was potential for images to be selected based on shape. Hence further cluster analyses was needed to identify the source of the variation specific to each image, and to conduct the final selection of images for the card set.

Considering colour on its own, a dendrogram with a stairwise structure was generated, with no particular clustering evident between the given set of images (Appendix D1). Apart from three ('Super Marlboro Red', 'Snow White' and 'Golden 3') that displayed distinct differences with stronger, more prominent and uniform coloration throughout the body, all other images could be represented in one complete group. The order in which images were placed on the dendrogam also displayed no obvious differences in relation to its categorized variety groups. However, striped, patterned and spotted discus were seen to be slightly more similar to each other than solid discus, which were generally more uniform with less complex colour combinations than the former group. Wild forms tend to be more related to each other as well, having stronger characteristics for brown and darker colours. Nevertheless, as colorations between discus varieties may overlap and could show great similarity in observed levels of redness and luminance, distinguishing these images based on the analyses of colour alone would be difficult to provide a systematic way to observe differences, and aid the final selection for the card sort.

Results from both colour and shape were similar as well, producing a dendrogram with a stairwise structure that is exactly the same as looking at colour alone, with no particular clustering between variety groups (Appendix D2). This suggested that discus varieties among the 70 selected images were generally similar to each other based on colour and shape. However, there was an evident structure in the results related to shape alone, revealing distinctive clusters and differences which could not be inferred from those associated with colour (Figure 3.4). These observations suggested that colour was generally more dominant as a feature between images, having expressed similarities so strong which may have outweighed particular differences seen with shape. However, as strong levels of variation were visible between images based on shape, five sub-groups and one out-value were identified to provide a systematic way of filtering the images, and aid the final selection for the card sort. Clusters were generally divided between discus based on the level of change away from a typical round shape, moving from evidence of a compressed body with a 'mango' shape, a 'spade' or 'heart' shape, towards a 'diamond' and other potential forms of high body shapes.

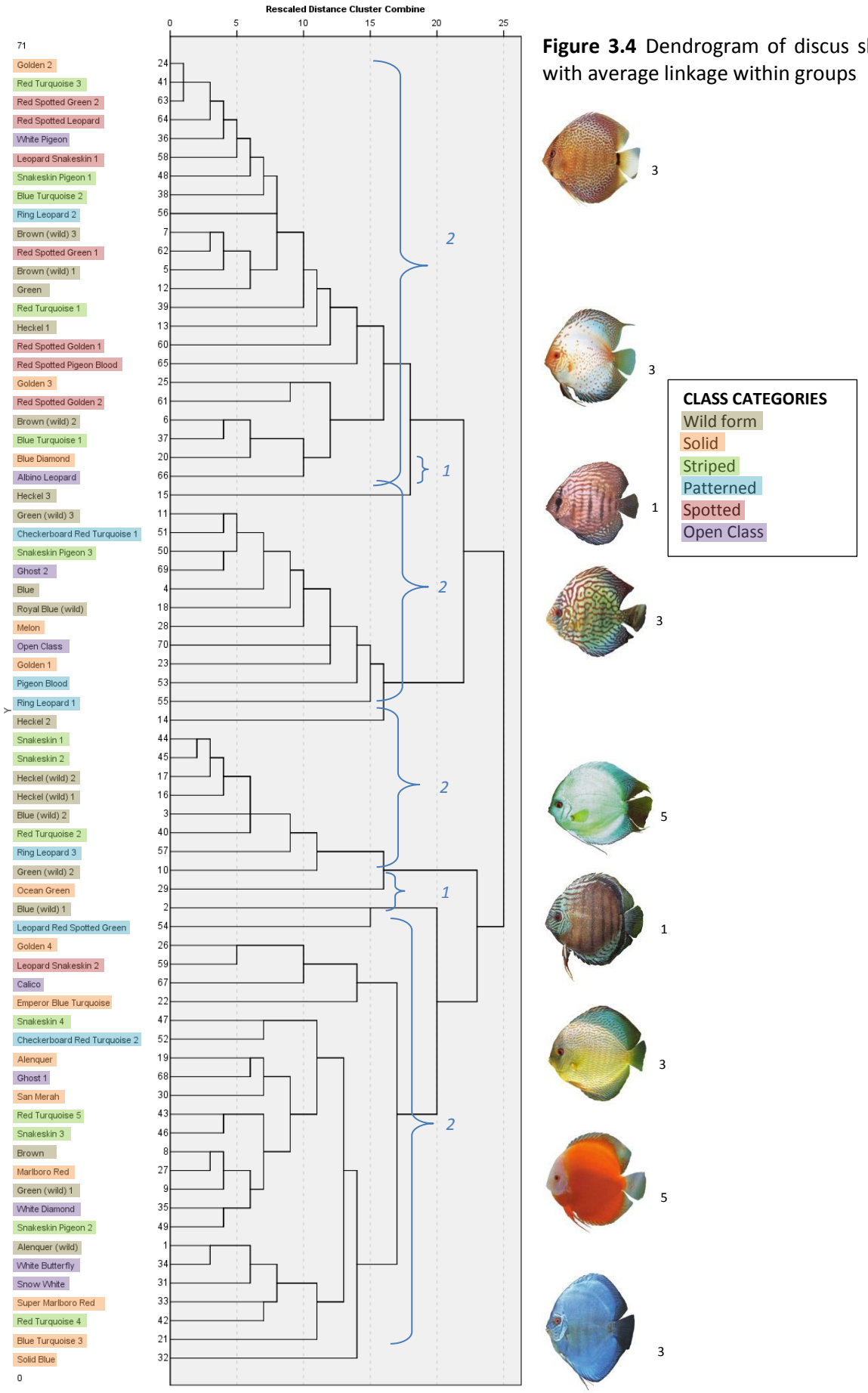


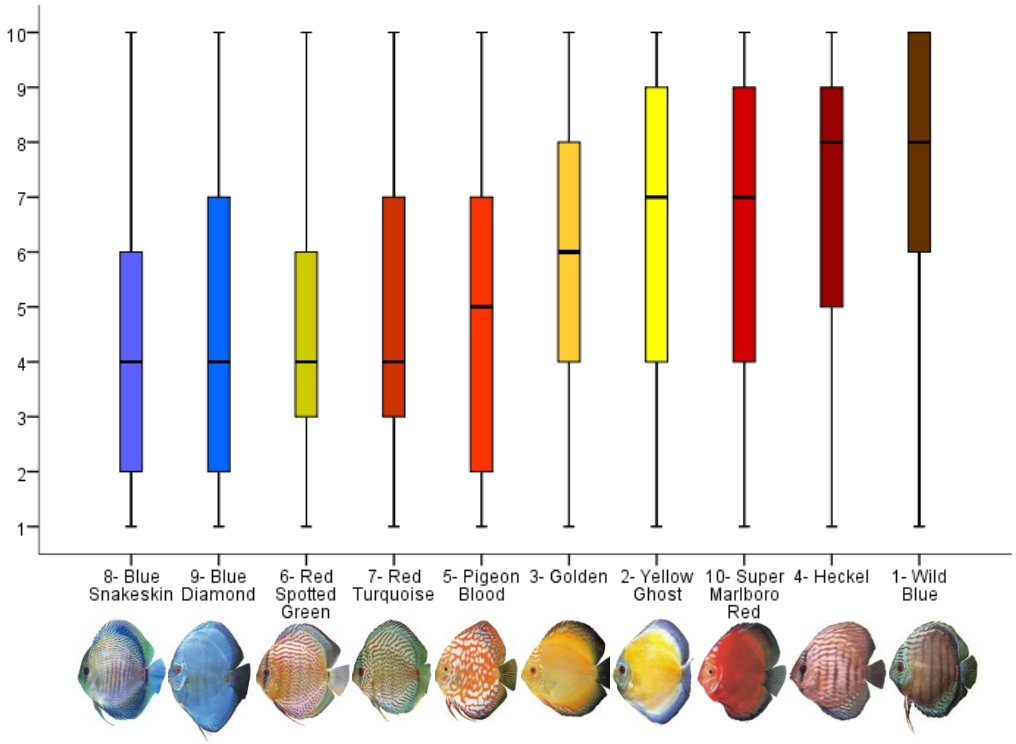
Figure 3.4 Dendrogram of discus shape with average linkage within groups

Subgroupings are derived and illustrated with brackets on the dendrogram. Images that represent the change in discus shape at different stages of the diagram are also included. All images are given footnotes with reference to printed books on page 28.

3.2.2 SUMMARY OF RESULTS

Overall preferences for discus characteristics were described with boxplots, where a general liking towards the Blue Snakeskin was seen among responses for colour (Figure 3.5), pattern (Figure 3.6) and shape (Figure 3.7).

Figure 3.5 Boxplot overview of rank scores for images based on colour



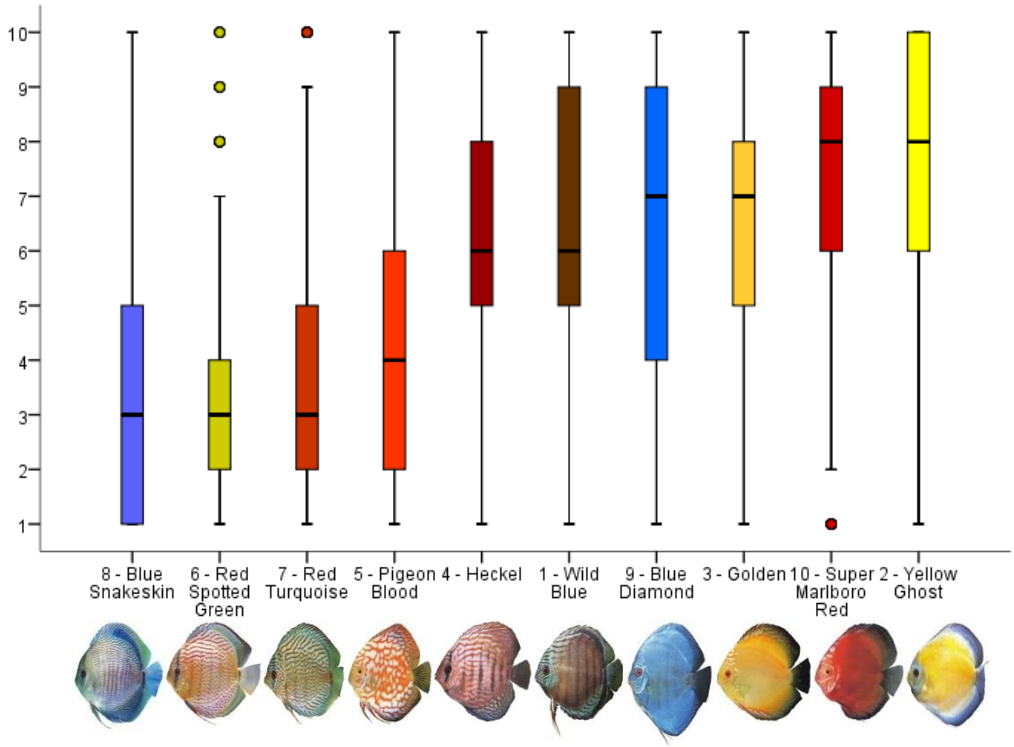
Results for colour revealed a stronger preference towards artificially cultivated varieties, such as the Blue Snakeskin and Blue Diamond, and away from wild varieties such as the Heckel and Wild Blue (Figure 3.5). A trend towards brighter colours, especially blue and more metallic colorations, and away from darker colours such as deep red or brown was evident as well. As the Red Spotted Green was a highly cultivated wild form, and Red Turquoise was a second generation cultivated wild form, having relatively high rank positions may be related to results from selective breeding, which may have emphasized the development of brighter and more vibrant colorations as opposed to dark originals from the wild. Discus with prime orange and yellow colorations, with reference to the Pigeon Blood, Golden and Yellow Ghost were placed at mid-rank positions, suggesting a lesser interest, whether positive or negative, for such colours among respondents.

In general, all images have been ranked consistently at all 10 positions, with no particular outliers in rank choices among respondents. This suggests a strong variation in rank orders for colour among respondents. Particular variations were observed for Blue Diamond and Pigeon Blood with larger interquartile ranges both between ranks 2 and 7. This indicates that a core 50% of respondents expressed preferential differences for the images, with higher tendencies in placing Blue Diamond at higher positions between ranks 2 and 4, and

Pigeon Blood at lower positions between ranks 5 and 7. Similar variations were seen for Yellow Ghost and Super Marlboro Red with both interquartile ranges between ranks 4 and 9. In both cases, a greater tendency was seen in placing the images at lower positions, between ranks 7 and 9, hinting a stronger dislike among the population and a negative influence associated with both discus to colour.

With regards to pattern, an overall trend towards discus with patternation, as opposed to plain or solid discus with no patterning was observed (Figure 3.6). Preferences were particularly evident for finely striped and spotted discus, such as the Snakeskin variety and Red Spotted Green. Both discus also displayed a combination of spots and striations across the head, body and fins, suggesting a general increase in attractiveness in relation to the complexity of visible patterns. However, an opposing preference away from complexity and towards regularity was seen among solid discus, with uni-coloured fish such as the Blue Diamond ranking relatively higher than the multi-coloured Yellow Ghost.

Figure 3.6 Boxplot overview of rank scores for images based on pattern



Outliers are marked with a circle for 'out' values, and a star for extreme values. This was observed for Red Spotted Green, with 11 outliers at Rank 8, six at Rank 9 and five at Rank 10. In addition, 14 outliers at Rank 10 were seen for Red Turquoise, and 9 at Rank 1 for Super Marlboro Red.

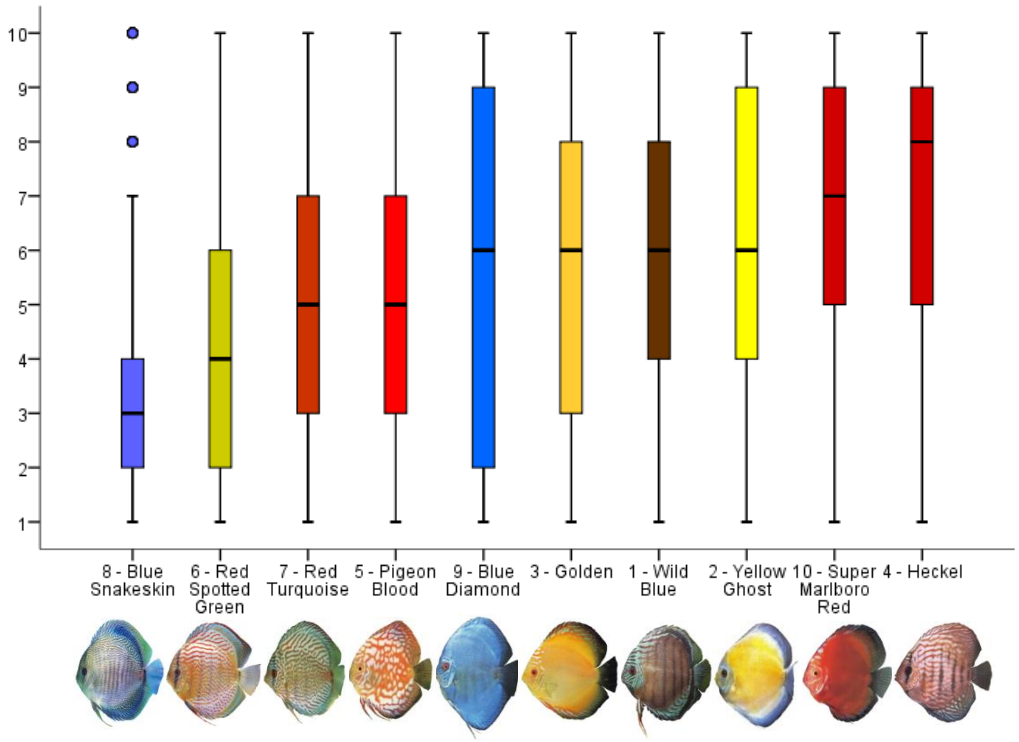
Patterned discus with unique mosaic prints such as the Pigeon Blood, selectively bred with circular and pearl-like white patches across the body, was also placed at a relatively high rank position, but was less preferred over general patterns. In addition, pattern density and regularity seemed to also influence rank choices. Discus with consistent and dense patterning, such as the Blue Snakeskin, appear to outweigh sparsely patterned options such as the Heckel, which carries irregular and broken striations across the body, and Wild Blue with striations only present around the head, the arch and across the anal fin.

In general, more distinct preferences and clearer trends were observed for pattern, with evidence of shorter interquartile ranges and whiskers across images. This was particularly evident for Red Spotted Green, with a core 50% of respondents ranking the image at a high position between 2 and 4, and an upper whisker to Rank 7 with outliers at Ranks 8, 9 and 10. Such results indicate that interests for the discus were geared consistently towards the positive end, and that the image was more likely to be placed at higher rank positions in the card set. Outliers were also observed at Rank 10 for Red Turquoise and Rank 1 for Super Marlboro Red, indicating slight positive associations with the former image and slightly negative associations with the latter. Although a large interquartile range was seen for Wild Blue and Blue Diamond in particular, ranking at the lower end between 5-9 and 4-9 respectively, tendencies for respondents to place the former at a mid-rank position and the latter at a lower rank position suggests a lesser interest for Wild Blue, and negative preferences for Blue Diamond in terms of pattern.

Compared to the aforementioned characteristics, rank orders for shape were the most varied among respondents. A clear preference for Blue Snakeskin was evident with a short interquartile range between ranks 2 and 4, short whiskers from ranks 1 to 7 and outliers for ranks 8, 9 and 10 (Figure 3.7). General trends towards rounder bodied and high-finned discus, such as the Blue Snakeskin, and diamond-shaped or high-bodied discus, such as the Pigeon Blood and Blue Diamond, was seen as well. Despite having a longer body, the Red Spotted Green was also placed at a high rank position due to an overall smooth and round exterior. Yet discus with less defined shapes such as the Wild Blue, an overall uneven outlook such as the Yellow Ghost and Super Marlboro Red, and especially spade-shaped or sharp-edged discus such as the Heckel were ranked at much lower positions in the card sort. Conversely, the long-bodied and spade-shaped Golden seems to be another anomaly with high finnage and an even and smooth exterior shape, resulting with a relatively higher rank at an intermediate position of the set than others. However, differential preferences and heterogeneity within the sample population was evident among all images apart from the Blue Snakeskin, having been ranked consistently at all 10 positions by respondents, with interquartile ranges across a minimum of five ranks.

Particularly strong variations were observed for Blue Diamond, with a core 50% of respondents placing the image at positions that ranged largely between a high-ranked 2 to a low 9. This indicates a strong level of heterogeneity in shape preferences for Blue Diamond across respondents, with equal likelihood to place the image at either side of the card sort. Nevertheless, slight tendencies to place the image at positions of higher to middle ranks were observed, suggesting an overall positive association of the Blue Diamond to preferences for shape.

Figure 3.7 Boxplot overview of rank scores for images based on shape



Outliers are marked with a circle for 'out' values, and a star for extreme values. 13 outliers at Rank 8, nine at Rank 9 and seven at Rank 10 were observed for Blue Snakeskin.

Overall, a Spearman's correlation on the mean ranks expressed general positive associations across responses for all three characteristics (Table 3.12). Strong significant correlations were seen between rank orders for colour and shape ($r_s = 0.806$, $N = 10$, $p < 0.01$, two-tailed) and pattern and shape ($r_s = 0.818$, $N = 10$, $p < 0.01$, two-tailed). Considering that preferences seemed to be most varied for shape, yet its related associations were overall the most significant, it is proposed that shape may be more difficult as a factor for respondents to focus their selections on its own. As a result, when difficulties in decision-making are encountered, it is suggested that responses for shape may be prone to influences from other features with more specific preferences when choosing between discus.

Table 3.12 Spearman's rank correlation coefficients of associations between colour, pattern and shape

Association	*N*	r_s	*p*
Colour * Pattern	10	0.661**	0.038
Colour * Shape	10	0.806***	0.005
Pattern * Shape	10	0.818***	0.004

*Significance levels are indicated as ** for $p < 0.05$ and *** for $p < 0.01$.*

Potential influences associated between responses for colour and pattern were also observed, though less significant with correlations at $r_s = 0.661$ ($N = 10$, $p < 0.05$, two-tailed). As pattern placement on the body and fins, complexity and fullness are of no relation to colour and seemed to be of particular importance, slight differences may be evident in orders judged by colour or pattern alone. Nevertheless, rank orders for pattern seem to be associated with colour complexity in relation to plain or solid discus, which suggests that

colour may play an overall bigger role in the selection for discus, and is prone to influence orders when complications are encountered.

These associations also suggest the presence of a general aesthetic preference for particular discus among the sampled group. In the event where the respondent may be subconsciously incorporating other characteristics and selecting for a preferred attribute instead of the subject of the card sort exercise, such as selecting for preferred base colour instead of pattern, this could result in potential biases. Mental acknowledgements of a personal favourite could induce such biases by expressing similar rankings for images in all three characteristics, leading to associations in results. Outcomes for the Blue Snakeskin showed the greatest potential for these occurrences, with first position rankings recorded in all three categories (Figure 3.5; 3.6; 3.7).

3.2.3 BASIC DEMOGRAPHICS

Before analysing market and respondent heterogeneity, basic variations in ordered preferences for discus color, pattern and shape between demographic groups within the sample population were investigated. This refers to potential differences between gender and age groups, in which all inferences of quantitative analyses will be summarized and used to provide additional context for the discussion of the main CS results.

Gender

Of 430 respondents, 313 males and 115 females took part in the card sort. Two respondents with missing demographic information were excluded in the analyses for gender.

Overall, males and females displayed high levels of similarities in discus preferences, with strong positive associations determined on the mean ranks of images for colour ($r_s = 0.869$, $N = 10$, $p < 0.01$, two-tailed) and pattern ($r_s = 0.794$, $N = 10$, $p < 0.01$, two-tailed; Table 3.13). This was reflected in the boxplots, which saw both groups with clear rank patterns that exhibited general trends which were highly consistent to those observed in the summary of results (Appendix E1; E6). Thus it can be said that, irrespective of gender, respondents carried an overall preference for vibrant, more refined and selectively bred cultivated varieties than wild forms, and generally favours discus with patterning over plain.

Nevertheless, slight differences in strength of preferences were evident between groups (see detailed results in Appendix E). Boxplots for colour saw females expressing clearer interests and stronger preferences at the extremes, with a more distinctive spread or distribution of median rank scores across images. In contrast, males expressed great overlap with similar interquartile ranges and shared scores, particularly between the top four images, which suggest broader interests and more heterogeneous preferences than the former. This reveals that females were more consistent in their preferences for colour, whilst males may contain stronger individual variation within the group. This was reflected in both GLMs and Kruskall-Wallis results of images, where females were predicted

significantly more likely to place higher rank positions for the brighter Blue Snakeskin and Yellow Ghost, and lower rank positions for darker and red/brown colorations of the Red Turquoise, Super Marlboro Red and Wild Blue relative to males. In the case of pattern, males expressed more specific interests with clearer preferential structures and solid positioning of images instead, as opposed to females with more heterogeneous preferences from larger interquartile ranges, overlapping median scores and lesser outliers than the former. Yet, apart from Kruskal-Wallis results showing a greater tendency for higher positions of Red Turquoise for males, the GLMs only found significant differences on the placement of solid discus varieties, which may be more associated with interests for colour. This is evident with male responses showing significant but less strong positive associations in rank orders for colour and pattern (r_s = 0.673, N = 10, p < 0.05, two-tailed), suggesting possible influences from preferences for colour characteristics during pattern exercises (Table 3.13).

Table 3.13 Spearman's rank correlation coefficients of associations between and within gender groups

Association		*N*	r_s	*p*
Between groups	c_Male * c_Female	10	0.869***	0.001
	p_Male * p_Female	10	0.794***	0.006
	s_Male * s_Female	10	0.588	0.074
Within groups	c_Male * p_Male	10	0.673**	0.033
	c_Male * s_Male	10	0.879***	0.001
	p_Male * s_Male	10	0.830***	0.003
	c_Female * p_Female	10	0.614	0.059
	c_Female * s_Female	10	0.541	0.106
	p_Female * s_Female	10	0.879***	0.001

*Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

On the other hand, groups expressed the greatest variation in rank orders for discus shape, with insignificant associations at the 95% level (p = 0.074). Both groups were clearly similar in their interests for the rounder-bodied and high-finned Blue Snakeskin, and lesser for undefined, unevenly shaped and spade-shaped discus, which were again highly consistent to orders observed in the CS summary. However, GLM and Kruskal-Wallis results found opposing preferences between groups, which may potentially be related to an acquired interest towards particular features or discus varieties. As males placed significantly higher positions for the oval-shaped and high-bodied Blue Diamond, as well as the round-bodied Wild Blue regardless of its short finnage and lesser defined shape, the group was suggested to have had broader shape preferences and potentially greater interests in traditional wild varieties and features as well. In contrast, females placed significantly higher rank positions for spade and more irregular shaped discus, with reference to Heckel, the longer-bodied Golden, and Super Marlboro Red, which seemed likely as an acquired interest considering the general disinterest for the type. At the same time, as the latter two were both pigeon blood varieties, potentially greater interests on the variety were also taken into account.

All things considered, discus shape seemed to be the most difficult attribute to order and most easily influenced by pattern characteristics, with strong significant correlations observed for the two attributes across both male (r_s = 0.830, N = 10, p < 0.01, two-tailed) and female responses (r_s = 0.879, N = 10, p < 0.01, two-tailed). Nevertheless, with significant associations to all attributes, males were proposed to have experienced the most difficulty in focusing orders for specific characteristics alone, and that complex decision-making may be involved as rankings are prone to influences or considerations from other discus features. In comparison, female responses expressed no other associations, indicating distinctive orders and clear preferences for colour and pattern.

Age Group

Of 430 respondents that took part in the card sorting, 38 were born earlier than 1990, 130 in 1980-1989, 88 in 1970-1979, 81 in 1960-1969, 66 in 1950-1959, 20 in 1940-49 and three in 1930-1939. Four respondents with missing demographic information were excluded for analyses on age group.

Similar to gender, strong similarities and significant associations in rank choices across age groups were observed for colour and pattern (Table 3.10). Parallel to the CS summary, boxplots for colour revealed comparable orders with top ranks for bright and metallic blue colorations, which were Blue Snakeskin for most and Blue Diamond for the 1970-1979 and 1960-1969 working demographic, as well as high interests for the bright orange/red Pigeon Blood (see detailed results in Appendix F). Preferences for pattern were most consistent across groups, geared also towards discus with patterning, particularly the densely patterned and finely-striated Blue Snakeskin, and away from plain discus with greater disinterest in Yellow Ghost, with an unusual sharp colour contrast on the body and fins.

Yet, slight differences for colour were observed, with GLM results revealing significantly stronger interests by the younger >1990 group, and the mid 1970-1979 with the least interests in the core working demographic. The most evident were variations related to the middle-aged to older demographic, where individuals expressed greater preferences for traditional wild and deep red colours over the brighter gold colorations instead. This was reflected in the boxplots, which saw high ranks for Red Spotted Green among the 1940-1949, and Red Turquoise for groups 1980-1989, 1960-69 and 1950-1959, comparable to those of Blue Diamond and Pigeon Blood. As both are highly cultivated and brighter wild forms which are refined in their traditional features, this suggests that older groups, with potentially more wild interest, may be attracted to their attributes as a compromise of both artificially cultivated and wild characteristics. The GLM results also saw greater interests among the mid 1970-1979 demographic for the deep Super Marlboro Red, where individuals were significantly more likely to place higher rank positions relative to both younger and older groups. However, only strong significant associations were observed between these groups, which suggested that the variations were minimal in their influence towards the overall preference (Table 3.14). Instead, less significant associations were related to the older 1930-

1939 demographic, but due to a small sample size, a likely bias in results leads to issues of plausibility for such variations, and thus were not inferred for the analyses.

Table 3.14 Spearman's rank correlation coefficients of associations between and within age groups

	Association	***N***	r_s	***p***
Between groups	c_>1990 * c_1980-1989	10	0.912***	< 0.001
	c_>1990 * c_1979-1979	10	0.790***	0.007
	c_>1990 * c_1960-1969	10	0.869***	0.001
	c_>1990 * c_1950-1959	10	0.869***	0.001
	c_>1990 * c_1940-1949	10	0.843***	0.002
	c_>1990 * c_1930-1939	10	0.909***	< 0.001
	c_1980-1989 * c_1970-1979	10	0.818***	0.004
	c_1980-1989 * c_1960-1969	10	0.976***	< 0.001
	c_1980-1989 * c_1950-1959	10	0.952***	< 0.001
	c_1980-1989 * c_1940-1949	10	0.890***	0.001
	c_1980-1989 * c_1930-1939	10	0.888***	0.001
	c_1970-1979 * c_1960-1969	10	0.818***	0.004
	c_1970-1979 * c_1950-1949	10	0.794***	0.006
	c_1970-1979 * c_1940-1949	10	0.841***	0.002
	c_1970-1979 * c_1930-1939	10	0.742**	0.014
	c_1960-1969 * c_1950-1959	10	0.891***	0.001
	c_1960-1969 * c_1940-1949	10	0.841***	0.002
	c_1960-1969 * c_1930-1939	10	0.851***	0.002
	c_1950-1959 * c_1940-1949	10	0.902***	< 0.001
	c_1950-1959 * c_1930-1939	10	0.845***	0.002
	c_1940-1949 * c_1930-1939	10	0.702**	0.024
	p_>1990 * p_1980-1989	10	0.927***	< 0.001
	p_>1990 * p_1979-1979	10	0.927***	< 0.001
	p_>1990 * p_1960-1969	10	0.891***	0.001
	p_>1990 * p_1950-1959	10	0.903***	< 0.001
	p_>1990 * p_1940-1949	10	0.915***	< 0.001
	p_>1990 * p_1930-1939	10	0.742**	0.014
	p_1980-1989 * p_1970-1979	10	0.903***	< 0.001
	p_1980-1989 * p_1960-1969	10	0.867***	0.001
	p_1980-1989 * p_1950-1959	10	0.903***	< 0.001
	p_1980-1989 * p_1940-1949	10	0.964***	< 0.001
	p_1980-1989 * p_1930-1939	10	0.754**	0.012
	p_1970-1979 * p_1960-1969	10	0.939***	< 0.001
	p_1970-1979 * p_1950-1949	10	0.915***	< 0.001
	p_1970-1979 * p_1940-1949	10	0.964***	< 0.001
	p_>1990 * p_1940-1949	10	0.915***	< 0.001
	p_>1990 * p_1930-1939	10	0.742**	0.014
	p_1980-1989 * p_1970-1979	10	0.903***	< 0.001
	p_1980-1989 * p_1960-1969	10	0.867***	0.001
	p_1980-1989 * p_1950-1959	10	0.903***	< 0.001
	p_1980-1989 * p_1940-1949	10	0.964***	< 0.001
	p_1980-1989 * p_1930-1939	10	0.754**	0.012
	p_1970-1979 * p_1960-1969	10	0.939***	< 0.001
	p_1970-1979 * p_1950-1949	10	0.915***	< 0.001
	p_1970-1979 * p_1940-1949	10	0.964***	< 0.001
	p_1970-1979 * p_1930-1939	10	0.796***	0.006
	p_1960-1969 * p_1950-1959	10	0.867***	0.001

	Association	N	r_s	p
Between groups	p_1960-1969 * p_1940-1949	10	0.879***	0.001
	p_1960-1969 * p_1930-1939	10	0.790***	0.007
	p_1950-1959 * p_1940-1949	10	0.915***	< 0.001
	p_1950-1959 * p_1930-1939	10	0.766***	0.010
	p_1940-1949 * p_1930-1939	10	0.796***	0.006
	s_>1990 * s_1980-1989	10	0.770***	0.009
	s_>1990 * s_1979-1979	10	0.455	0.187
	s_>1990 * s_1960-1969	10	0.527	0.117
	s_>1990 * s_1950-1959	10	0.758**	0.011
	s_>1990 * s_1940-1949	10	0.778***	0.008
	s_>1990 * s_1930-1939	10	0.231	0.521
	s_1980-1989 * s_1970-1979	10	0.709**	0.022
	s_1980-1989 * s_1960-1969	10	0.830***	0.003
	s_1980-1989 * s_1950-1959	10	0.952***	< 0.001
	s_1980-1989 * s_1940-1949	10	0.967***	< 0.001
	s_1980-1989 * s_1930-1939	10	0.529	0.116
	s_1970-1979 * s_1960-1969	10	0.915***	< 0.001
	s_1970-1979 * s_1950-1949	10	0.745**	0.013
	s_1970-1979 * s_1940-1949	10	0.717**	0.020
	s_1970-1979 * s_1930-1939	10	0.936***	< 0.001
	s_1960-1969 * s_1950-1959	10	0.830***	0.003
	s_1960-1969 * s_1940-1949	10	0.815***	0.004
	s_1960-1969 * s_1930-1939	10	0.790***	0.007
	s_1950-1959 * s_1940-1949	10	0.948***	< 0.001
	s_1950-1959 * s_1930-1939	10	0.559	0.093
	s_1940-1949 * s_1930-1939	10	0.543	0.105
Within groups	c_>1990 * p_>1990	10	0.632**	0.050
	c_>1990 * s_>1990	10	0.498	0.143
	p_>1990 * s_>1990	10	0.867***	0.001
	c_1980-1989 * p_1980-1989	10	0.467	0.174
	c_1980-1989 * s_1980-1989	10	0.661**	0.038
	p_1980-1989 * s_1980-1989	10	0.879***	0.001
	c_1970-1979 * p_1970-1979	10	0.636**	0.048
	c_1970-1979 * s_1970-1979	10	0.806***	0.005
	p_1970-1979 * s_1970-1979	10	0.673**	0.033
	c_1960-1969 * p_1960-1969	10	0.758**	0.011
	c_1960-1969 * s_1960-1969	10	0.903***	< 0.001
	p_1960-1969 * s_1960-1969	10	0.867***	0.001
	c_1950-1959 * p_1950-1959	10	0.685**	0.029
	c_1950-1959 * s_1950-1959	10	0.697**	0.025
	p_1950-1959 * s_1950-1959	10	0.697**	0.025
	c_1940-1949 * p_1940-1949	10	0.767***	0010
	c_1940-1949 * s_1940-1949	10	0.818***	0.004
	p_1940-1949 * s_1940-1949	10	0.723**	0.018
	c_1930-1939 * p_1930-1939	10	0.555	0.096
	c_1930-1939 * s_1930-1939	10	0.884***	0.001
	p_1930-1939 * s_1930-1939	10	0.604	0.065

*Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

Similar to colour, rank orders for pattern were also found with less significant associations between certain age groups. Between the higher ranked images, boxplots found greater interests for the unique mosaic Pigeon Blood among the youngest >1990 group, the multi-patterned Red Spotted Green among groups of the core working demographic, and the more traditional and thickly striated Red Turquoise among the older 1950-1959 and 1940-1949 demographic. This suggests a division of interests, with younger individuals preferring more unusual traits in modern varieties as opposed to older individuals preferring the more traditional patternations. But since all related results were associated to the older 1930-1939 group, and no significant differences were determined, results can be concluded as an expression of overall preferences for pattern, showing no major variations across age groups.

In contrast, preferential differences for shape were most apparent with comparisons to both the younger >1990 and older 1930-1939 demographic, revealing the greatest variation of interests between the extremes and the intermediate age group or working demographic (Table 3.14). Excluding the older group, associations with the younger >1990 were only significant in rank orders between 1940-1949 and 1950-1959, and insignificant for the remaining groups. This represents the most distinct preferences for discus across all age demographics. In general, groups displayed consistent preferences to the CS summary, with the strongest interests in high-finned discus and particularly the round-bodied Blue Snakeskin, which was most apparent among the mid 1970-1979 demographic. However opposing preferences were reflected in the GLM results, with younger >1990 and 1980-1989 groups expressing significantly lower interests on the high-finned and high-bodied Blue Diamond relative to the older demographics. Again, the greatest interests were exhibited by individuals of 1970-1979, which was also the case for the uneven but oval-shaped Yellow Ghost relative to the working demographic. This suggests that individuals from the core-demographic group may carry the strongest attractions to the high-bodied or oval shape. Additionally, results found both >1990 and 1980-1989 groups placing higher rank positions for the spade-shaped Heckel than other groups of the working demographic. Individuals from <1990 also placed significantly higher ranks for the high-finned, yet spade-shaped and long-bodied Golden than older demographics apart from 1940-1949 and 1950-1959, which incurred similar interests. Thus, it can be inferred that sources of interest for the particular spade shape was mainly among the younger population, but may also be observed among older generations of the working demographic.

All in all, responses to rank orders for shape were found to be most strongly associated to preferences observed for other discus attributes. All age groups showed influences either from colour or pattern, which suggests an overall greater difficulty in identifying orders for discus shape among respondents. Individuals of 1960-1969 exhibited the greatest influence within their results, having strong significant associations to both colour and pattern with shape ($p < 0.001$; $p < 0.001$). Though lesser significant associations were observed for the 1950-1959 group, associations across the working demographic suggest a likely

consideration of multiple factors among individuals who may be specialists or professionals in the industry, carrying potentially more complex assessments and an overall preference for discus. But overall, lesser significances between colour and pattern within groups indicate more distinct preferences, and potentially clearer elicitations for the given attributes among individuals. This was most apparent with no significant associations among the 1980-1989, with the largest representation of respondents, and the older 1930-1939, expressing the most independent and specific interests with minimal influences by other attributes in their rank orders. Nevertheless, respondents of the younger generation seem to be overall the least influenced by external characteristics in their rank orders, and is more able to justify their ordering with a focus on particular criteria.

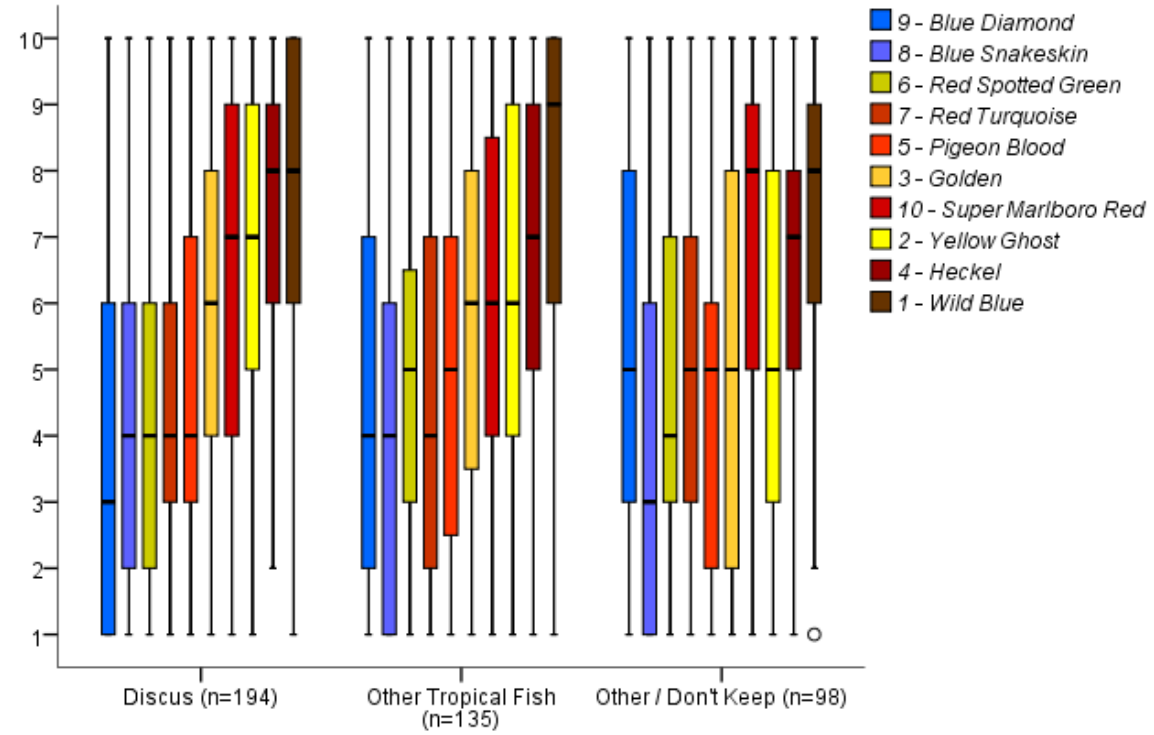
3.2.4 FISHKEEPING

An assessment on heterogeneities between respondent groups based on fishkeeping background and experience was also investigated prior to the main analyses on market regions and respondent classes. This was done to identify variations in preferences between individuals within and outside of the discus community. As such information will be particularly relevant in providing extended information to support the analyses on respondent heterogeneity, between traders and public consumers, detailed displays of results from the quantitative analyses were included, and inferences made will be used to support the discussion of CS results.

Of 430 respondents, 329 tropical fish keepers, of which 194 were discus keepers, and 98 that were either keepers of other fish or have not kept fish at all had took part in the card sorting. Three respondents with missing information were excluded in the analyses for fishkeeping. Levels of keeping experience were also additionally recorded, but due to small sample sizes between groups, comparisons were excluded from the CS analysis.

Boxplots were constructed with a focus on discus keeping, and comparisons with other respondents of different fishkeeping experiences. Results for colour were consistent with trends observed in the CS summary, revealing overall interests towards brighter-coloured, especially metallic blue discus, and away from the darker brown and deep red colorations (Figure 3.8). However, preferential differences were particularly evident for discus keepers in relation to other fish keepers and non-keepers. While discus keepers showed greater interests for Blue Diamond, the image was ranked much lower in the set for other keepers and non-keepers, which expressed a liking towards Blue Snakeskin instead. Discus keepers also displayed broader interests with similar rank scores for images ranked higher in the set, and more specific disinterests with a clear descending order of lesser preferred images at the lower set. This can be seen with evidence of a clearer preference structure and greater preferential strength for the less desired gold and red/brown colorations, reflecting much lower median rank positions for images such as the highly contrasted Yellow Ghost than other fish keepers and non-keepers.

Figure 3.8 Boxplot of rank scores for images based on colour and fishkeeping



Outliers are marked with a circle for 'out' values, and a star for extreme values. This was observed for Wild Blue among other fish keepers and non-keepers.

In contrast, other keepers and non-keepers expressed the most heterogeneous and broad interests for discus, with only clearer identifications of two to three preferred and less preferred images at the extremes, and an overall shared interest with mid-rank positions and the same median across five images of the set. This suggests that individuals may show greater abilities to identify their definite favourites and disinterests, whereas sorts between images of intermediate rank positions may have been more difficult due to neutral preferences for colour. General interquartile ranges for the latter were also relatively larger than discus keepers, particularly in terms of blue and gold colorations such as Blue Snakeskin, Blue Diamond, Golden and Yellow Ghost, revealing greater individual variation within the group.

On the other hand, rank orders for other tropical fish keepers seemed to carry elements of similarities to both groups, particularly with discus keepers. The group incurred shared interests for the metallic Blue Snakeskin with other keepers and non-keepers as the most preferred image of the set. Yet, descending orders for less preferred colorations were more comparable to responses from discus keepers at the lower part of the set. Consistent to preferences from the latter, Blue Diamond was also ranked high in the set, which suggests that tropical fish keepers in general, including discus keepers, carry similar associations and preferences for discus colour. Nevertheless, a distinctly higher preference for Red Turquoise, the slightly darker cultivated wild form, over Red Spotted Green, the brighter and more refined cultivated wild form, was observed. This suggests a potential interest for cultivated wild varieties with more traditional wild colorations.

Significant differences in mean rank scores between keepers were reflected in GLMs for Yellow Ghost (F (2,424) = 7.610, $p < 0.005$, $\eta_p^2 = 0.035$), Red Spotted Green (F (2,424) = 4.607, $p < 0.05$, $\eta_p^2 = 0.021$) and Super Marlboro Red (F (2,424) = 3.118, $p < 0.05$, $\eta_p^2 = 0.014$; Appendix G1). LSD post-hoc tests revealed the greatest variances in comparisons related to discus keepers for Red Spotted Green, and other fish keepers and non-keepers for Yellow Ghost and Super Marlboro Red (Appendix G2). For every one unit increase in the option of acquiring the respective discus, the model predicts responses of a significant increase in rank score by respondents who have not kept discus for Red Spotted Green relative to discus keepers, and a significant decrease in rank score by all tropical fish keepers for Yellow Ghost and Super Marlboro Red relative to other fish keepers and non-keepers (Table 3.15). Such results indicate that the greatest differences did lie between discus keepers and other fish and non-keepers, in which the former expressed greater interests for cultivated wild forms with a greater likelihood to place higher rank positions for the Red Spotted Green, and the latter with acquired interests for the unusually contrasted Yellow Ghost and deeper Super Marlboro Red.

Table 3.15 Parameter estimates for significant models between groups on fishkeeping, based on colour

Image	Source	B-Effect	Std. Err.	*t*	*p*	Partial η^2
2 – Yellow Ghost	Intercept	5.398***	0.284	19.031	< 0.001	0.461
	Discus	1.355***	0.348	3.893	< 0.001	0.035
	Other Tropical Fish	0.824**	0.373	2.212	0.027	0.011
	Other / Don't Keep	0				
6 – Red Spotted Green	Intercept	4.093***	0.174	23.466	< 0.001	0.565
	Other / Don't Keep	0.805***	0.301	2.674	0.008	0.017
	Other Tropical Fish	0.633**	0.272	2.325	0.021	0.013
	Discus	0				
10 – Super Marlboro Red	Intercept	7.071***	0.283	25.021-	< 0.001	0.596
	Discus	-0.772**	0.347	2.228	0.026	0.012
	Tropical Fish	-0.842**	0.371	-2.267	0.024	0.012
	Other / Don't Keep	0				

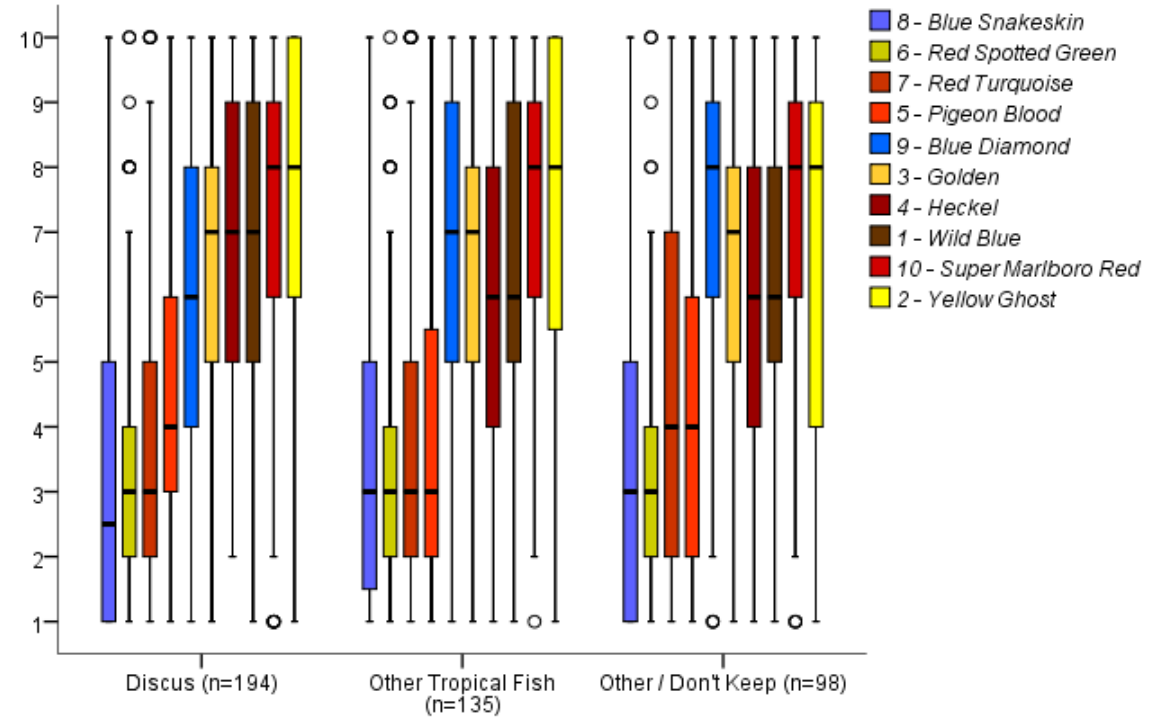
*Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

For models that did not meet assumptions on normality, a Kruskal-Wallis Test was performed, with significant differences observed between median rank scores for Heckel (X^2 = (2, N = 427) = 19.151, $p < 0.001$) and Blue Diamond (X^2 = (2, N = 427) = 21.339, $p < 0.001$; Appendix J1). Results from a Mann-Whitney-U post-hoc test revealed the most significant variations in paired comparisons related to discus keepers for both Heckel and Blue Diamond (Appendix J2). With regards to Heckel, the median rank for discus keepers were larger than both groups, thus suggesting a tendency to place lower rank positions and exhibit lesser preferences for its brown coloration. In the case of Blue Diamond, larger median ranks were seen among other fish keepers and non-keepers instead, followed by other tropical fish keepers than discus keepers. Thus, it can be said that individuals with no experience in keeping discus tend to place lower rank positions and exhibit lesser preference for the metallic Blue Diamond, which is a direct contrast strong preferences

observed among discus keepers and in the CS summary. No significant differences were observed in mean ranks and median rank sores for other images (Appendix G1; J1).

Boxplot results on pattern revealed the most similar preferences across groups (Figure 3.9). Particularly consistent were orders in the upper half of the set, where an overall preference towards the dense and finely striated Blue Snakeskin, followed by the multi-patterned Red Spotted Green was observed between all keepers and non-keepers. Orders were overall consistent to the CS summary as well, revealing a general interest for discus with full patterning, with gradual disinterest towards sparsely patterned and plain discus. However, groups revealed specific interests to particular attributes with variations in secondary interests for pattern. Higher ranks and greater attractions towards the Red Turquoise with traditional thick striations were most evident among all tropical fish keepers, including discus, while other keepers and non-keepers preferred the unique mosaic-patterned Pigeon Blood instead. Yet, as the greatest median rank position for the latter was placed by other tropical fish keepers, it can be said that striations of all forms were seemed most favoured by the group over discus keepers and other fish keepers and non-keepers.

Figure 3.9 Boxplot of rank scores for images based on pattern and fishkeeping



Outliers are marked with a circle for 'out' values, and a star for extreme values. This was observed among discus keepers for Red Spotted Green and Red Turquoise; other tropical fish keepers for Red Spotted Green and Super Marlboro Red; and other fish keepers and non-keepers for Red Spotted Green, Blue Diamond and Super Marlboro Red.

However, unlike observations for colour, rank orders by other tropical fish keepers, particularly of the lower set, were more comparable to other keepers and non-keepers instead. This was evident with discus keepers expressing a clearer preference structure and specific order of interests, whereas both other groups reflected a general divide in

preferences, with shared interests between the more desired patternations, and similarly lesser interests and median rank scores for the less desirable traits. Apart from a parallel disinterest for the unusually contrasted Yellow Ghost, rank orders by individuals who have not kept discus were more consistent to the CS summary, whereas discus keepers expressed particularly higher interests for the solid Blue Diamond and Golden, with higher rankings placed than sparsely patterned or plain varieties. This suggests that discus keepers may have generally preferred both fish over the remainders, potentially due to exhibitions of other favoured characteristics which could have influenced their decisions for a higher placement.

The observed variations were reflected with significant differences found in GLMs for Heckel (F (2,424) = 4.276, $p < 0.05$, $\eta_p^2 = 0.020$) and Blue Diamond (F (2,424) = 14.677, $p < 0.001$, $\eta_p^2 = 0.065$; Appendix H1). The LSD post-hoc indicates that both images showed significant variations in relation to discus keepers (Appendix H2). The parameter estimates revealed a greater likelihood for respondents who have not kept discus to express significantly lower rank scores for Heckel, and significantly higher rank scores for Blue Diamond than discus keepers (Table 3.16). This indicates that acquired interests for particular traits or varieties were observed between individuals within and outside the discus community. People outside the discus community seemed to express greater interests for Heckel despite the general disinterest towards its broken-stripes and sparse patternation on the body, whereas discus keepers significantly preferred and are more likely to place a much higher rank for the plain Blue Diamond than others.

Table 3.16 Parameter estimates for significant models between groups on fishkeeping, based on pattern

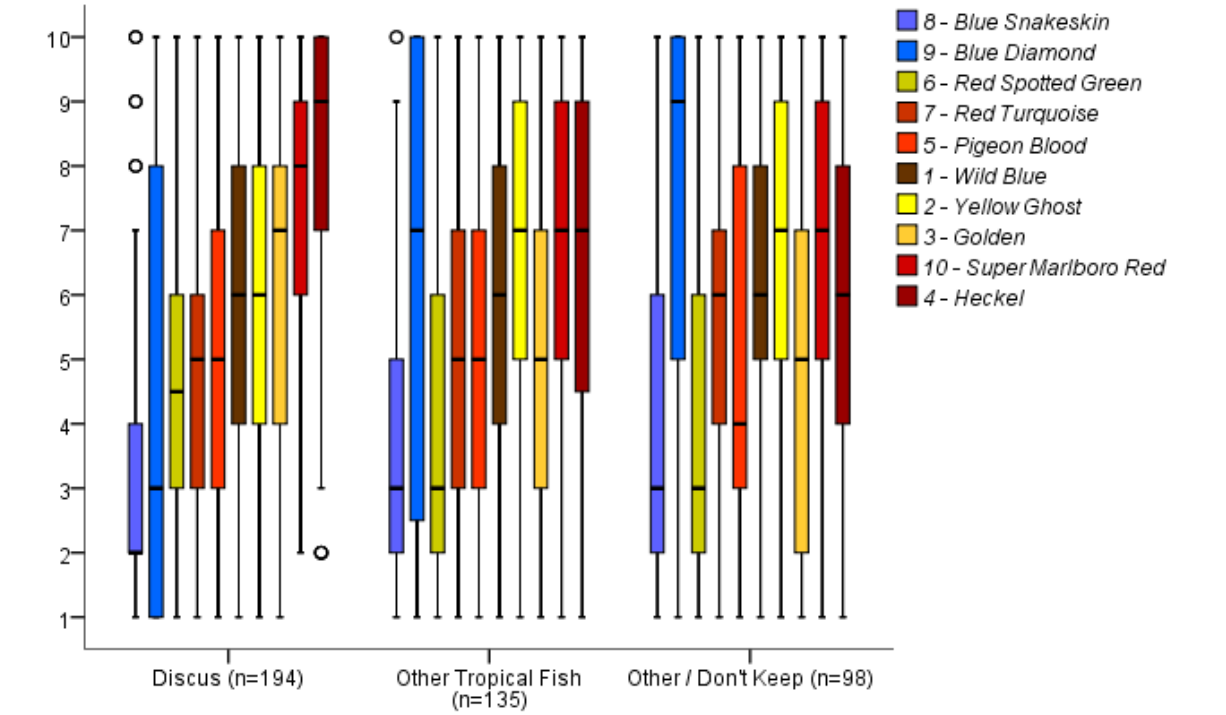
Image	Source	B-Effect	Std. Err.	*T*	*p*	Partial η^2
4 – Heckel	Intercept	6.680***	0.161	41.459	< 0.001	0.802
	Other Tropical Fish	-0.651**	0.252	-2.587	0.010	0.016
	Other / Don't Keep	-0.619**	0.278	-2.226	0.027	0.012
	Discus	0				
9 – Blue Diamond	Intercept	5.691***	0.187	30.411	< 0.001	0.686
	Other Tropical Fish	1.124***	0.292	3.848	< 0.001	0.034
	Other / Don't Keep	1.605***	0.323	4.970	< 0.001	0.055
	Discus	0				

*Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

In this case, only results for Red Turquoise carried issues with homoscedasticity, and thus was subjected to non-parametric analyses which revealed significant differences between median ranks (X^2 = (2, N = 427) = 8.060, $p < 0.05$; Appendix J3). The Mann-Whitney U post-hoc test showed variations for comparisons in relation to other fish keepers and non-keepers Appendix J4). As the median rank score for other keepers and non-keepers were the highest compared to the others, this indicates that the group tends to place lower rank positions and thus lesser interests for Red Turquoise than tropical fish keepers in general. No other significant differences were observed for pattern (Appendix H1; J3)

On the other hand, preferences for discus shape were most varied between groups, with the most apparent differences observed in orders by discus keepers, while similarities were evident between other tropical fish keepers and other keepers and non-keepers (Figure 3.10). Similar to the CS summary, overall trends in orders from relatively smooth-edged and rounder shapes to sharper and irregular shapes were generally evident in groups, with strong interests to the high finned and round-bodied Blue Snakeskin as well. However, discus keepers again expressed an overall clearer preference structure for shape, with relatively more distinctive orders of median ranks, along with stronger preferences evident from shorter interquartile ranges, whiskers and more outliers than other groups. This suggests that greater discus knowledge among enthusiasts may have an added advantage in identifying specific features for shape, thus leading to potentially more identifiable orders of preferences and lesser difficulties in deciding between sorts than other groups.

Figure 3.10 Boxplot of rank scores for images based on shape and fishkeeping



Outliers are marked with a circle for 'out' values, and a star for extreme values. This was observed among discus keepers for Blue Snakeskin and Heckel, and among other tropical fish keepers for Blue Snakeskin.

Opposing preferences were most apparent in responses for the high-bodied Blue Diamond, in which discus keepers expressed substantially greater interests for the shape by placing the image second among the set. This differs greatly with other groups with placements at the lower half of the set, and especially for other keepers and non-keepers that revealed the lowest median at rank 9. However, consistent preferences for strong disinterests were only evident among other keepers and non-keepers, as large interquartile ranges that spanned across most of the card set, at 8-9 ranks, were reflected for both discus keepers and other tropical fish keepers, which suggest indications of extreme heterogeneity and individual variation in preferences for Blue Diamond by different tropical fish keepers. Groups also displayed opposing differences in their most undesired traits, with discus keepers expressing

stronger disinterests towards the long-bodied Golden and spade-shaped Heckel, whereas respondents who have no experience with discus preferred less of the 'oblong' Yellow Ghost and unevenly shaped Super Marlboro Red instead.

These variations were reflected with significant differences observed in GLMs for Yellow Ghost (F (2,424) = 6.513, $p < 0.05$, $\eta_p^2 = 0.030$), Golden (F (2,424) = 14.598, $p < 0.001$, $\eta_p^2 = 0.064$) and Red Spotted Green (F (2,424) = 4.529, $p < 0.05$, $\eta_p^2 = 0.021$; Appendix I1). The LSD post-hoc revealed highly significant variations in comparisons related to discus keepers for all three images (Appendix I2). The parameter estimates revealed a greater likelihood for respondents who have not kept discus to place significantly higher rank scores or lower rank positions for Yellow Ghost, and significantly lower rank scores or higher positions for Golden than discus keepers (Table 3.17). This suggests a greater interest for the unusual Yellow Ghost among discus keepers, and particular attractions to the long-bodied shapes of Golden by individuals outside of the discus community. The model also saw other keepers and non-keepers with a greater likelihood for lower rank scores and greater preferences for high-finned but long-bodied Red Spotted Green than discus keepers, suggesting an overall disinterest for long-bodied shapes among the latter.

Table 3.17 Parameter estimates for significant models between groups on fishkeeping, based on shape

Image	Source	B-Effect	Std. Err.	*t*	*P*	Partial η^2
2 – Yellow Ghost	Intercept	5.830***	0.185	31.460	< 0.001	0.700
	Other / Don't Keep	0.864***	0.320	2.701	0.007	0.017
	Other Tropical Fish	0.933***	0.289	3.225	0.001	0.024
	Discus	0				
3 - Golden	Intercept	6.108***	0.193	31.707	< 0.001	0.703
	Other / Don't Keep	-1.649***	0.333	-4.959	< 0.001	0.055
	Other Tropical Fish	-1.153***	0.301	-3.833	< 0.001	0.033
	Discus	0				
6 – Red Spotted Green	Intercept	4.639***	0.179	14.836	< 0.001	0.612
	Other / Don't Keep	-0.894***	0.310	-2.888	0.004	0.019
	Other Tropical Fish	-0.521	0.280	-1.859	0.064	0.008
	Discus	0				

*Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

As four models did not meet assumptions on normality, a Kruskal-Wallis Test was performed, which saw significant differences for all four images involving Heckel (X^2 = (2, N = 427) = 66.652, $p < 0.001$), Blue Snakeskin (X^2 = (2, N = 427) = 11.287, $p < 0.005$), Blue Diamond (X^2 = (2, N = 427) = 57.196, $p < 0.001$) and Super Marlboro Red (X^2 = (2, N = 427) = 7.151, $p < 0.05$; Appendix J5). The Mann-Whitney U post-hoc revealed significant differences in all comparisons related to discus keepers for Heckel and Blue Snakeskin (Appendix J6). As discus keepers expressed higher median rank scores for the former image and lower for the latter, the group was found to have shown stronger interests with a likely higher rank position for high-finned and round-bodied shapes, as opposed to individuals who have not kept discus, which expressed greater preferences for the more angular and spade shaped

Heckel. On the other hand, significant differences for Blue Diamond were expressed for all paired comparisons between groups (Appendix J6). Reflective of observations from the boxplots, median rank scores by discus keepers were lower at higher positions of the CS than tropical fish keepers at intermediate positions, and opposed to other keepers and non-keepers at much lower positions of the CS. Such results suggest that tropical fish keepers tend to show greater interests for the shape of the Blue Diamond than others, with particularly stronger preferences by discus keepers. Lastly, in terms of the irregularly shaped Super Marlboro Red, the test only saw significant differences between discus keepers and other fish keepers and non-keepers, with a higher median score and lower rank position among the former ($p < 0.001$; Appendix J6). With lesser specific requirements for shape, these results suggest that individuals outside of the tropical fish keeping community carry potential to be influenced by an overall personal preference to the fish itself, and thus may be more able to tolerate the unevenness expressed in the shape for Super Marlboro Red than most discus keepers with more particular preferences for the attribute. No significant differences were observed for other images (Appendix I1; J6)

With all things considered, Spearman's rank correlations found strong positive associations in rank orders between all groups for colour and pattern (Table 3.18). This suggests that preferences were generally similar regardless of the specific variations, and overall preferences for the attributes were expressed with minimal impacts from fishkeeping background, Nevertheless, lesser significant associations were determined between discus keepers and non-keepers for colour ($N = 10$, $p < 0.05$, two-tailed), indicating slight preferential differences which may be related to or sourced from extreme differences in levels of knowledge or experience in discus. In contrast, no significant associations were seen between groups for shape, except between other tropical fish keepers and non-keepers ($r_s = 0.867$, $N = 10$, $p < 0.005$, two-tailed). Such results suggest that preferences for shape were most varied, with distinct differences between discus keepers and others, but similarities may exist for individuals outside of the discus community.

However, as responses from both discus keepers and the group of other keepers and non-keepers expressed positive associations with all characteristics, this suggests that preferences for other discus features may have incurred some level of influence or consideration in their sorts. Non-keepers were found to be the most easily influenced, as rank orders carried strong significant similarities between colour and pattern ($r_s = 0.782$, $N = 10$, $p < 0.01$, two-tailed) and pattern and shape ($r_s = 0.952$, $N = 10$, $p < 0.01$, two-tailed), suggesting an expression of overall preferences for discus in general. In contrast, discus keepers expressed less significant associations between colour and pattern ($r_s = 0.758$, $N = 10$, $p < 0.05$, two-tailed), revealing relatively more distinct interests for the two attributes than other keepers and non-keepers. Overall, both groups were also observed to have the greatest difficulties in ranking for shape independently. However, as orders by discus keepers seemed to be more influenced by colour, as opposed to greater influences from

pattern by other keepers and non-keepers, this reveals a general greater importance of the respective attributes in their decision-making.

Table 3.18 Spearman's rank correlation coefficients of associations between and within groups on fishkeeping

	Association	*N*	r_s	*P*
Between groups	c_Discus * c_Tropical	10	0.794***	0.006
	c_Discus * c_Other/Don't	10	0.697**	0.025
	c_Tropical * c_Other/Don't	10	0.903***	< 0.001
	p_Discus * p_Tropical	10	0.879***	0.001
	p_Discus * p_Other/Don't	10	0.782***	0.008
	p_Tropical * p_Other/Don't	10	0.903***	< 0.001
	s_Discus * s_Tropical	10	0.600	0.067
	s_Discus * s_Other/Don't	10	0.261	0.467
	s_Tropical * s_Other/Don't	10	0.867***	0.001
Within groups	c_Discus * p_Discus	10	0.758**	0.011
	c_Discus * s_Discus	10	0.857***	0.001
	p_Discus * s_Discus	10	0.745**	0.013
	c_Tropical * p_Tropical	10	0.588	0.074
	c_Tropical * s_Tropical	10	0.636**	0.048
	p_Tropical * s_Tropical	10	0.830***	0.003
	c_Other/Don't * p_Other/Don't	10	0.782***	0.008
	c_Other/Don't * s_Other/Don't	10	0.709**	0.022
	p_Other/Don't * s_Other/Don't	10	0.952***	0.952

*Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

In comparison, other tropical fish keepers expressed the most distinct preferences with no significant association between responses for colour and pattern ($p < 0.10$), revealing greater abilities to focus orders and the reflection of particular interests for the aforementioned attributes, Nevertheless, influences in orders for shape were also observed, indicating that the attribute was difficult to order among individuals across groups. In this case, other tropical fish keepers were more similar to non-keepers, with greater influences from preferences for pattern than colour.

3.2.5 MARKET HETEROGENEITY

The analysis for market heterogeneity was aimed towards examining potential variations within the broad market regions, with a focus in comparisons between geographical sub-regions, and resident countries or local markets at a more refined level. Due to consistencies in results, general summaries for differences between overall markets and sub-regions were included, with more detailed syntheses between resident countries.

Of 430 respondents that took part in the card sort, 201 resided in the European market region and 188 in the Far East Asian market region. Analyses on sub-regions were focused towards North Europe, of which there were 176 residents, South East Asia with 132, and East Asia with 56. Overall, 176 resided in the UK, 95 in Singapore, 19 in Malaysia and 43 in Hong Kong, along with an additional 95 from a mix of other countries. Two respondents with missing demographic information were excluded in the analyses.

General market overview

As a whole, results between general market regions revealed an overall similarity of preferences and a general favouring for discus, with strong significant positive associations observed for all three characteristics between regions (see detailed results in Appendix K). In terms of colour, both European and Far East Asian markets seem to share a preference for brighter colorations, especially Blue Snakeskin, and away from darker brown colorations such as Heckel and Wild Blue. However European respondents appeared to show significantly greater preferences for red varieties, particularly the greener Red Turquoise, whereas Far East Asian respondents differed with relatively stronger interests towards gold varieties such as the Yellow Ghost and Golden instead. Both markets expressed a similar view towards patternation, generally favouring varieties with complete coverage of patterns, and lesser of sparsely patterned and plain varieties. Yet significant differences were observed with European respondents expressing more positive interest towards Red Turquoise with thick striations, and Far East respondents on the plain but sharp, unusually contrasted and multi-coloured Yellow Ghost instead.

Thoughts on both images in terms of shape were also significantly different between markets. General interests towards rounder and high finned discus such as the Blue Snakeskin, and against unevenly shaped discus such as the Super Marlboro Red were observed. However, the analyses revealed that the European market has more room for the high-finned Red Turquoise, despite being slightly beaky with a sharper snout, and significantly more likely to rank a relatively higher position for Wild Blue as well, despite its undefined round shape. On the other hand, the Far East Asian market exhibited more interest towards the high-finned Yellow Ghost, despite an uneven shape with a shorter snout and a rounder frontal or head region. This suggests a general interest for the more traditional wild types and forms in the European market and for unusual cultivated varieties and features in the Far East Asian market, leading to greater tolerances for 'imperfections'. Greater interests for the high-finned and high-bodied Blue Diamond were also expressed in the latter market, suggesting an attraction to high-bodied shapes. Nevertheless, strong heterogeneous preferences for images, and most notably for Blue Diamond, were evident in both markets, suggesting the need for further analyses within market regions.

Sub-Region

Variations between geographical sub-regions were most significant between North Europe and East Asia, which exhibited preferences and significant differences that were similar and very much correlated to previous observations of general market regions (see detailed results in Appendix L). However, South East Asia seemed to carry preferences that were evident and distinctive to both North Europe and East Asia. Interests for colour seem to be shared with North Europe, with both markets expressing relatively greater interest towards the orange-red Pigeon Blood, and lesser to golden colorations that were more preferred among East Asia. Both market views also overlapped in terms of less desirable colour traits,

having expressed lesser interests towards pale colorations seen in Yellow Ghost, with a 'bleached white', yellow and blue contrast across the body and fins, and Heckel with a patchier and faded brown coloration across the body. In terms of pattern, although North Europe still carries the strongest preference for Red Turquoise, both markets expressed significantly higher interests for the variety, along with similar interests for discus with patterning relative to East Asia.

Overall, East Asia seems to display the most varied and heterogeneous preferences, with a larger group of images expressed at similar median ranks for colour, and carrying strong interests for plain discus as well. In terms of shape, great interests were also expressed towards Golden, a long-bodied discus. In this case, South East Asia expressed elements of similarity with East Asia, expressing similar rank orders for shape in terms of less desirable characteristics, and significantly more interest to the unusually shaped Yellow Ghost than North Europe. Consistent with previous observations, preferences for the high-bodied Blue Diamond were still largely heterogeneous within all three markets, though South East Asia was found with significantly higher interests than others. Hence, it can be said that individuals from the sub-region may potentially define more of the positive interest expressed for high-bodied shapes in the Far East Asian market.

As results on geographical sub-regions were largely similar and less varied than resident countries, greater emphasis was placed on analysing the latter to evaluate preferences at the source for market variations. Thus, the analyses focused on results obtained from the UK, Singapore, Malaysia and Hong Kong, allowing the potential for further explanations and understanding of the observed differences in overall markets at a more refined level.

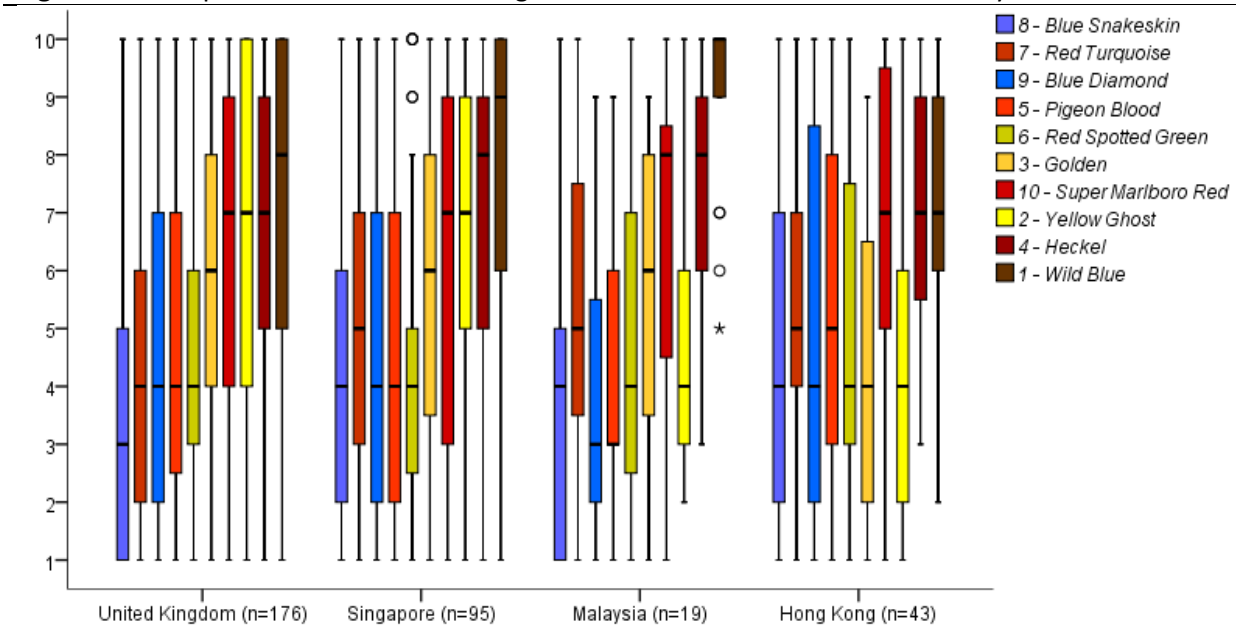
Resident Country

In terms of colour, the boxplot revealed the greatest similarities in responses from the UK and Singapore (Figure 3.11). Overall, all groups were consistent in trends towards brighter colorations and away from darker brown alternatives. Particularly strong were UK interests for the metallic Blue Snakeskin, which differed to Far East Asian countries with broader and shared interests to other bright colorations. Nevertheless, consistent orders for both higher ranked images and less desirable colorations at the lower set were displayed for the UK and Singapore, revealing relatively parallel preferences for discus colour between the two markets. However, slight individual differences were evident with the UK placing a significantly higher rank for the traditionally coloured and slightly darker Red Turquoise, as observed of the European market, in relation to Singapore at only mid-rank positions. The UK also expressed the strongest disinterest for Yellow Ghost with interquartile ranges to rank 10.

In contrast, Malaysia expressed the greatest dissimilarities to the UK, with top ranks for Blue Diamond and Pigeon Blood instead. Malaysia also expressed the strongest and most distinct preferences for lesser desired brown colorations across markets, particularly Wild Blue with

a solid low rank position indicated by a median rank of 10, short interquartile ranges from ranks 9-10 and multiple outliers. In addition, opposing views with UK and Singapore towards Yellow Ghost were evident at high rank positions of the set, suggesting a greater and more positive interest to its colorations.

Figure 3.11 Boxplot of rank scores for images based on colour and resident country



Outliers are marked with a circle for 'out' values, and a star for extreme values. This was observed among responses from Singapore for Red Spotted Green and Malaysia for Wild Blue.

Compared to other markets, Hong Kong expressed the widest preferences for discus colorations with high rank positions given to most images of the set, suggesting greater difficulties in eliciting orders between images. But unlike others, Hong Kong gave top ranks to the lesser regarded Yellow Ghost and Golden, which indicates the strongest attractions to gold colorations across markets. Nevertheless, a visible categorization of images between the desirable and less desirable was observed, with particular disinterests evident for brown and darker coloured images. Thus, it can be said that the Hong Kong respondents expressed similar levels of preference for multiple colorations, but were more decisive in identifying and ranking away from discus with less desirable traits.

These variations were evident with significant differences observed in GLMs for Yellow Ghost (F (3,329) = 11.467, $p < 0.001$, $\eta_p^2 = 0.095$), Golden (F (3,329) = 4.004, $p < 0.01$, $\eta_p^2 = 0.035$) and Red Turquoise (F (4,597) = 3.110, $p < 0.05$, $\eta_p^2 = 0.028$; Appendix G3). Results from the LSD post-hoc revealed that variations were most apparent in comparisons related to the UK as well as Singapore for Yellow Ghost, Hong Kong for Golden, and the UK for Red Turquoise as well (Appendix G4). The model estimates reflected the same observations in the boxplots, with significantly lower rank scores and thus greater interests for the gold and blue Yellow Ghost in Hong Kong and Malaysia, as opposed to similar disinterests and no significant differences between the UK and Singapore (Table 3.19). Hong Kong also expressed the greatest interests for golden colorations with relatively lower rank scores for

Golden than the UK and Singapore, revealing opposing preferences and stronger disinterests among the latter. However, the distinct European interest for Red Turquoise was observed with UK responses expressing a greater likelihood for lower rank scores and higher rank positions than Singapore, and opposing preferences with much higher rank scores from Hong Kong.

Table 3.19 Parameter estimates for significant models between resident countries, based on colour

Image	Source	B-Effect	Std. Err.	*t*	*P*	Partial η^2
2 – Yellow Ghost	Intercept	6.778***	0.204	33.154	< 0.001	0.770
	Singapore	-0.147	0.345	-0.425	0.671	0.001
	Malaysia	-2.042***	0.655	-3.117	0.002	0.029
	Hong Kong	-2.383***	0.461	-5.165	< 0.001	0.075
	United Kingdom	0				
	Intercept	6.632***	0.278	23.830	< 0.001	0.633
	United Kingdom	0.147	0.345	0.425	0.671	0.001
	Malaysia	-1.895***	0.499	-2.780	0.006	0.023
	Hong Kong	-2.236***	0.682	-4.486	< 0.001	0.058
	Singapore	0				
3 - Golden	Intercept	4.465***	0.404	11.043	< 0.001	0.270
	United Kingdom	1.546***	0.451	3.428	0.001	0.034
	Singapore	1.093**	0.487	2.242	0.026	0.015
	Malaysia	1.061	0.730	1.453	0.147	0.006
	Hong Kong	0				
7 – Red Turquoise	Intercept	4.330***	0.186	23.307	< 0.001	0.623
	Singapore	0.702**	0.314	2.238	0.026	0.015
	Malaysia	0.828	0.595	1.392	0.165	0.006
	Hong Kong	1.019**	0.419	2.431	0.016	0.018
	United Kingdom	0				

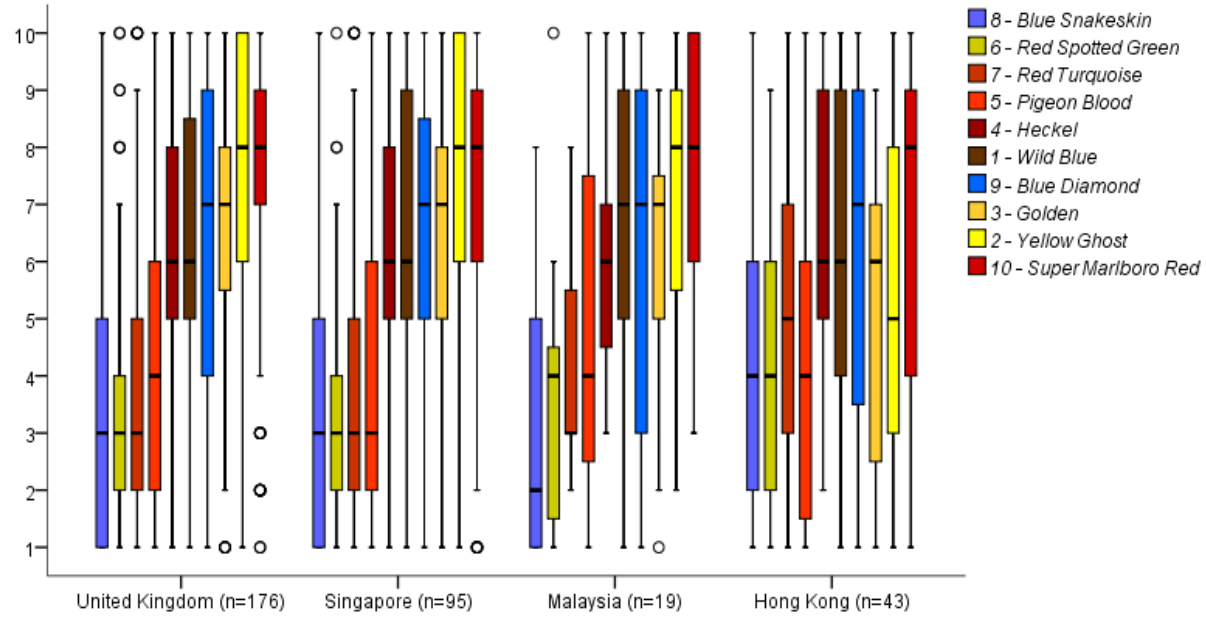
*Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

For models that did not meet assumptions on normality, a Kruskal-Wallis test was conducted and significant differences were determined in median ranks for Wild Blue (X^2 = (3, N = 333) = 9.836, p < 0.05; Appendix J7). The Mann-Whitney U post-hoc revealed that variations were most evident in relation to Malaysia (p < 0.005; Appendix J8). The results saw Malaysia with the largest median rank across markets, thus revealing the least interest in Wild Blue for colour. In contrast, Hong Kong expressed the lowest median rank, which indicates a relatively greater interest followed by UK and Singapore. This suggests that the Hong Kong market may have some room for wild varieties or colorations, though brighter colorations are still much preferred than the former. No significant differences in mean or median rank scores were observed for other images (Appendix G3; Appendix J7).

Boxplot results on pattern also revealed strong similarities in rankings between the UK and Singapore (Figure 3.12). Overall, rank orders for the entire set were very much parallel between the two markets, with the highest ranks on discus with striations and multiple patterns, particularly the densely striated Blue Snakeskin. Although Singapore revealed slightly more interests for the mosaic-patterned Pigeon Blood than the UK, the general

trend remained analogous for the two markets, with a decreasing preference from sparsely-striated to plain discus.

Figure 3.12 Boxplot of rank scores for images based on pattern and resident country



Outliers are marked with a circle for 'out' values, and a star for extreme values. This was observed among respondents from the UK for Red Spotted Green, Red Turquoise, Golden and Super Marlboro Red; Singapore for Red Spotted Green, Red Turquoise and Super Marlboro Red; and Malaysia for Red Spotted Green and Golden.

Malaysia also expressed similar pattern preferences to the UK and Singapore, with top ranks for Blue Snakeskin and a general decreasing order from sparsely striated to plain discus. However, greater interest to particular varieties were seen with higher ranks for the thickly striated Red Turquoise, and particularly the plain Blue Diamond and Golden with relatively higher positions than the sparsely striated Wild Blue. As other plain varieties were at much lower ranks than the aforementioned, this also suggests a potential for influences from colour preferences in rank orders. Yet, greater individual variation in preferences for Blue Diamond and Pigeon Blood were observed with larger interquartile ranges than other markets.

Nevertheless, preferential differences and heterogeneity between respondents were most evident within the Hong Kong market, with all images displaying large interquartile ranges across a minimum of five ranks in the set. Although a similar trend exists, rank orders were overall the most dissimilar to other markets with top ranks for the mosaic-patterned Pigeon Blood instead, and higher rank positions for the unusual Yellow Ghost and Golden over sparsely patterned discus as well. In addition, all median ranks of images were more concentrated in intermediate positions and less distributed across the set, revealing broader interests for pattern in the market.

Significant differences were observed in GLMs for Yellow Ghost (F (3,329) =7.418, $p < 0.001$, $\eta_p^2 = 0.063$) and Red Turquoise (F (3,329) = 4.945, $p < 0.005$, $\eta_p^2 = 0.043$; Appendix H3). The LSD post-hoc indicated variations in comparisons related to Hong Kong for both images

(Appendix H4). The model predicted that Hong Kong respondents were more likely to place significantly lower rank scores and express greater interests for Yellow Ghost than Malaysia, Singapore and especially in opposition to the UK, while significantly higher rank scores and lesser interests may be seen for Red Turquoise relative to Singapore and particularly the UK (Table 3.20). These results support the inferences made from boxplot observations between markets.

Table 3.20 Parameter estimates for significant models between resident countries, based on pattern

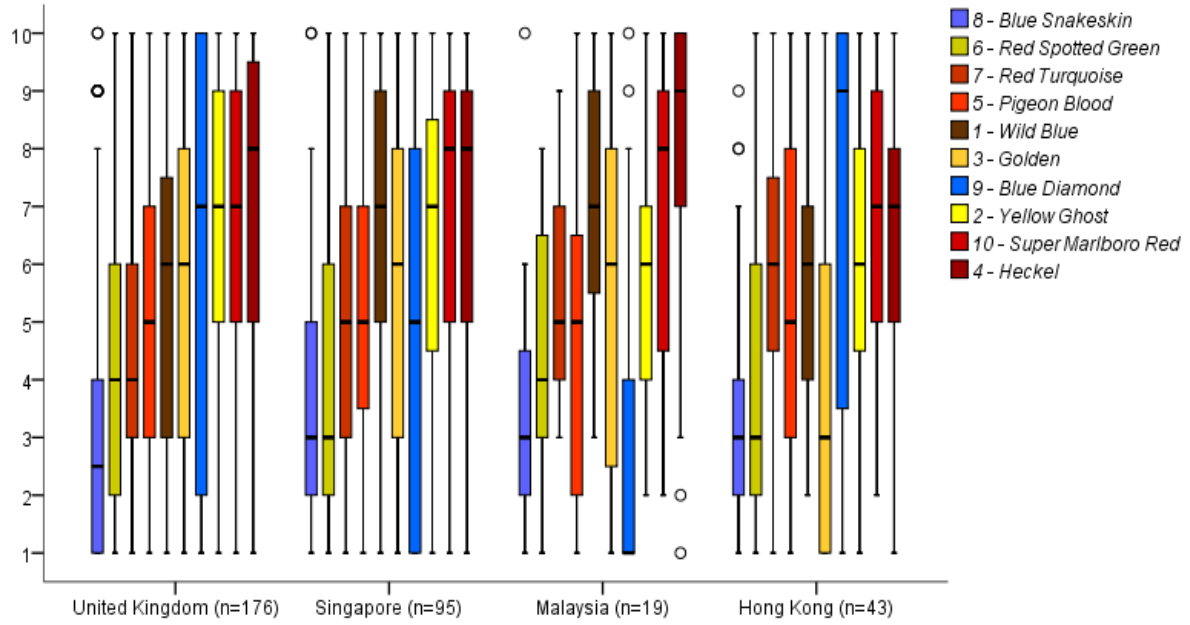
Image	Source	B-Effect	Std. Err.	*t*	*p*	Partial η^2
2 – Yellow Ghost	Intercept	5.605***	0.394	14.213	< 0.001	0.380
	United Kingdom	2.054***	0.440	4.670	< 0.001	0.062
	Singapore	1.816***	0.475	3.822	< 0.001	0.043
	Malaysia	1.448**	0.712	2.033	0.043	0.012
	Hong Kong	0				
7– Red Turquoise	Intercept	5.093***	0.364	13.982	< 0.001	0.373
	United Kingdom	-1.553***	0.406	-3.823	< 0.001	0.043
	Singapore	-1.146***	0.439	-2.610	0.009	0.020
	Malaysia	-1.040	0.658	-1.581	0.115	0.008
	Hong Kong	0				

*Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

As three models did not meet assumptions on normality, a Kruskal-Wallis Test was conducted and significant differences were observed for Golden (X^2 = (3, N = 333) = 13.123, p < 0.005; Appendix J9). The Mann-Whitney U post-hoc revealed variations related to Hong Kong for all comparisons except Malaysia (Appendix J10). As Hong Kong displayed a smaller median rank, it can be send that respondents tend to place higher rank scores and express greater interests for Golden than the UK and Singapore. No significant differences were observed for Blue Diamond (X^2 = (3, N = 333) = 0.566, p < 0.95) and Super Marlboro Red (X^2 = (3, N = 333) = 1.457, p < 0.70). No significant differences were observed on other images (Appendix H3; Appendix J9).

Boxplot results for shape revealed the greatest variations in rank orders, though particular similarities were observed between the UK and Singapore as well (Figure 3.13). Consistent to overall trends on discus shape, both markets displayed a greater interest for high fins and discus with an overall smooth and round exterior, especially the Blue Snakeskin, while lesser interests were on spade and unevenly shaped discus, with the lowest for the angular, uneven, spade-shaped and sharp snouted Heckel. However, UK respondents expressed greater interests for Wild Blue, with higher rank positions than other markets, despite its bumpy exterior and undefined round shape. Singapore also expressed a greater interest for Blue Diamond with higher rank positions than other markets, though with large interquartile ranges across 8-9 ranks for both UK and Singapore, high levels of heterogeneity and individual variation within markets were reflected in preferences for the high-bodied shape.

Figure 3.13 Boxplot of rank scores for images based on shape and resident country



Outliers are marked with a circle for 'out' values, and a star for extreme values. This was observed among respondents from the UK for Blue Snakeskin; Singapore for Blue Snakeskin; Malaysia for Blue Snakeskin, Blue Diamond and Heckel; and Hong Kong for Blue Snakeskin.

Conversely, Malaysian respondents were observed with the greatest interests and top ranks for the high-bodied and oval-shaped Blue Diamond instead. Yet, rankings in the lower set were found to be consistent with Singapore, expressing South East Asian similarities with lower median ranks and stronger disinterests for the undefined Wild Blue and irregular shapes of Super Marlboro Red and Heckel than other markets. Therefore, the greatest preferential differences lay among the Hong Kong market, with the top rank given to the high-finned Golden instead, despite a longer body, and lesser interests for Red Turquoise relative to other markets. An opposite preference to Malaysia was also seen with placements of Blue Diamond at the lowest rank position. Nevertheless, preferences for both Golden and Blue Diamond, the highest and lowest ranked of images, displayed large interquartile ranges and thus greater potential for heterogeneity within the Malaysian market, revealing possibilities of substantial differences in rank orders with Hong Kong respondents.

These preferences were reflected in the GLM results, where significant differences were observed for Golden (F (3,329) = 3.942, $p < 0.01$, $\eta_p^2 = 0.035$), Red Turquoise (F (3,329) = 3.895, $p < 0.01$, $\eta_p^2 = 0.034$) and Blue Diamond (F (3,329) = 7.373, $p < 0.001$, $\eta_p^2 = 0.063$; Appendix I3). Post-hoc results revealed variations in comparisons related to Hong Kong for Golden, both Hong Kong as well as Malaysia for Blue Diamond and only between the UK and Hong Kong for Red Turquoise ($p < 0.005$; Appendix I4). The parameter estimates indicated a greater likelihood for Hong Kong respondents to rank significantly lower scores and thus express greater interests for the long-bodied Golden than the UK, Singapore and particularly Malaysia with the highest rank scores (Table 3.21). This suggests a general interest for the variety, and potential influences of rank orders from strong preferences for golden

colorations (Figure 3.11). On the other hand, Malaysia expressed the strongest interests for high-bodied Blue Diamond by expressing a greater likelihood in placing significantly lower rank scores than Singapore, followed by the UK and most substantially with likely opposing preferences to Hong Kong. As no significant differences were found for the UK relative to Hong Kong, similar levels of undesirability with the Blue Diamond was suggested between the two markets. Additionally, the model predicts that UK residents were more likely to respond with significantly lower rank scores for Red Turquoise than Hong Kong, revealing strong influences from general interests in the variety due to consistent results with high rank positions for colour and pattern as well.

Table 3.21 Parameter estimates for significant models between resident countries, based on shape

Image	Source	B-Effect	Std. Err.	*t*	*p*	Partial η^2
3 - Golden	Intercept	3.884***	0.423	9.184	< 0.001	0.204
	United Kingdom	1.497***	0.472	3.173	0.002	0.030
	Singapore	1.527***	0.510	2.996	0.003	0.027
	Malaysia	1.906**	0.764	2.495	0.013	0.019
	Hong Kong	0				
7 – Red Turquoise	Intercept	5.907***	0.368	16.061	< 0.001	0.439
	United Kingdom	-1.293***	0.410	-3.152	0.002	0.029
	Singapore	-0.844	0.443	-1.904	0.058	0.011
	Malaysia	-0.328	0.664	-0.494	0.622	0.001
	Hong Kong	0				
9 – Blue Diamond	Intercept	7.093***	0.536	13.239	< 0.001	0.348
	United Kingdom	-1.013	0.598	-1.696	0.091	0.009
	Singapore	-2.019***	0.646	-3.127	0.002	0.029
	Malaysia	-3.988***	0.968	-4.120	< 0.001	0.049
	Hong Kong	0				
	Intercept	3.105***	0.806	3.853	< 0.001	0.043
	United Kingdom	2.974***	0.848	3.506	0.001	0.036
	Singapore	1.968**	0.883	2.229	0.026	0.015
	Hong Kong	3.988***	0.968	4.120	< 0.001	0.049
	Malaysia	0				

*Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

As two models expressed violations in homoscedasticity, a Kruskal-Wallis test was performed and significant differences were observed for Wild Blue (X^2 = (3, N = 333) = 18.779, p < 0.001; Appendix J11). In this case, the Mann-Whitney U post-hoc test revealed significant variations between UK and Singapore (p < 0.001), UK and Malaysia (p < 0.05), and Singapore and Hong Kong (p < 0.01; Appendix J12). As both Singapore and Malaysia expressed the same median rank score of 7, which was higher than the UK and Hong Kong with the same score of 6, this indicates that the former markets expressed relatively lesser interests in Wild Blue than the latter. As both the UK and Hong Kong expressed relatively higher interests in the image for colour as well, it can be said that there is potentially some general interest in wild varieties for both markets that could influence rank orders. Nevertheless, the intermediate rank scores suggest that preferences are not strong among

respondents, and in the case of shape, such varieties may only be considered when more favoured options are unavailable. No significant differences were observed for other images (Appendix I3; J11).

Overall, results from Spearman's rank correlations were consistent with previous observations, with strong positive associations observed in Spearman's rank correlations between all groups for pattern (Table 3.22). This reflects a significant overall preference for the attribute among the sampled population, with no strong differences across market regions. Particularly evident were rank orders between UK and Singapore, with strong associations for all three characteristics ($p < 0.005$), highlighting that preferences for discus were indeed generally similar between the two markets. Responses from Malaysia also found similarities with the UK, Singapore as well as Hong Kong in discus preferences, though having less significant colour and shape associations with the UK ($r_s = 0.758$, $N = 10$, $p < 0.05$, two-tailed) and no significant shape associations with Hong Kong ($r_s = 0.273$, $N = 10$, $p < 0.50$, two-tailed) suggest the presence of slight differences and more distinct preferences in the respective attributes between markets. Thus, where strong associations for all three characteristics were evident with Singapore ($p < 0.01$), this indicates that similarities exist within the South East Asian market, and that the Singapore market incurs a mix of discus preferences with similarities to both European and Far East Asian markets.

In comparison, the greatest variations and most distinct preferences were observed for Hong Kong, where there were no significant associations with UK for colour ($r_s = 0.455$, $N = 10$, $p < 0.20$, two-tailed), with Singapore for colour ($r_s = 0.491$, $N = 10$, $p < 0.20$, two-tailed) and shape ($r_s = 0.462$, $N = 10$, $p < 0.20$, two-tailed), and as mentioned with Malaysia for shape. This reveals that views by the Hong Kong market on discus colour were most different to UK and Singapore, and that there is potentially a divide on preferences for discus shape within the Far Eastern market, with Hong Kong expressing more particular and distinctive choices than what is seen in the South East Asian markets.

Results within groups give rise to such inferences with no associations seen in rank orders by Hong Kong respondents, suggesting the presence of more specific interests and standards for all three characteristics, and strong abilities to focus and sort for the given attributes independently. UK respondents also expressed distinct orders and preferences with no associations in most rankings apart from a less significant association between colour and shape ($r_s = 0.733$, $N = 10$, $p < 0.05$, two-tailed). As previous results revealed that discus shape was frequently more difficult to sort than other features among respondents, it is suggested that UK respondents may have incurred slight difficulties as well, and potentially influenced their rank orders by colour interests that were of greater importance in the decision-making. This was also observed for Singapore and particularly Malaysia, yet responses seemed to be more heavily influenced with slight associations by both colour and pattern among the former ($p < 0.05$), and stronger associations by both among the latter ($p < 0.01$). Additionally, associations in rankings between colour and pattern were evident in the two markets,

revealing an overall combined preference with considerations to both attributes in rankings. However, a less significant association for Malaysia suggests that residents were less influenced and that preferences are slightly different for the two attributes.

Table 3.22 Spearman's rank correlation coefficients of associations between and within resident countries

Association		*N*	r_s	*p*
Between groups	c_UK * c_SIN	10	0.891***	0.001
	c_UK * c_MAL	10	0.758**	0.011
	c_UK * c_HK	10	0.455	0.187
	c_SIN * c_MAL	10	0.806***	0.005
	c_SIN * c_HK	10	0.491	0.150
	c_MAL * c_HK	10	0.867***	0.001
	p_UK * p_SIN	10	0.936***	< 0.001
	p_UK * p_MAL	10	0.879***	0.001
	p_UK * p_HK	10	0.709**	0.022
	p_SIN * p_MAL	10	0.936***	< 0.001
	p_SIN * p_HK	10	0.778***	0.008
	p_MAL * p_HK	10	0.867***	0.001
	s_UK * s_SIN	10	0.815***	0.004
	s_UK * s_MAL	10	0.673**	0.033
	s_UK * s_HK	10	0.794***	0.006
	s_SIN * s_MAL	10	0.881***	0.001
	s_SIN * s_HK	10	0.462	0.179
	s_MAL * s_HK	10	0.273	0.446
Within groups	c_UK * p_UK	10	0.600	0.067
	c_UK * s_UK	10	0.733**	0.016
	p_UK * s_UK	10	0.467	0.174
	c_SIN * p_SIN	10	0.818***	0.004
	c_SIN * s_SIN	10	0.697**	0.025
	p_SIN * s_SIN	10	0.762**	0.010
	c_MAL * p_MAL	10	0.748**	0.013
	c_MAL * s_MAL	10	0.930***	< 0.001
	p_MAL * s_MAL	10	0.770***	0.009
	c_HK * p_HK	10	0.370	0.293
	c_HK * s_HK	10	0.539	0.108
	p_HK * s_HK	10	0.879	0.001

*Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

3.2.6 RESPONDENT HETEROGENEITY – CLASS

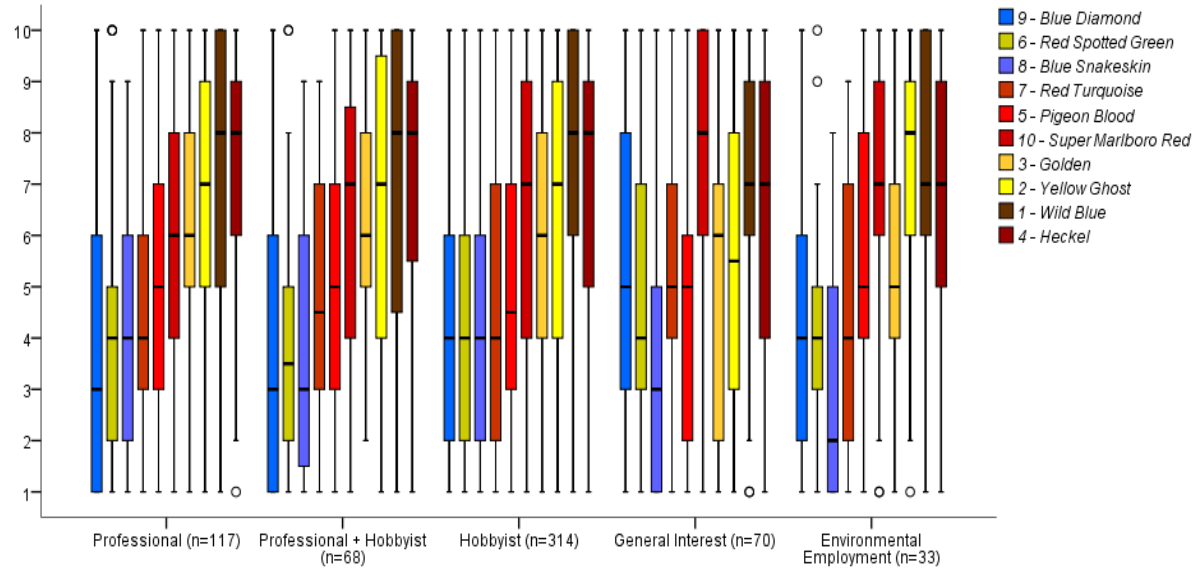
The analysis on respondent heterogeneity is a comparison between professionals and different types of public consumers, which were categorized by respondent class. The CS analysis includes an additional group for individuals who classified themselves as both professionals and hobbyists, to allow an extended understanding on potential differences between the general hobbyist and the referred type of 'specialist hobbyists' with professional background in discus.

Of 430 respondents, a total of 117 professionals and 314 hobbyists, of which 68 were classified as both professionals and hobbyists, and 70 of general interest, with three

selected as both hobbyist and of general interest, took part in the card sort. Professional respondents were comprised of 74 breeders, 35 retailers, 26 wholesale importers of both discus and aquarium related products, 30 exporters and seven competition judges of both discus and other tropical fish, with many applicable to multiple classifications. Across all classes, 33 respondents also had environmentally related employment including, but not limited to, conservation academics, journalists and photographers for aquarist magazines, and authors of discus books or related publications. No missing data was found and all were involved in the analyses on respondent class.

Boxplot results for colour saw expressions of the main colour trend for bright and blue varieties in all classes, and revealed similar preferences between professionals, professional hobbyists and hobbyists in general (Figure 3.14). Top ranks for the metallic Blue Diamond was evident in all three groups, with higher scores and the strongest interests observed among those associated with professionalism in the industry. Yet hobbyists expressed slightly broader interests, with similar rankings and shared preferences for the multi-coloured Red Spotted Green and blue and purple-tinted Blue Snakeskin as well. Nevertheless, rank orders towards the less desired traits were highly consistent between groups, reflecting secondary interests on red varieties, followed by gold and darker brown colorations that lead to the least desired Wild Blue.

Figure 3.14 Boxplot of rank scores for images based on colour and respondent class



Outliers are marked with a circle for 'out' values, and a star for extreme values. This was observed among professionals for Red Spotted Green and Heckel; professional hobbyists for Red Spotted Green; respondents with general interest for Wild Blue; and respondents with environmental employment for Red Spotted Green, Super Marlboro Red and Yellow Ghost.

In contrast, public respondents with general interest and environmental employment expressed varied interests, with greater preferences for Blue Snakeskin instead. Although the environmentally employed still placed high ranks for Blue Diamond, respondents with general interest gave mid-rank positions and reflected the lowest desirability across classes. Instead, the latter group seemed to exhibit greater interests in unusual varieties, placing relatively higher positions than other classes for the orange-red Pearl Pigeon Blood over the

Blue Diamond, and the highly contrasted Yellow Ghost at mid ranks, while the deeply coloured Super Marlboro Red was found less desired than brown colorations. This differed with the environmentally employed as well, which expressed secondary interests on cultivated wild forms that are Red Spotted Green and Red Turquoise, with refined elements of traditional red and green traits, and the lowest desirability for Yellow Ghost instead.

These variations were reflected in the GLM results, with significant differences evident for Yellow Ghost (F (4,425) = 3.148, $p < 0.05$, $\eta_p^2 = 0.014$), Heckel (F (4,425) = 2.623, $p < 0.05$, $\eta_p^2 = 0.034$) and Blue Diamond (F (4,425) = 4.392, $p < 0.005$, $\eta_p^2 = 0.002$; Appendix G5). The LSD post-hoc revealed the greatest variations in comparisons related to respondents with general interest for all three images (Appendix G6). The model estimates predicted that individuals with general interest are more likely to place a significantly lower rank score and express relatively greater interests for Yellow Ghost than all other groups, particularly in relation to individuals with specialist background (Table 3.23). The most significant were the environmentally employed, who may prefer more traditional colorations than the unusual and highly artificially cultivated forms, and professionals who may carry more specific interests and standards in assessing for discus colour and appearance than potentially just an aesthetic preference or acquired interest among general consumers. Individuals with general interest were also found more likely to express greater interests for Heckel with a higher rank position than hobbyists and particularly all associated professionals, revealing potential for an acquired interest in its blend of pink and lighter brown colorations than enthusiasts and specialists. However, the group expressed opposing preferences for Blue Diamond, with significantly lesser interests for the solid blue coloration relative to professionals and hobbyists.

Table 3.23 Parameter estimates for significant models between respondent classes, based on colour

Image	Source	B-Effect	Std. Err.	*t*	*p*	Partial η^2
2 – Yellow Ghost	Intercept	5.400***	0.341	15.837	< 0.001	0.012
	Professional	1.301***	0.431	3.018	0.003	0.015
	Prof. + Hobbyist	1.159**	0.486	2.386	0.017	0.009
	Hobbyist	1.004***	0.377	2.664	0.008	0.012
	Env. Employment	1.782***	0.602	2.958	0.003	0.014
	General Interest	0				
4 – Heckel	Intercept	6.486***	0.285	22.743	< 0.001	0.464
	Professional	0.976**	0.361	2.707	0.042	0.012
	Prof. + Hobbyist	0.955***	0.406	2.352	0.007	0.009
	Hobbyist	0.642**	0.315	2.035	0.019	0.007
	Env. Employment	0.060	0.504	0.119	0.906	< 0.001
	General Interest	0				
9 – Blue Diamond	Intercept	5.343***	0.335	15.937	< 0.001	0.298
	Professional	-1.633***	0.424	-3.854	< 0.001	0.024
	Prof. + Hobbyist	-1.578***	0.478	-3.304	0.001	0.018
	Hobbyist	-1.066***	0.371	-2.875	0.004	0.014
	Env. Employment	-0.737	0.592	-1.244	0.214	0.003
	General Interest	0				

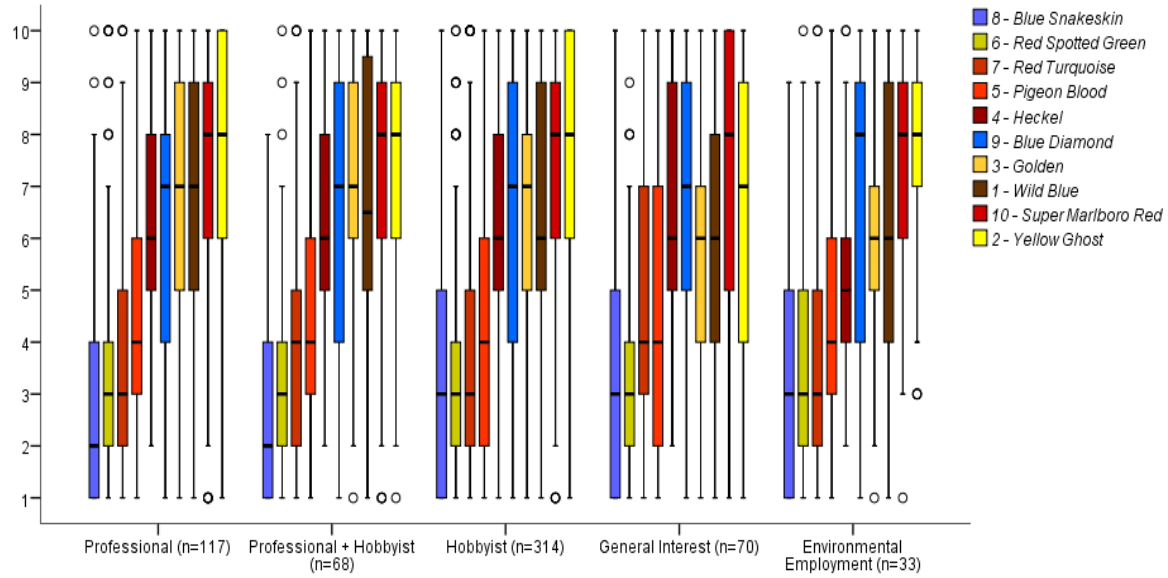
*Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

As two models did not meet assumptions on normality, Kruskal-Wallis and Mann-Whitney U post-hoc tests were performed with significant differences revealed for Golden (X^2 = (4, N = 430) = 11.931, $p < 0.05$; Appendix J13). Variations were evident in paired comparisons related to professionals, with hobbyists ($p < 0.05$) and respondents with general interest ($p < 0.05$), as well as between professional hobbyists and those with general interest ($p < 0.05$); Appendix J14). As both professionals and professional hobbyists exhibited higher median rank scores than the compared groups, it can be said that all related professionals tend to place lower positions and express lesser interests for Golden colours than public consumers who are hobbyists or individuals with general interest for discus, with no significant differences between general and professional hobbyists. No other significant differences in mean and median rank scores were observed for colour (Appendix G5; J13).

With regards to pattern, the boxplot exhibited the most similar and consistent rank orders between groups, expressing an overall preference for striations, particularly the Blue Snakeskin with the strongest interests among related professionals, and full patterning over sparsely striated and plain discus throughout (Figure 3.15). Although associated professionals and hobbyists still expressed the greatest similarities in preference structure, this consistency across all five groups reveals a strong match in discus preferences between traders and consumers. Nevertheless, slight variations were still observed, particularly in the lower half of the set where professionals placed higher rank positions for the plain Blue Diamond and Golden discus over the sparsely striated Wild Blue, potentially as a result of associations to high interests in colour. Yet, respondents with general interest incurred greater variations with lesser interests in traditional thick striations than other classes, as seen by the Red Turquoise, and expressed slightly more interest to the least desired Yellow Ghost with greater disinterests to Super Marlboro Red instead,

This was expressed with significant differences found only in the GLM for Red Turquoise (F (4,597) = 5.273, $p < 0.001$, η_p^2 = 0.034; Appendix H5). The LSD post-hoc revealed that variations were present in all comparisons related to respondents with general interest (Appendix H6). Consistent to the previous observations, the model predicts that individuals of all four classes are more likely to give significantly lower rank scores and express the least interests for Red Turquoise in relation to those with general interest (Table 3.24), In contrast, the greatest interest was observed for hobbyists, indicating the strongest preferences for traditional wild striations, followed by high interests among professionals, the environmentally employed and professional hobbyists as well.

Figure 3.15 Boxplot of rank scores for images based on pattern and respondent class



Outliers are marked with a circle for 'out' values, and a star for extreme values. This was observed among professionals for Blue Diamond, Red Spotted Green, Red Turquoise and Super Marlboro Red; professional hobbyists for Red Spotted Green, Red Turquoise, Golden, Super Marlboro Red and Yellow Ghost; hobbyists for Red Spotted Green and Red Turquoise; respondents with general interest for Red Spotted Green; and respondents with environmental employment for Red Spotted Green, Pigeon Blood, Heckel, Blue Diamond, Super Marlboro Red and Yellow Ghost.

Table 3.24 Parameter estimates for significant models between respondent classes, based on pattern

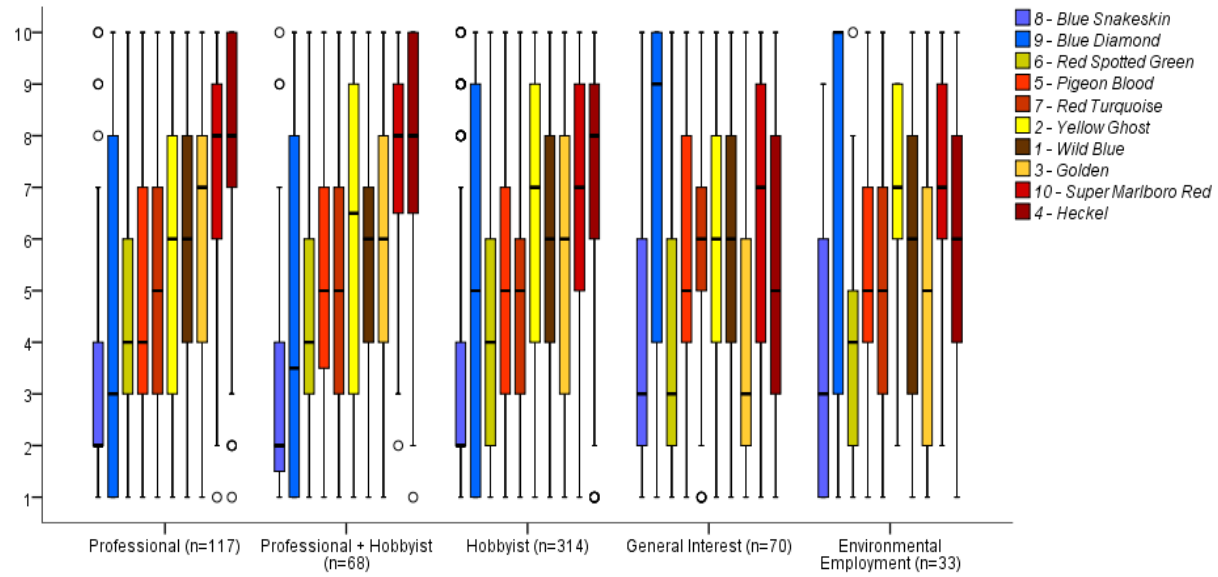
Image	Source	B-Effect	Std. Err.	*t*	*P*	Partial η^2
7 – Red Turquoise	Intercept	5.057***	0.315	17.751	< 0.001	0.345
	Professional	-1.322***	0.360	-3.671	< 0.001	0.022
	Prof. + Hobbyist	-1.160***	0.406	-2.858	0.004	0.014
	Hobbyist	-1.433***	0.285	-4.548	< 0.001	0.033
	Env. Employment	-1.269**	0.503	-2.522	0.012	0.011
	General Interest	0				

*Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

As five models did not meet assumptions on normality, non-parametric analyses were performed, with only significant differences found in median rank scores for Golden (X^2 = (4, N = 430) = 16.263, p < 0.005; Appendix J15). The Mann-Whitney U test indicated that most variations lay in comparisons related to respondents of general interest, with professionals (p < 0.005), professional hobbyists (p < 0.005) and hobbyists (p < 0.005), as well as to respondents with environmental employment, with professionals (p < 0.05) and professional hobbyists (p < 0.05; Appendix J16). As both respondents with general interest and the environmentally employed expressed a smaller median rank than the compared groups, such results suggest that public respondents tend to place higher rank positions for Golden, which could potentially be associated with colour preferences as well. Regardless, the results indicate that the general consumer and environmentally employed may carry greater interests for the image over all related professionals, as well as hobbyists with the former. No significant differences were observed for other images (Appendix H5; J15).

Boxplot results for shape revealed a divide in preferences between two clustered groups of individuals with a background in discus, with strong similarities between all related professionals and hobbyists, and other respondents of the general public with similarities between respondents with general interests and with environmental employment (Figure 3.16). Overall, rank orders across all classes exhibited elements of the main trend for discus shape; towards high-finned and rounder or smoother outlines, particularly the Blue Snakeskin, and away from angular, spade and uneven shapes. This preference structure for roundness was most evident among all associated professionals and hobbyists, with clearer interests displayed by a wide distribution of median ranks across the set, and incurring the strongest disinterest for the spade-shaped and angular Heckel across classes. This group of specialists with background in discus also expressed the strongest interests for Blue Snakeskin, with short interquartile ranges and multiple outliers that indicate the most consistent preferences and least individual variation within groups.

Figure 3.16 Boxplot of rank scores for images based on shape and respondent class



Outliers are marked with a circle for 'out' values, and a star for extreme values. This was observed among professionals for Blue Snakeskin, Super Marlboro Red and Heckel; professional hobbyists for Blue Snakeskin, Super Marlboro Red and Heckel; hobbyists for Blue Snakeskin and Heckel; respondents with general interest for Red Turquoise; and respondents with environmental employment for Red Spotted Green.

In contrast, respondents with general interest, outside of the discus community, revealed broader interests with shared top ranks for the long-bodied Red Spotted Green and Golden. This was similar to orders by environmentally employed respondents with high ranks for the aforementioned images, revealing overall stronger preferences for the high-finned, long-bodied discus in this group. Greater interests for spade shapes were also expressed with higher ranks for Heckel in both groups, particularly for those with only general interest in discus.

Yet, preferential differences across classes of the two clustered groups were evident in the results. Inconsistent to the general trend for relatively rounder shapes, both professional hobbyists and hobbyists in general exhibited opposing interests with higher rank positions

for the spade-shaped and long-bodied Golden than the oblong Yellow Ghost. As respondents outside the discus community expressed the greatest interests for both shapes as well, this suggests that public consumers may potentially carry overall greater interests in such fish shapes, which seems to be less preferred among professionals of the industry. Thus, although all related hobbyists generally seem to carry similar discus preferences to professionals, respondents may exhibit a potential for broader shape preferences with space for interests in spade shapes and long-bodied discus as well.

Nevertheless, the greatest heterogeneity was observed in preferences for the high-bodied Blue Diamond. All associated professionals seem to show the greatest interest and highest rank positions for the shape, whereas hobbyists expressed relatively neutral preferences at mid-rank positions, followed by significant disinterests among general consumers and particularly environmentally employed individuals. As environmentally employed individuals expressed significantly lower interests for the oblong and round-fronted Yellow Ghost as well, it can be said that the group may be the least interested in unusual or more elongated shapes of artificially cultivated varieties. Yet, as all classes displayed substantially large interquartile ranges, particularly hobbyists with the largest across nine ranks, it is made aware that high levels of heterogeneity and individual variation is evident among classes, revealing potential opposing preferences between respondents within groups as well.

These variations were reflected in the GLM results, with significant differences observed for Golden (F (4,597) = 9.141, $p < 0.001$, $\eta_p^2 = 0.058$) and Blue Diamond (F (4,597) = 10.934, $p < 0.001$ $\eta_p^2 = 0.068$; Appendix I5). The LSD post-hoc indicated that variations were evident in comparisons related to professionals as well as professional hobbyists for Golden, and related to professionals, professional hobbyists and hobbyists for Blue Diamond (Appendix I6). The combined models for Golden predicted significantly higher rank scores and the least interests among professionals relative to other classes, followed by slightly more interest among hobbyists, the environmentally employed and the strongest preferences by respondents with general interest (Table 3.25). As no significant differences and similar results were found between professionals and professional hobbyists, similar low interests can be inferred. Thus, this indicates that the discus industry and community, with regards to traders as well as hobbyists with discus keepers and enthusiasts, expressed the least interests in long-bodied and spade-shapes, yet greater attractions were expressed by general consumers outside of the discus community, and the environmentally employed.

In terms of Blue Diamond, the combined models revealed consistent results with previous observations, with a greater likelihood of significantly lower rank scores and greater preferences by professionals relative to hobbyists, followed by significantly lesser interests among the environmentally employed and the greatest undesirability among those with general interest. Similar results and no significant differences between professionals and professional hobbyists also suggest similarly high interests among the latter as well. Thus, with regards to high-bodied discus, a wider distribution of preferences are predicted, with

the strongest interests by traders in the industry, neutral preferences for hobbyists with potential for high heterogeneity and individual variation within the group, and the least interests among the environmentally employed and particularly general public consumers outside of the discus community.

Table 3.25 Parameter estimates for significant models between respondent classes, based on shape

Image	Source	B-Effect	Std. Err.	*t*	*p*	Partial η^2
3 - Golden	Intercept	6.171***	0.247	25.028	< 0.001	0.512
	Prof. + Hobbyist	-0.009	0.407	-0.023	0.982	< 0.001
	Hobbyist	-0.645**	0.289	-2.234	0.026	0.008
	General Interest	-2.157***	0.403	-5.352	< 0.001	0.046
	Env. Employment	-1.504***	0.526	-2.862	0.004	0.014
	Professional	0				
	Intercept	6.162***	0.323	19.052	< 0.001	0.378
	Professional	0.009	0.407	0.023	0.982	< 0.001
	Hobbyist	-0.636	0.357	-1.784	0.075	0.005
	General Interest	-2.147***	0.454	-4.729	< 0.001	0.036
	Env. Employment	-1.495***	0.566	-2.642	0.008	0.12
	Prof. + Hobbyist	0				
	Intercept	5.525***	0.151	36.712	< 0.001	0.693
	Professional	0.645**	0.289	2.234	0.026	0.008
	Prof. + Hobbyist	0.636	0.357	1.784	0.075	0.005
	Env. Employment	-0.859	0.488	-1.760	0.079	0.005
	General Interest	-1.511***	0.353	-4.287	< 0.001	0.030
	Hobbyist	0				
9 – Blue Diamond	Intercept	4.342***	0.328	13.247	< 0.001	0.227
	Prof. + Hobbyist	0.026	0.541	0.048	0.962	< 0.001
	Hobbyist	1.037***	0.384	2.701	0.007	0.012
	General Interest	2.930***	0.536	5.468	< 0.001	0.048
	Env. Employment	2.810***	0.699	4.021	< 0.001	0.026
	Professional	0				
	Intercept	4.368***	0.430	10.159	< 0.001	0.147
	Professional	-0.026	0.541	-0.048	0.962	< 0.001
	Hobbyist	1.011	0.474	2.133	0.033	0.008
	General Interest	2.904***	0.604	4.810	< 0.001	0.037
	Env. Employment	2.784***	0.752	3.701	< 0.001	0.022
	Prof. + Hobbyist	0				
	Intercept	5.379***	0.200	26.885	< 0.001	0.548
	Professional	-1.037***	0.384	-2.701	0.007	0.012
	Prof. + Hobbyist	-1.011**	0.474	-2.133	0.033	0.008
	Env. Employment	1.773***	0.649	2.732	0.006	0.012
	General Interest	1.892***	0.469	4.038	< 0.001	0.027
	Hobbyist	0				

*Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

As three models did not meet assumptions on normality, a Kruskal-Wallis Test was performed, and significant differences were identified for Heckel (X^2 = (4, N = 430) = 40.805, $p < 0.001$; Appendix J17). The Mann-Whitney U post-hoc revealed that variations were most apparent in comparisons related to professionals, professional hobbyists and hobbyists (Appendix J18). By comparing median rank scores, the lowest score of 6 was reflected for both respondents of general interest and environmental employment with no significant differences, whereas the highest score of 9 was seen for professional, followed by a slightly lower score of 8 for both professional hobbyists and hobbyists. Thus, these results indicate that preferences for spade shapes, as seen with Heckel, seem to be the greatest among general public consumers outside the discus community and the environmentally employed as well, with lesser interests among the discus community for both the general and specialist hobbyists, and the least interest with the lowest rank position among professionals of the industry. No significant differences were observed for other images for shape (Appendix I5; Appendix J17).

With all things considered, results from Spearman's rank correlations were consistent with previous observations, with strong positive associations between all group combinations for pattern (Table 3.26). This suggests that an overall preference for the attribute was observed within the sampled population, with no strong differences in rank orders between respondent classes. This was particularly evident between professionals, professional hobbyists and hobbyists with significant positive associations for all characteristics ($p < 0.001$), revealing that there were indeed strong similarities within the discus industry and discus community on overall preferences for colour, pattern and shape. Nevertheless, less significant colour associations were observed in the public sector, between hobbyists and respondents with general interest as well as those with environmental employment ($p < 0.05$). Similarly, less significant associations were observed in all comparisons of the three groups for shape as well ($p < 0.05$). Thus, this suggests that slight heterogeneities were evident in colour and shape preferences within the public sector, particularly in relation to hobbyists with potentially varied fishkeeping background, the general public, and people with an environmental background. However, as there were no significant colour or pattern associations between all related professionals and those with general interest ($p < 0.10$), it can be inferred that the most significant differences in preferences for both attributes lie between the general public and related professionals in the industry. In addition, as no significant shape associations were observed with environmentally employed respondents as well, all in all, discus shape was found to reveal the most distinct preferences between individuals with extreme differences in levels of discus knowledge or background.

Table 3.26 Spearman's rank correlation coefficients of associations between and within respondent classes

	Association	*N*	r_s	*p*
Between groups	c_Prof * c_Prof+Hobb	10	0.989***	< 0.001
	c_Prof * c_Hobb	10	0.964***	< 0.001
	c_Prof * c_Gen	10	0.600	0.067
	c_Prof * c_Env	10	0.818***	0.004
	c_Prof+Hobb * c_Hobb	10	0.939***	< 0.001
	c_Prof+Hobb * c_Gen	10	0.576	0.082
	c_Prof+Hobb * c_Env	10	0.806***	0.005
	c_Hobb * c_Gen	10	0.697**	0.025
	c_Hobb * c_Env	10	0.745**	0.013
	c_Gen * c_Env	10	0.891***	0.001
	p_Prof * p_Prof+Hobb	10	0.988***	< 0.001
	p_Prof * p_Hobb	10	0.936***	< 0.001
	p_Prof * p_Gen	10	0.794***	0.006
	p_Prof * p_Env	10	0.915***	< 0.001
	p_Prof+Hobb * p_Hobb	10	0.960***	< 0.001
	p_Prof+Hobb * p_Gen	10	0.782***	0.008
	p_Prof+Hobb * p_Env	10	0.903***	< 0.001
	p_Hobb * p_Gen	10	0.851***	0.002
	p_Hobb * p_Env	10	0.948***	< 0.001
	p_Gen * p_Env	10	0.927***	< 0.001
	s_Prof * s_Prof+Hobb	10	0.976***	< 0.001
	s_Prof * s_Hobb	10	0.867***	0.001
	s_Prof * s_Gen	10	0.345	0.328
	s_Prof * s_Env	10	0.370	0.293
	s_Prof+Hobb * s_Hobb	10	0.891***	0.001
	s_Prof+Hobb * s_Gen	10	0.321	0.385
	s_Prof+Hobb * s_Env	10	0.382	0.276
	s_Hobb * s_Gen	10	0.661**	0.038
	s_Hobb * s_Env	10	0.709**	0.022
	s_Gen * s_Env	10	0.964**	< 0.001
Within groups	c_Prof * p_Prof	10	0.697**	0.025
	c_Prof * s_Prof	10	0.867***	0.001
	p_Prof * s_Prof	10	0.709***	0.022
	c_Prof+Hobb * p_Prof+Hobb	10	0.661**	0.038
	c_Prof+Hobb * s_Prof+Hobb	10	0.842***	0.002
	p_Prof+Hobb * s_Prof+Hobb	10	0.770***	0.009
	c_Hobb * p_Hobb	10	0.553	0.097
	c_Hobb * s_Hobb	10	0.842***	0.002
	p_Hobb * s_Hobb	10	0.766***	0.010
	c_Gen * p_Gen	10	0.830***	0.003
	c_Gen * s_Gen	10	0.830***	0.003
	p_Gen * s_Gen	10	0.903***	< 0.001
	c_Env * p_Env	10	0.794***	0.006
	c_Env * s_Env	10	0.588	0.074
	p_Env * s_Env	10	0.855***	0.002

*Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

In terms of associations within groups, respondents with general interests were found with significant associations between all rank orders. This suggests that the group was most easily influenced by other characteristics in their decision-making, and potentially found the ranking most difficult to order for particular attributes independently. In terms of colour and pattern, environmentally employed respondents expressed strong associations and were most likely to express overall discus preferences with considerations to both attributes. However, as all related professionals had less significant associations, with no significant associations between hobbyists as well, groups seemed to exhibit more distinct preferences for colour and pattern, particularly among hobbyists with preferential differences observed. Overall, shape was found to be the most difficult to rank independently across all groups, with strong influences by both colour and pattern except for environmentally employed respondents, with significant influences found only from pattern and not from colour. Thus, it can also be said that pattern may be the most important characteristic to be considered in discus choice by environmentally employed respondents.

3.2.7 SURVEY EVALUATION

A general evaluation between CS methods and procedures were conducted to examine potential differences in results. Of 430 respondents that took part in the card sort, comparisons were made on survey language with 400 completed in English and 30 in Chinese. Greater emphasis was placed in analysing survey type, which accounted for 375 conducted in person and on paper, and 55 completed independently by respondents online. Basic evaluations were also made on survey completeness, with 141 respondents having only completed the demographics and the card sort, and 289 that have taken part in the entire survey, with complete sections for demographics, card sorting and the choice experiment. All data was accounted for in the analyses.

Survey Language

Despite differences in sample size, only minimal variations were observed between results retrieved from different survey languages (see detailed results in Appendix M). No significant differences were observed for pattern. On the other hand, variations were observed with greater interest among English responses for Yellow Ghost in terms of colour, among English responses for Golden in terms of shape, and among English responses for Red Turquoise in terms of shape. Considering that the Traditional Chinese version was restricted to being answered by respondents of Chinese descent, who have decided to take the survey over the original English version, results for the survey seem to resemble outcomes that are observed from previous analyses of the Far East Asian and European markets. Thus, it is suggested that the observed variations were more likely to be related to differences in respondent background in relation to market regions. Strong positive associations were also evident for both survey versions among all results for colour, pattern and shape, which appeared to mimic outcomes observed from the summary analyses of all CS data as well. Hence, it can be said that responses were similar regardless of survey

language, and that any sort of discrepancy observed may be more associated with respondents of different backgrounds than errors impacted by translation.

Survey Type

For colour, significant differences between survey types were only evident in a GLM for Golden (F (1,428) = 4.198, $p < 0.05$, $\eta_p^2 = 0.010$; Appendix G7). Paper results were predicted as being more likely to obtain a higher rank score, thus a lower rank position for Golden in terms of colour than Online (Table 3.27). As online surveys received the highest frequency of Far East Asian respondents with over 45% from Hong Kong, and only 19% from the UK, it is suggested that online results may show greater tendencies to represent the Hong Kong market than others. Thus, greater interest for Golden colorations among online results may be sourced from preferences observed among Hong Kong respondents instead (Table 3.19).

Table 3.27 Parameter estimates for significant models between survey types, based on colour

Image	Source	B-Effect	Std. Err.	*T*	*p*	Partial η^2
3 - Golden	Intercept	0.4982***	0.357	13.950	< 0.001	0.313
	Paper	0.784**	0.382	2.049	0.041	0.010
	Online	0				

*Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

As five models did not meet assumptions on normality, differences were investigated through a Kruskal-Wallis test, which found significant variations between survey types for Yellow Ghost (X^2 = (1, N = 430) = 40.996, $p < 0.001$), Heckel (X^2 = (1, N = 430) = 4.220, $p < 0.05$), Red Spotted Green (X^2 = (1, N = 430) = 13.316, $p < 0.001$) and Blue Diamond (X^2 = (1, N = 430) = 8.274, $p < 0.005$; Appendix J19). As survey types were comprised of responses that compiled data from respondents of different backgrounds, such differences are proposed to be the result of a mix of preferences, with potentially greater representations of a particular socio-demographic within survey results over others. For example, a smaller median rank for Yellow Ghost among online results may be related to preferences from a greater representation of Hong Kong respondents than others (Table 3.19). However, as Paper results included responses from Hong Kong and other market regions, such differences seem just as likely to be related to heterogeneous preferences within a market, as well as errors impacted by different survey procedures. No significant differences were observed for other images for colour (Appendix G7; J19**).**

Significant differences for pattern were observed in GLMs for Yellow Ghost (F (1,428) = 42.491, $p < 0.001$, $\eta_p^2 = 0.090$), Heckel (F (1,428) = 16.939, $p < 0.001$, $\eta_p^2 = 0.038$), Red Spotted Green (F (1,428) = 3.545, $p < 0.005$, $\eta_p^2 = 0.022$) and Blue Snakeskin (F (1,428) = 14.069, $p < 0.05$, $\eta_p^2 = 0.032$; Appendix H7). Similarly, the variations could be related to respondent background, where Yellow Ghost was observed with a greater likelihood to have a lower rank score for online results, with a relatively higher Far East Asian percentage of respondents, than on paper (Table 3.28). However, as Blue Snakeskin was supposedly just as much preferred among both market regions with no significant variation (Appendix K), the

differences observed between survey types give rise to errors related to sample size, where greater interests among paper surveys are potentially due to a larger sample population and representation of market regions than online. In this case, the evaluation between survey types may be skewed due to the online sample population being significantly smaller, yet comprised of pattern preferences from a highly mixed group of respondent backgrounds. At the same time, as display errors were encountered among particular respondents for the online CS, rank orders may be impacted from such errors, leading to differences in results.

Table 3.28 Parameter estimates for significant models between survey types, based on pattern

Image	Source	B-Effect	Std. Err.	*t*	*P*	Partial η^2
2 – Yellow Ghost	Intercept	5.309***	0.333	15.954	< 0.001	0.373
	Paper	2.323***	0.356	6.519	< 0.001	0.090
	Online	0				
4 – Heckel	Intercept	7.473***	0.300	24.936	< 0.001	0.592
	Paper	-1.321***	0.321	-4.116	< 0.001	0.038
	Online	0				
6 – Red Spotted Green	Intercept	4.127***	0.267	15.436	< 0.001	0.358
	Paper	-0.885***	0.286	-3.090	0.002	0.022
	Online	0				
8 – Blue Snakeskin	Intercept	4.400***	0.309	14.252	< 0.001	0.322
	Paper	-1.240***	0.331	-3.751	< 0.001	0.032
	Online	0				

*Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

As five models did not meet assumptions on normality, a Kruskal-Wallis Test was performed, and significant differences observed for Wild Blue (X^2 = (1, N = 430) = 10.389, p < 0.001), Golden (X^2 = (1, N = 430) = 8.383 p < 0.005), Red Turquoise (X^2 = (1, N = 430) = 20.301 p < 0.001) and Super Marlboro Red (X^2 = (1, N = 430) = 10.802 p < 0.001; Appendix J20). For Wild Blue and Golden, online results were observed with slightly smaller median rank scores than paper, whereas the opposite was observed for Red Turquoise with much smaller median rank scores among paper results than online. However, a substantial difference was seen for Red Turquoise, with a much smaller median of rank 2 for online results, and a high rank 8 for paper results. As the variations, especially for Red Turquoise, seem to resemble differences observed between market regions (Table 3.20; Appendix K), it is suggested that differences may be related to greater representations of particular markets among survey types than others. However, as eight of 10 images expressed significant differences in results, it is made aware that external factors may have impacted the ranking of pattern between paper and online results, whether in relation to heterogeneous preferences by respondents of different backgrounds, or errors associated with different survey procedures. No significant differences were observed for other images for pattern (Appendix H7; J20)

Significant variations between mean ranks for shape were also observed for Red Turquoise (F (1,428) = 7.308, p < 0.001, η_p^2 = 0.017), Blue Snakeskin (F (1,428) = 6.142, p < 0.05, η_p^2 = 0.014) and Super Marlboro Red (F (1,428) = 24.492, p < 0.001, η_p^2 = 0.054); Appendix I7). Such results revealed potential impacts from having sample populations with different

representations of market regions between survey types as well. This was evident for Red Turquoise, where a greater interest was found among paper surveys with a significantly larger group of European respondents than online, thus revealing results that mimicked preferences observed for UK and the European market (Table 3.21; 3.29; Appendix K). However, as preferences for Blue Snakeskin and Super Marlboro Red were meant to be consistent between market regions, such differences propose an impact from different sample sizes between survey types, especially for the smaller group of online responses that might express a mix of preferences from respondents of multiple socio-demographic backgrounds.

Table 3.29 Parameter estimates for significant models between survey types based on shape

Image	Source	B-Effect	Std. Err.	*T*	*P*	Partial η^2
7 – Red Turquoise	Intercept	5.745***	0.324	17.742	< 0.001	0.424
	Paper	-0.937***	0.347	-2.703	0.007	0.017
	Online	0				
8 – Blue Snakeskin	Intercept	3.964***	0.298	13.310	< 0.001	0.293
	Paper	-0.790**	0.319	-2.478	0.014	0.014
	Online	0				
10 – Super Marlboro Red	Intercept	5.491***	0.313	17.546	< 0.001	0.418
	Paper	1.658***	0.335	4.949	< 0.001	0.054
	Online	0				

*Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

Six remaining models did not meet assumptions on normality, and were investigated for variances through a Kruskal-Wallis test instead. As a result, significant differences were found between survey types for Golden (X^2 = (1, N = 430) = 18.115, p < 0.001), Heckel (X^2 = (1, N = 430) = 13.316, p < 0.001), Pigeon Blood (X^2 = (1, N = 430) = 10.220, p < 0.001) and Blue Diamond as well (X^2 = (1, N = 430) = 38.264, p < 0.001; Appendix J21). Online responses seemed to show greater interest in Golden and Heckel with a lower median rank score than paper, whereas the opposite was seen for Pigeon Blood and Blue Diamond, with paper responses expressing greater interest with a lower median rank score than online instead. Whether in relation to greater representations of market regions, heterogeneous preferences within samples or errors associated with survey procedure, this strong level of variation suggests that multiple factors have impacted rankings for shape in relation to survey type. No significant differences were observed for other images for shape (Appendix I7; J21).

Overall, a Spearman's correlation gave rise to such variations by discovering no significant associations between survey types for all three categories (Table 3.30). Comparing responses within groups, paper surveys were revealed to be more consistent with the summary of results, where a less significant association was observed between colour and pattern (r_s = 0.709, N = 10, p < 0.05, two-tailed), and strong significant associations between colour and shape (r_s = 0.842, N = 10, p < 0.005, two-tailed) as well as pattern and shape (r_s = 0.806, N = 10, p < 0.005, two-tailed; Table 3.12; 3.30). This revealed an overall greater

likelihood for respondents to be influenced from other characteristics when deciding on rank orders for discus shape, and an influence between colour and pattern with evidence of some specific preferences for particular features.

Table 3.30 Spearman's rank correlation coefficients of associations between and within groups on survey type

Association		*N*	r_s	*p*
Between groups	c_Paper * c_Online	10	0.382	0.276
	p_Paper * p_Online	10	0.394	0.260
	s_Paper * s_Online	10	0.091	0.803
Within groups	c_Paper * p_Paper	10	0.709**	0.022
	c_Paper * s_Paper	10	0.842***	0.002
	p_Paper * s_Paper	10	0.806***	0.005
	c_Online * p_Online	10	0.479	0.162
	c_Online * s_Online	10	0.103	0.777
	p_Online * s_Online	10	0.248	0.489

*Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

On the contrary, no significant associations were observed between rank orders for online surveys, which differed to the general trend observed among all CS results (Table 3.12; 3.30). Hence, it can be said that the source of such variations in rankings are more related to issues encountered with the online survey. At the same time, a smaller sample size with a concentrated mix of respondent backgrounds would also impact the evaluation of results, thus creating biases which would lead to variations between survey types. Nevertheless, results from combining responses from both survey types, as observed with the summary of results, expressed marginal variations with the same trend observed as paper surveys (Table 3.12; 3.30). Hence, it can be said that such issues with the online survey are only evident when comparisons are made between survey types, and expressed minimal impacts when analysed between respondent backgrounds as a whole.

Survey Completeness

Lastly, with regards to survey completeness, significant differences were evident for Wild Blue and Blue Snakeskin in terms of colour and Pigeon Blood in terms of pattern (see detailed results in Appendix N). Although more variation was observed for shape, with significant results in rankings for Yellow Ghost, Heckel, Pigeon Blood, Red Spotted Green and Super Marlboro Red, such observations were similar to what is expected or observed from the summary of results, with greater heterogeneity within the sample population. Overall, results from respondents that only took part in CS revealed stronger interests with more significant rank scores to images relative to respondents who have completed both the CE and CS. As respondents for CS only would have completed the exercise first instead of second to the CE, respondents would have approached the survey with the CS images as a first impression of potential discus alternatives, allowing simple rankings to be made in a potentially clearer mind set and more straight-forward or impulsive approach. On the other hand, respondents that have completed both sections may encounter issues of fatigue,

which may impact results. Nevertheless, as such respondents would have had a prior insight into understanding their own preferences for discus, greater familiarity with other potential discus attributes and alternative characteristics may lead to potentially more comprehensive and detailed approaches to their rank orders, thus showing greater complexity in their decision-making.

But with all things considered, both groups expressed strong, positive and significant associations in rank orders for all three categories of the CS. This implies that there is no general difference in rank orders between respondents based on survey completeness, and that the variations observed laid minimal impacts on the results. Additionally, as both results seemed to resemble general trends that were observed between comparisons in respondent backgrounds and the overall summary of results, it can be inferred that there are no strong differences in data obtained from respondents that varied in levels of survey completeness.

4 DISCUSSION

All in all, observations on consumer preferences have provided an overall understanding on the main attributes that constitute the current international demand for discus.

Consistent results from the CE and CS revealed colour attributes to be of highest importance and the most influential in instigating discus choice across respondents. The CE saw the strongest interests for blue/green varieties, which was also reflected with top ranks for the Blue Snakeskin and Blue Diamond in the CS. While market observations revealed that solid blue discus, particularly Blue Diamonds, are considered a stable and popular consumer favourite by retailers, such results are reflective of a continuous demand that appears to have been solidly maintained over the years with frequent appearances in the marketplace (Anon., breeder, pers. comm.).

Recurring observations of the Blue Snakeskin as the top-ranked image for all CS categories also suggest that the fish expressed optimal features relative to other options in the set, and has the potential to be viewed as the 'ultimate discus' with universally agreeable and preferable characteristics across respondents.

Although preferences for other attributes lack in strength compared to colour, an understanding on discus type seems to have greatly influenced the decision-making process as well. The wider community expressed a favouring towards artificially cultivated varieties, which suggests a larger international market for cultivated discus over wild forms. This is parallel to current understandings of the global market situation, with estimates of the wild sub-division constituting to only 5% of the international trade (Anon., mixed professional, pers. comm.). As discus is already widely reputed as a challenging species to keep, due to specific needs and habits, this is likely to be associated with preferences among hobbyists to keep fish that are already accustomed to the tank environment, which would be relatively less susceptible to immediate stress and disease than those that are wild-caught (Anon, hobbyist, pers. comm.). In addition, as general trends towards brighter colorations and away from darker, brown alternatives were detected in the CS as well, it is suggested that lesser preferences associated with wild forms may be highly linked with coloration.

A slight shift towards modern discus was also observed with slight preferences for high-bodied shapes in the CE. Yet round discus is still favoured, and could be seen with trends towards high-finned and rounder shaped discus in the CS. Striations were also found to be of greater interest, and knowing that this is a natural trait among wild discus species, this pattern seems to be able to meet demands of consumers in both wild and cultivated markets. Thus, this indicates that there is an existing potential for growth in the wild market, and possible appeal to customers of a wider community.

The most consistent findings in the CE results are related to price, where most respondents expressed minimal concerns for the attribute when choosing between discus. These results

reflect current understandings that discus enthusiasts are generally more concerned with the phenotypic appearance of the fish rather than its price, and are willing to pay for discus with desirable characteristics (Anon., hobbyist, pers. comm.). Thus, if specific markets or consumer groups with greater wild interest can be identified, this would form a great starting point to achieving a larger international consumer base for the wild market, and would thus provide greater economic potential for discus as a candidate species for sustainable ornamental trade.

Overall, significant variations and heterogeneous preferences for discus were observed between specific markets, allowing for evaluations on the extent of consumer interest and market potential for wild and cultivated discus varieties in European and Far East Asian discus markets. Although similarities were existent between traders and hobbyists, heterogeneities between traders and different public consumer groups were observed. This allows a further understanding on potential gaps of knowledge on consumer interest between different actors of the supply chain, and an insight on the associated consumer attitudes and behaviour behind discus choice.

4.1 MARKET HETEROGENEITY

Both European and Far East Asian markets were found with great similarities in preferences for discus, which reflects the overall international market with an estimated 95% on cultivated varieties (Anon., mixed professional, pers. comm.). Nevertheless, a greater market potential for wild discus and red/brown colorations was observed among the European market, with high rankings for Wild Blue and Red Turquoise. These results reflects Europe's long-standing position in the ornamental trade of discus, where traditional consumer markets, especially Germany, have been involved in imports of wild discus and the development of strains since the early beginnings of the mid-1960s to 1980s (Göbel, 1999). Göbel (1999) states that imports of wild Heckels may have started around the early 1960s, and by around 1965, Blue and Green variants began to arrive in Europe. As the prices of well-coloured wild-caught specimens were substantially high due to its rarity and variability in colorations, successful breeding of new cultivated varieties did not occur in Europe until around the 1970s to 1980s, with introductions of the intensely red German Red Turquoise (Göbel, 1999; Au et al., 2007).

On the other hand, a solid market for artificially cultivated varieties was observed among the Far East Asian region, with the potential for marketing a wide variety of discus morphs including golden and white colorations as well as high-body shapes. High rankings were also observed for Yellow Ghost, Golden and Blue Diamond. This is directly reflective of Asia's specialization on cultivated discus, which began around the 1970s to 1980s as breeders perfected their skills in commercial productions of large quantities of discus for the hobbyist market (Au et al., 2007). Facilitating introductions of the Ghost discus, 9-bar and 14-bar Snakeskin, Pigeon Blood and Blue Diamond in the 1990s, these varieties, along with Wattley's Turquoise and the German Red Turquoise, became the pillars for the extensive

development of colour and patterns, and the commercialization and expansion of the cultivated discus industry.

4.1.1 UNITED KINGDOM

The UK is known to be a traditional consumer market that has expressed interests in discus since the development of the wild discus industry in Europe. Currently, Europe still remains as the principal importer of ornamental fish from the Brazilian Amazon, with UK included as one of the main markets in the trade (Prang, 2008).

The CE results suggest a large percentage of interest among keepers in wild-caught and cultivated discus, with high economic valuations of both types up to £113. These results are parallel to understandings of a wild market interest and observations from Au et al., (2007), which indicated that European hobbyists tend to have an affinity for natural aquaria, and are thus more willing and ready to pay higher prices for good quality wild fish. In the CS results, high placements for cultivated wild types such as Red Turquoise and Red Spotted Green were observed, with respondents describing the former as most "natural-looking" and a "pleasant reminder [of an] antique". Attractions to the latter was also seen to be due to an exhibited compromise of both wild and cultivated traits, with interests on the brighter form due to its "clean", "dense patterning" and combination of "mixed dots and lines", with an overall "round" and "classic discus shape." This reflects interests for refined features of wild discus attributes, namely thick striations, slight spots and a perceived "natural" shape that would be observed in the original wild Brown and Green varieties. As multiple respondents expressed that they are keeping these fish personally, and are more inclined to choose wild types as they would be "worth more [to sell] than normal discus," this indicates that a market for wild discus, whether wild-caught or cultivated, is still very much evident in the UK, and can definitely be a focus for marketing sustainably harvested discus. A large and evident consumer base for both wild types also increases conservation prospects by providing opportunities to minimize potential population pressures in the wild with similar alternatives. At the same time, marketing cultivated wild types will be able to appeal to hobbyists who prefer tank-bred origins for fishkeeping than wild-caught, creating further potential to expand the market into a much wider community.

However, as the global market emerges towards artificially cultivated varieties, the UK has caught up with displays of interest for such varieties among all types of keepers as well. Particular preferences for colour was placed among blue/green and red/brown discus in the CE, which coincides with observations of high rankings for Blue Snakeskin, Red Turquoise, Blue Diamond and Pigeon Blood in the CS. As these varieties are either mostly striated or solid varieties that were developed in the early stages of the artificially cultivated market, the UK seems to be potentially at an early and emerging stage of the movement, slowly heading towards modern discus while still carrying a conservative interest for particular cultivated strains (Anon., breeder, pers. comm.). This is seen with CE results expressing a

particular disinterest away from white discus, such as albino strains, due to its lack of coloration and its appearance looking “sick” and “weak”.

Evidence of an emerging cultivated market was also seen with significantly greater preferences for high-bodied discus than the traditional round shape in the CE. This change is in line with current situations of European discus competitions, which are beginning to open up and consider high-body entries in their awarded titles, when they were less inclined to do so in previous years (Anon., breeder, pers. comm.). Nevertheless, interests for the traditional round discus is still very dominant, with individuals expressing high rankings and tolerance for the shapes of Wild Blue and the cultivated wild form Red Turquoise for the CS, despite their imperfections with lesser defined shapes and a “beaky” snout. Yet negative preferences for the angular, spade-shaped Heckel reveal that standards for roundness are still of great importance to wild discus, as the image was considered less desirable even though it is a wild form (Anon., hobbyist, pers. comm.). Thus, despite a higher tolerance, wild-caught discus supplied into the UK market may still have to exhibit a general roundness or “discus shape” to obtain a greater value and more consumer appeal.

As the general public mostly opposes to fancy bodies and fin shapes, disinterests towards high-bodied forms were still evident among respondents, with comments referring to images such as Blue Diamond to be “highly deformed”, to have “fins [that are] too big”, and a “body [that is] too long or elongated upwards” (Ploeg, 2013b). Particularly low rankings for the unusual and highly contrasted Yellow Ghost was also observed, as it seemed to be too far away from the original discus colorations, patterns and shapes than the natural wild discus (Anon., hobbyist, pers. comm.). Negative associations by respondents include comments that describe the fish as “fake”, “unnatural,” and “doesn’t blend” in terms of its sharp yellow, blue and black colorations. In terms of pattern, respondents seemed less interested in solids as they believe that discus should have some level of patterning in its body, like its wild predecessor. Thus, the imaged was described as “unpleasant” and “too plain”, with a particular disliking towards its “yellow/blue contrast” and “messy” and “smudged pattern.” In terms of shape, as the discus is far from a round or a smooth high-bodied shape, UK respondents commented that the image was “not ‘discus-shaped”, had a “big head” and an “asymmetrical” “wide body”, and was “poorly-defined” with a “squashed face.” Such associations may also be related to the general distaste of unusually sharp, Genetically Modified (GM), glow-in-the-dark fish, such as the fluorescent greenish yellow medakas (*Oryzias latipes*), which are popular in the USA but not accepted by the public and illegal in Europe (Fosså, 2002). As it relies on the employment of genetic engineering to produce new fish varieties to improve colour, shape and developing characteristics such as faster growth, considering that there is already growing scepticism across aquarium hobbyist circles on the industry’s use of artificial colouring and physical manipulation, opponents may view the forms as “monstrous extremes” and frown on that reminder as well (Fosså, 2002).

Overall, this emphasizes the extent of interest among UK respondents towards a 'natural' or 'original' wild discus appearance, which suggests a high environmental valuation and appreciation of natural goods. As people's preferences for a product is expressed by the price that they are willing to pay, the fact that UK consumers are willing to pay a high price for wild discus suggests a high economic valuation of the product in association to its wild environmental attribute (DEFRA, 2004). Similar to assessing levels of nature appreciation in natural environments, respondents that express a greater appreciation for natural resources may express a willingness to want to protect, keep, conserve or preserve an environmental feature (DEFRA, 2004). Thus, disinterest may be expressed towards artificial cultivated varieties with attributes or phenotypic developments that may fall too far off the 'acceptable' spectrum. Considering the strong influence from knowing discus type among keepers, it can be said that a considerable nature conservation value may be present (O'Mahony & Doyle, 2007). As such, potential strategies to increase awareness on sustainably harvested ornamental fish and the equitable sharing of trade profits in the community may be considered, with hopes to trigger interests and invoke greater opportunities among a wider audience to purchase or be introduced to sustainable wild-caught discus.

At the same time, as the UK market has maintained conservative preferences for artificially cultivated varieties for over three decades since the development of new strains, this suggests the potential for consumer behaviour that is related to a fear of change or the unknown (Cao et al., 2009). Studies on judgment and decision-making revealed that individuals may prefer "familiar goods, status quo choices, and gambles which seem unambiguous, and that individuals feel competent to evaluate" (Cao et al., 2009). In this case, individuals may favour investments that they are more familiar with and potentially exhibit the endowment effect, where individuals may hold strongly to past choices or investments that they currently have (Cao et al., 2009). This would potentially refer to wild discus, where the market is completely familiar with, and individuals, particularly older keepers, have been keeping for a long time.

4.1.2 SINGAPORE

Singapore is the world's leading exporter of ornamental fish, with principal exports to the USA, UK, Japan, Germany and France (Ling & Lim, 2006). In 2002, Singapore was observed to be producing 44% of the ornamental fish in its exports, with around 64 working farms (Ling & Lim, 2006). However, ever since the change in using recycled or reusing reclaimed water after 2002, there has been a significant decline in the ornamental fish industry due to changes in water quality (Anon., retailer, pers. comm.). Keeping ornamental fish requires a lot of care and equipment, especially in terms of maintaining water quality for species that are highly sensitive to bacterial infection and easily-stressed, such as discus (Soh, 2005). Water changing is particularly important to remove ammonia waste, maintain fish health and increase the rate of growth of discus. However, due to high chloramine levels in the recycled water, it is deemed unsuitable for ornamental fish, meaning all keepers and

professionals will have to obtain chemicals to condition the water and acquire extra equipment, such as aeration tanks, to break the chemical bonds and treat the water before use (Anon., retailer, pers. comm.). Due to high costs and competition with other producing countries such as Malaysia, the industry cannot compete as Malaysia is already supplied with water that is highly suitable for ornamental fish and is constantly producing top quality strains (Anon., breeder, pers. comm.). As a result, along with high maintenance costs, many farms have been driven out of business. Currently, Singapore only consists of private and specialist home breeders for discus, and less than five commercial discus farms (Anon., breeder, pers. comm.). However, the export industry is still a world leader due to its international transport links, which allows many neighbouring countries, including Malaysia, to transit through Singapore and re-export their imports from the country (Anon., exporter, pers. comm.).

The results revealed that Singapore buyers expressed elements of similarity in their preferences with the European as well as Far East Asian markets. Singapore respondents seemed to share similar preferences across different colorations apart from white-based discus, where a distinct preference away from the option was observed in the CE. Some Singapore respondents also expressed an interest for wild discus, displaying preferences towards wild forms over artificially cultivated varieties. These observations overlap with wild preferences observed in the UK and affinities to carry an appreciation of natural goods, which would create great potential for further international consumer interest in purchases of wild-caught discus if the associated conservation values are high (O'Mahony & Doyle, 2007). Similarities were also observed in the CS, where both UK and Singapore ranks were highly similar for pattern. These results are in line with our understanding that Singapore is a leading exporter and also the top supplier to wholesale importers in the UK. As exporters need to provide supplies that meet the demand of its consumers, this similarity suggests that Singapore respondents, potentially professionals, expressed preferences that responded to consumer demand observed in the UK (Anon., exporter, pers. comm.). This suggests that there is wild market potential in Singapore, but potentially more in the sense of export-imports to meet international market demands, which would become too costly and would risk greater mortality if Singapore is not the destination and only a transit from South America.

However the CS revealed distinctively lesser preferences for Red Turquoise, suggesting that wild preferences in Singapore are less strong than the UK market. A higher preference for the high-bodied Blue Diamond was also observed. However, heterogeneous preferences for shape were expected within the population, as the interests for high-bodied discus are often dependent on whether the consumer carries wild or artificial cultivated interests. This is observed in the CE as well, where most Singapore residents expressed no particular preferences for shape; though a slight desirability towards high-bodied discus was observed for particular customers. In this case, a distinct preference for patterned and spotted discus was seen. Overall, these results were generally parallel to those observed in the Far East

Asian market, with evident similarities with Hong Kong and particularly Malaysia in the CS. As Singapore is a transit hub with major re-exports with imports from Malaysia, preferences for Singapore respondents may carry interests that are correspondent to their suppliers. Malaysia also supplies to Hong Kong through exports that transit through Singapore (Anon., exporter, pers. comm.). Thus, as the Hong Kong market reflects supplies from Malaysia, and Malaysia is more geared towards the cultivated forms, it is evident that Singapore professionals may also exhibit preferences that overlap with the Far East Asian cultivated market as well.

Overall, Singapore respondents revealed an understanding of both European and Far East Asian markets, by painting a combined picture that incorporates consumer demand from both wild and cultivated markets. These results reflect Singapore's success as a leading exporter of the world, by being able to accommodate to both industries with various markets, and aid the expansion or potential growth for either trade through its connections and trade pathways.

4.1.3 MALAYSIA

With the decline of the producing industry in Singapore, Malaysia has risen up and is now considered one of, if not the largest and main producers of ornamental fish in the Far East Asian region (Anon., breeder, pers. comm.). Ironically, the domestic market is much smaller despite its large productions, as Malaysia is mainly a supplier for international end-user markets (Anon., exporter, pers. comm.). However, the worldwide economic downturn has had a significant impact on Malaysian ornamental fish exports to the EU, with 2012 records showing a significant decrease in imports by principal countries in Spain and Germany at 47% and 40% respectively (Foo, 2012). Nevertheless, the Malaysian ornamental fish industry plays a tremendous role in the global cultivated market for discus, and with land resources that are optimal for breeding both wild and cultivated forms at low cost productions, Malaysia carries an ever-growing potential for experimentations of new varieties and supplying newly marketed species for the trade (MOA, 2003).

CS results for Malaysia revealed similar trends to the Far East Asian and South East Asian market, where there is a high affinity towards blue and red colorations, discus with patterning, and smooth, high-bodied and high-finned forms. Nevertheless, as it is a producing country, numerous morphs and multiple attributes may be accepted to ensure that opportunities for potential new varieties remain open for investigation. This is observed in the CE, where certain respondents, potentially commercial breeders or exporters, may express broader interests with a greater likelihood to purchase either option than others.

The CS results also revealed a significantly greater interest on the unusually contrasted Yellow Ghost relative to Singapore and the UK for colour. As respondents for Malaysia are mostly trade professionals, this is in line with Malaysia's ornamental fish industry for cultivated varieties, which carries a near-endless potential for the improvement and development of new discus morphs. Due to fierce competition, breeders are constantly in a

race to develop new varieties that may command a high premium on its first introduction to the market (MOA, 2003). However, as the variety is made public and supplies increase with other competitors, the prices will tend to stabilize as market demand is being met (MOA, 2003). These introductions of new varieties are commonly associated with mutations, which may often be of unique colorations, patterning or shapes. At the same time, Ghost varieties are often useful to breeders for cross-breeding as well (Anon., hobbyist, pers. comm.). Thus, mutations or indifferent colour varieties such as the Yellow Ghost can be shown greater interest in the Malaysian market. Nevertheless, the image was ranked lower for its "asymmetrical" shape, revealing stricter guidelines or standards among professionals to select between discus for shape. This is directly related to sorting and grading procedures among breeders, where shape plays a substantial role in the selection of quality discus.

However, such mutations are only more likely to be expressed through inbreeding, which provides chance for breeders to quickly select traits that are desirable in captive-bred individuals, and allow for recessive traits to be expressed in inbred populations (Nielson, 1994). As inbreeding may cause severe reductions in fertility and viability from inbreeding depression and subsequently outbreeding depression, stabilizing the gene is not easy to maintain both quality and health of the individual (Nielson, 1994). Although the number of domesticated varieties have grown extensively, excessive breeding has unfortunately led to increased impacts such as morphological deformations, which would impair swimming abilities and potentially reduce survival; and the fading of melanin in stress bars for achievements of clean or solid discus, which would cause communication to be less effective within discus groups, and greater difficulties for hobbyists to identify stressed fish due to the transparency of the bars (Anon., hobbyist, pers. comm.; Fosså, 2004). Thus, there have been extensive efforts to improve fishkeeping and breeding efforts, which have allowed knowledge transfer on the stabilization of genes and improvements in selected traits to ensure the quality and health of the discus and the cultivated trade (Anon., breeder, pers. comm.).

Considering the time and effort involved in the breeding process, perhaps it is also important to consider whether particular traits have market potential and worth the likely trials and errors or impacts that it would bring. Nevertheless, as the number of domesticated varieties continues to grow, greater demand for artificially cultivated varieties has left little space for the wild freshwater industry (Fosså, 2004). And for potentially sustainable alternatives like wild-caught or cultured discus, or other sustainable wild ornamental fish, perhaps greater attention can be placed on testing the culture potential for such varieties in Malaysia, where an optimal natural environment is provided for ornamental fish keeping, and market potential from Malaysia to other Asian countries to increase trade flow for the sustainable wild market.

4.1.4 HONG KONG

The Hong Kong market for discus was found to be mainly comprised of a specialized group of experienced hobbyists and enthusiasts, carrying a wide range of interests and specific standards for choosing discus (Anon., retailer, pers. comm.). CE results suggest broad attractions towards blue/green, golden or even white colorations, patterned or spotted, slightly more for round and artificially cultivated varieties, with preferences away from red/brown, plain or striped and wild-caught varieties (see Segment 2 of LCM 1; Segment 2 of LCM 8, Appendix B14). Such results seem to reflect current understandings of the demand, with a distinct preference towards modern discus, and a lesser interest in wild forms (Anon., retailer, pers. comm.).

As the skills required in selective breeding and refining the markings of patterned or spotted discus are highly specialized, greater appreciation by experienced hobbyists to purchase complex patterned discus and a general greater appeal of the varieties has led to its populous demand in Hong Kong, where common favourites include the finely spotted Leopard Snakeskin and other high-finned varieties (Anon., retailer, pers. comm.). This was observed in the CS, where interests towards bright, blue and multi-patterned cultivated varieties were seen with high rankings for Blue Snakeskin. Respondents also seemed to express specific standards in discus choice, and by viewing the discus as living art pieces, expressed greater appreciation of high quality and selective bred achievements (Anon., breeder, pers. comm.; Ploeg, 2013b). The CS saw compliments for the fish as “bright” and “multi-coloured”, with “delicate,” “intricate patterns” and “a variety of [both] striped and spots”, and “perfectly-shaped” for being “round,” “high-finned” and with a “smooth outline” for its overall shape.

Contrary to results received from respondents of other countries, Hong Kong residents also seemed to place similar and high rankings for multiple images in the CS, expressing great potential for numerous artificially cultivated varieties to be marketed in the region. These include the Blue Diamond, which remains a general consumer favourite even though keepers may prefer patterned more, Golden, Yellow Ghost and Red Spotted Green that are highly varied in terms of colour, pattern and shape. Retailers were also found to be selling bulldog varieties, which are super high body forms sourced from deformed individuals that were born with lordosis (Soh, 2005). Overall, the variety seems to be of acquired interest to consumers worldwide, but breeders may show interest due to its potential to cross-breed with other strains and produce high-body forms (Anon., hobbyist, pers. comm.). An exception is seen for the Taiwan market, where breeders have revealed that a level of public demand is present due to opposing preferences with fondness of its “squished-in”, “unusual”, “bulldog-headed” shape (Anon., breeder, pers. comm.).

Currently, the global aquatic ornamental industry is facing a difficult situation where innovations in products are limited with only a few new species introduced to the market (Ploeg, 2013a). Thus, with the market being highly attracted to new varieties, colour morphs

and forms, understanding that a fish might be "new", "unusual" or even a never-before seen variety might encourage greater interests among Hong Kong respondents (Anon., hobbyist, pers. comm.). This is observed where respondents from Hong Kong exhibited a distinct and particular favouring towards golden varieties in both CE and CS results, particularly with opposing preferences to the UK and Singapore with the Yellow Ghost. Despite being perceived by others as "asymmetrical" and "oddly shaped", Hong Kong respondents perceived the fish as "interesting" due to its "indifferent" appearance and seemingly "rare to find" traits, expressing a "full golden body with a blue fin arch at [the] edge of fins". These results appear to be in line with theories of consumer behaviour in relation to rarity, where a predisposition for placing a high value on rare and exotic goods may be expressed by certain individuals (Gault et al., 2008). This is also revealed in the CS for the Blue Snakeskin, with respondents describing their colour preferences under perceptions of the fish as an "exotic" variety. Considering that the CS results saw some room for a wild market with Hong Kong ranking relatively higher positions than all other countries for Wild Blue in terms of colour, this predisposed idea of rarity and uniqueness may allow a potential chance for wild-caught discus to be introduced further in the Hong Kong market and increase market potential. Although the CE results saw preferences for artificially cultivated and cultivated wild types over wild-caught by non-keepers, the main segment representative of the largest representation of Hong Kong respondents found no significant difference in type (LCM 1, Table 3.4). Thus, since the market is mainly of artificially cultivated freshwater fish and mainly specialists within the discus community, sales of wild-caught ornamental freshwater fish could be considered relatively 'new' to some hobbyists in the market, and may attract keepers who may have the skills or experience to attempt in keeping wild-caught discus. Further research on the extent of appeal on particularly sustainable wild-caught fish in Hong Kong would be needed to provide a proper assessment on market potential.

Moreover, discus retailers on Goldfish Street in Hong Kong consists of a group that is specialized in selling high quality and unique cultivated varieties, often bred from award-winning breeders or imported directly from top breeders in Malaysia. Being 'branded' and 'awarded', discus sold by these retailers seem to express a sense of reliability to customers that seek for insurance in obtaining 'quality discus' (Anon., hobbyist, pers. comm.). But despite the high prices, respondents seem to be familiar with frequent claims by the general discus community to "associate a higher price with quality" (Anon., hobbyist, pers. comm.). This was expressed among Hong Kong residents in the CE, where price was found to be of least concern to consumers when purchasing discus, and especially among keepers who are willingness to pay premium values for discus than other groups, even if they carry lesser desirable traits (Segment 2 of LCM 1, Table 3.4). Thus, along with general understandings that discus itself is often considered a 'luxurious' ornamental fish, it can be said that certain Hong Kong consumers may carry a subconscious appreciation and tendency to purchase luxury or branded items, which is associated with ornamental fish as well, and keepers are generally more prepared and willing to pay a premium to acquire rare and high quality

varieties by these highly reputed breeders and retailers (Livengood et al., 2004; Segment 3 of LCM 1, Table 3.4). During previous visits, certain retailers were already seen selling a tank of wild discus and angelfish. Thus, if sustainable wild-caught discus could be monitored and experimented for introduction into the Hong Kong market through specialized sellers, where there is already a consumer base, there could be potential for high returns. Knowledge transfer from direct contact to specialist keepers will also help raise awareness of responsible hobbyist ownership and fishkeeping care and expertise.

Nevertheless, as the Hong Kong market is highly competitive, where retailers have to take into consideration of high maintenance costs and rent, high quality discus are often extremely expensive, and are less affordable to the everyday consumer (Anon., retailer, pers. comm.). As an alternative, the Hong Kong market also consists of retailers that sell low-grade or cheaper varieties of discus to meet local public demands for fishkeeping (Anon., breeder, pers. comm.). This allows respondents of general interest, or everyday consumers with a general liking towards fishkeeping to be given the choice to keep discus as a one-off hobby (Anon., breeder, pers. comm.) This is reflected in the CE, where younger non-keepers expressed specific interests for blue/green and red/brown varieties that are of lesser interest to specialist keepers, and a more distinct interest for high-bodied shapes while still only willing to pay much less for desired discus than other groups (Segment 4 of LCM 1, Table 3.4).

However, emerging markets like China were found to have lesser import restrictions, possibly due to opening markets in WTO agreements, and animal health requirements that are less strict than Western countries (Ploeg, 2013a). This raises concerns in the production of such low grade alternatives give rise to welfare concerns from lesser pressures for breeders and exporters to produce high quality fish (Ploeg, 2013a). A study on the marine ornamental trade in Hong Kong revealed that many retailers actually import large numbers of fish from the Philippines due to lower freight costs, even with knowledge that they are potentially selling cyanide-caught fish with higher chances of mortality (Tsang, 2001). As new hobbyists are less able to identify unhealthy fish, and particularly those of cyanide-caught origins, mortality during keeping was found to be as short as under a week (Tsang, 2001). With demand being fuelled towards cheaper fish with little regard for quality, if left unregulated, such actions could drive the continued use of destructive fishing methods, and cause further environmental impacts (Tsang, 2001). Thus, it was made aware that licensing of ornamental fish retailers is needed to ensure proper levels of fishkeeping knowledge, standards on fishkeeping to ensure the welfare and health of sold fish, and the introduction of eco-labels that certify the appropriate use of capture methods to educate consumers of the issue on their purchase (Tsang, 2001).Preferences for discus may be highly associated with cultural factors as well. In general, the hobby is highly popular in South East China due to cultural associations with ‘feng shui’ (Anon., hobbyist, pers. comm.). As the word ‘fish’ in Chinese is pronounced with a similar tone to words for ‘abundance’ and ‘affluence’, fish itself symbolizes wealth, thus creating greater appeal and attraction to individuals of all

possible backgrounds in the wider public to be interested in keeping fish (Cultural China, 2014). Particular colorations such as red and gold are more associated with 'luck and 'affluence', leading to a greater potential for purchases of such varieties in the wider community; especially among businessmen who seem to be more interested in placing symbols of luck and wealth within their homes (Anon., hobbyist, pers. comm.). During Chinese New Year, such varieties may also increase in popularity with more sales by a larger group of customers, who may not be long-term fish keepers or experienced hobbyists (Anon., retailer, pers. comm.). This is observed in the CE results, where a high interest for red/brown varieties was also observed among Hong Kong non-keepers, with greater interest for the orange-red Pigeon Blood in the CS as well (Segment 3 of LCM 8, Appendix B14). The Super Marlboro Red was not ranked highly in the CS, but due to comments on disagreements with its shape, it is suggested that customers may have exhibited a trade-off in its characteristics, and decided to purchase an alternative due to its perceived imperfections.

4.2 RESPONDENT HETEROGENEITY

Overall, similar preferences were observed between genders, particularly in the CS for colour. Yet slight differences can be observed with males expressing a lesser preference for the highly contrasted Yellow Ghost and solid Golden for pattern, and significantly greater preferences for the high-finned, round Blue Snakeskin and high-finned, high-bodied Blue Diamond in terms of shape. As fishkeeping is generally a male-dominant hobby, it is seen that male enthusiasts are more likely to exhibit specific preferences towards and away from particular fish based on systematic characteristics than females or other individuals of general interest (Anon., academic, pers. comm.).

Looking at the CE results, male tropical fish keepers tend to express specific interests for wild discus, with a particular disinterest to white colorations and a favouring for plain, striped and high-bodied discus. Economic valuations for attributes were also substantially high to accommodate wild interests. On the other hand, female non-keepers expressed a particular favouring towards blue, patterned and spotted discus, cultivated varieties and a much lower price, with significantly lower valuations of the product attributes. These results suggest that male keepers may express greater valuation for discus, especially wild discus, due to a more extensive knowledge and interest in the hobby, and females who have not kept discus before preferred tank-bred varieties which are cheaper, relatively easier to keep, and are much less inclined to pay a premium for discus. However, the gender divide seems different within the European market, as the CE results revealed that a group of European keepers, with a tendency to be females, were found to carry cultivated interests for discus instead of wild. Particular liking towards striped and high-bodied varieties, and away from white-colorations was also observed, which is in line with European market preferences in general. This suggests that European female tropical fish keepers may carry a significant representation of the artificially cultivated market that is observed for the European market.

With regards to age group, the CS revealed that younger respondents of the >1990 to 1980-1989 age group tends to prefer metallic colorations, whereas the core working age demographic seems to carry greater interest on wild and deep red varieties, suggesting a potential link to traditional discus markets or older discus keepers with stronger wild interests. As the younger population is more likely to be either amateur hobbyists or the everyday consumer, their preferences may cover more of the artificially cultivated forms, and potentially be a lot more specific and simpler to act on, as there are less factors or criteria that they might be assessing the images for. The working demographic tends to be trade professionals, thus multiple interests for different attributes may be related to breeders who prefer to acquire a large variety of potential discus for breeding purposes, or exporter who would benefit from a larger supply of a variety of discus to meet changes in demand. Moreover, the senior 1940-1949 demographic seems to have placed a high ranking for Red Turquoise. As the variety is part of a historic strain that has been introduced into the market as one of the earliest cultivated discus, respondents that have experienced its introduction in the 1960s to 1970s may have a greater fondness for such discus (Au et al., 2007). Similar for pattern, all other demographic groups apart from the 1940-1949 gave top ranks to the finer striated Blue Snakeskin discus, whereas the senior age group placed similar ranks with the traditional and thickly striated Red Turquoise. However, significant heterogeneity was observed for high bodied shapes, in which the younger >1990 demographic with less discus keeping experience seems to be particularly disinterested and preferred longer-bodied “fish-like” shapes instead. In contrast, the entire working age demographic, from the younger 1980-1989 to the retired 1940-1949, expressed greater interest, indicating potentially more discus keepers, but exhibited a large potential for heterogeneous preferences within groups due to a mix of respondent backgrounds and preferences for discus.

Based solely on fishkeeping experience, discus keepers and other tropical fish keepers expressed certain similarities in the CS, with a favouring towards marine attributes of blue colorations and striations. Yet, discus keepers in particular preferred high-finned and high-bodied discus, especially the Blue Diamond; whereas other tropical fish keepers preferred high-finned discus but with opposing interests to Blue Diamond. This suggests that discus keepers may carry more specific standards for shape, and are potentially more able to identify the morphological variations in discus images than other tropical fish keepers. At the same time, high-bodied discus seems to be a specific interest within the discus community. With regards to other fish keepers and non-keepers, however, the elicited preferences were generally more similar to tropical fish keepers, with a favouring for Blue Snakeskin instead of Blue Diamond for colour, potentially of personal preference, and favouring high-finned discus with opposing preferences for Blue Diamond. Thus, it can be said that respondents outside the discus community carry similar preferences in general, but differences can be observed, and potentially opposing in terms of shape, when compared with discus keepers with specific knowledge between strains.

4.2.1 TRADE PROFESSIONALS

Preferences of trade professionals generally reflect what seems to be most popular in the industry, and particularly what is demanded by their customers. However, in cases where breeding is involved, professionals were found to have considered personal judgement on preferred purchases of particular types that may be useful for breeding purposes, and unusual varieties that they would want to acquire for their stock as well. Typically, the buyer may either purchase discus at a local retailer, or, if they are specialist buyers, wholesale importers or resellers themselves, contact an exporter to supply discus directly to them (Anon., exporter, 2014). As the professional industry largely consists of home breeders, as seen in Malaysia and Singapore, exporters can either be specialist breeders themselves and supply their own discus to customers, partners with a commercial breeder to co-supply their own discus, or carry links with over ten individual contract breeders that supply their discus to the exporter (MOA, 2003; Anon., exporter, pers. comm.). A common strategy among commercial breeders is to keep and develop a variety of strains that might potentially appeal to a wider audience (Anon., breeder, pers. comm.). Thus, this is reflected in the CE results, where Chinese professionals or individuals with specialist background tend to show similar levels of interest to multiple discus attributes, and are significantly more likely to purchase either option given in the survey.

As the market is highly competitive between private and commercial breeders to produce new and improved strains to the market, some breeders may want to export their own discus themselves to ensure a high quality and direct trade to international customers; while minimizing risks of losing perfected bloodlines or genes from their current 'experimentations' to competitors (Livengood et al., 2004; Anon., breeder, pers. comm.). However, as keeping discus professionally is a full time job that involves a long routine of water changes, disease control, feeding, grading and breeding, others may prefer to focus on the breeding, and supplying only to trusted professionals of the trade (Au et al., 2007; Anon., breeder, pers. comm.). With a working relationship between an exporter and multiple contract breeders, this is a strategy to allow independent breeders to gain access or knowledge on what is demanded by the market or the consumer, regardless of whether they are established in the market or not. To exporters, this is also a strategy to obtain a constant, diverse and adaptable supply of discus to ensure that they are prepared to meet any changes in demand (Anon., exporter, pers. comm.). Thus, strong similarities in preferences observed by professionals, professional hobbyists and hobbyists in the CS reflect the results of this relationship, where professionals displayed a general match of preferences to consumer demand within the hobbyist community. However, this was not the case in comparison to the wider public or general consumer outside of the community, which revealed discrepancies in preferences for discus.

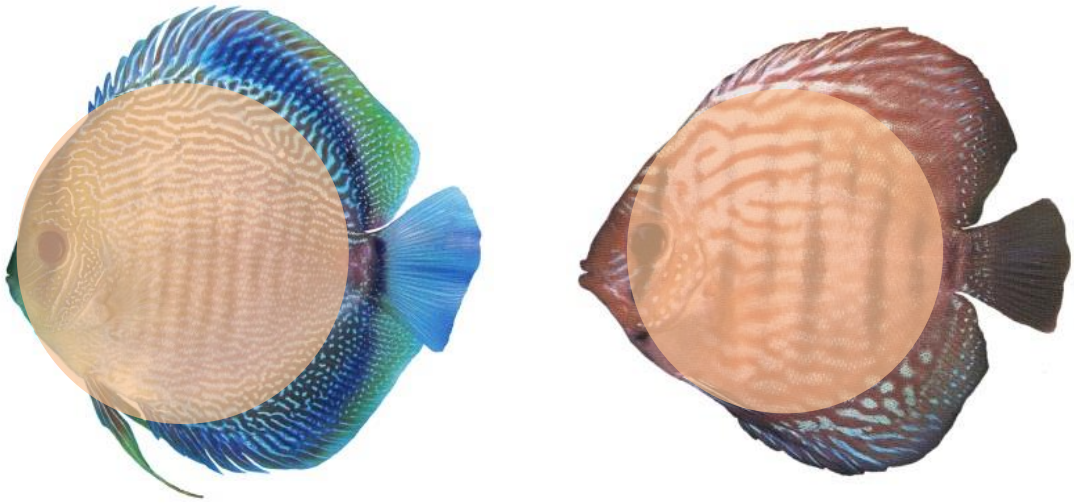
Results from the CE revealed that Chinese professionals expressed a strong preference towards artificially cultivated varieties, with no particular strong preference for colour and pattern characteristics, and away from wild varieties. A slight interest towards high bodied

discus was also seen, though round discus is also accepted. These results directly resemble the Far East Asian demand, where a wide variety of cultivated forms are accepted among different consumers with heterogeneous preferences (Yip, 2002). Thus, professionals and especially suppliers in the Far East markets tend to specialize on perfecting and improving cultivated strains, which would bring greater cash returns with a higher profit margin than wild discus. Some breeders are also known to keep wild forms to outcross individuals and perfect the pattern markings and physical traits (Anon., breeder, pers. comm.). However, these discus are generally acquired in small quantities and are only kept for breeding purposes, as Far East Asian professionals aim to produce larger sized discus; and discus with stronger wild genes tend to be of a smaller body size with an undefined shape (Anon., breeder, pers. comm.). These are observed in the CS results as well, where professionals and professional hobbyists were observed to have placed the seemingly large and high bodied Blue Diamond at much higher ranks for shape, and have placed the less defined and smaller wild forms such as Wild Blue and Heckel at lower rank positions. This reveals that there may be a slight demand by Chinese professionals to want to purchase wild discus for breeding purposes, but not for retail.

When breeders apply quality control measures in the selection of discus, individuals from the brood-stock are sorted and graded based on their potential to exhibit high quality discus features, and to be part of a breeding pair for experimental approaches to cross-breeding (Soh, 2005). Generally the selection will always include an assessment on body shape, and depending on the strain and stage of selection, fish may be sorted further based on fullness of colour and the placement, regularity and clarity of pattern markings (Soh, 2005; Anon, pers. comm.). Thus, these are reflected in the rank orders of CS results, where detailed explanations on rank orders are given, and images are strictly assessed for the representation of their particular traits. In terms of colour, individuals seem to make their assessment based on the uniformity, coverage and intensity of secondary colour characteristics, which is particular important in solid discus (Au et al., 2007; Anon., breeder, 2007). This was observed where high rankings were placed for Blue Diamond in colour, and a relatively higher position between other solid discus for pattern. Uniform and discrete markings for pattern are more desirable than uneven markings as well (Au et al., 2007). Though the Red Spotted Green was asymmetrical in terms of its spots and stripes, the spotting was relatively more distinct with clearer striations than others in the set, thus leading to a high rank position in the CS. Discus are then assessed for their overall roundness in shape and the presence of deformities. The idea is to inspect the entire outline of the fish by visualizing an imaginary round circle for a round discus, and a vertically-placed oval for a high body discus (Au et al., 2007; Figure 4.1). Any points that are not aligned with the circle, caves in, or protrude substantially outward are considered less desirable, ‘smooth’, or ‘round (Au et al., 2007). Overall, the Blue Snakeskin was ranked highest for all three characteristics, suggesting that the fish has met all criteria and is relatively the most preferable among professionals. Others have even expressed their favouring of the fish by

referring to the image as the "only good one," with the best perceived compromise of features among the wide range of different forms of discus attributes represented in the set.

Figure 4.1 Visualizing shape between discus images



Blue Snakeskin [3]
(high finned, considered good quality round)

Heckel [3]
(spade-shaped, does not fit circle)

As breeding facilities are often limited and the process of stabilizing the genes for desired phenotypic characteristics may easily take four to five years, breeders tend to discard the individuals that do not meet the selection criteria, and focus efforts on breeding fish that do carry potential for high qualities (Anon., breeder, pers. comm.). This is in line with CS results on shape, where an overall symmetrical, rounder and high finned Blue Snakeskin, as well as the high-finned Blue Diamond with a seemingly large and high-body shape is most preferred and ranked highly among professionals and professional hobbyists. On the other hand, images with shapes that are less defined, long-bodied and uneven are ranked much lower in the group than others. Certain breeders may also decide to sell these lower graded discus to local retailers to obtain some cash return. However, specialist breeders who have perfected certain traits may be reluctant to do so, as even their deselected fish are considered to be of higher quality, and are genetic carriers of traits where they would prefer not to give access to competitors (Anon. breeder, pers. comm.).

Acceptance towards white discus such as Albino varieties are also observed among Far East Asian professionals in the CE results, with no significant difference between blue/green colorations. This is in line with particular interests observed among breeders, who prefer to take on the challenges in stabilizing the gene and attempt to improve or create a new variety (Anon., hobbyist, pers. comm.). However, this significantly differs to European professionals who tend to stay away from white-based discus due to a lesser demand, and difficulties in breeding to achieve red irises, which are among the main features to reach an up-market value for discus (Anon., breeder, pers. comm.).

Generally, as the Blue Diamond and Red Turquoise are long-standing and common varieties with continuous demand by all types of consumers, commercial breeders tend to keep a constant supply of these fish, and retailers may exhibit interests to acquire these varieties due to their stability in the marketplace (Anon., retailer, pers. comm.). To some professionals, selling these varieties can be a form of security, as they are solid products of interest that would appeal to a wide audience and would ensure some level of cash return (Anon., retailer, pers. comm.). This is reflected in CE results with an overall preference for blue/green and striped discus, followed by red/brown, as well as high interests reflected among professionals in the CS, with a top ranking for Blue Diamond for colour, and a relatively high rank for Red Turquoise for pattern. As Red Turquoise discus could be sold as wild forms as well, further research with a focus on the extent of consumer interest in the current wild discus demand will be needed in order to determine whether Red Turquoises dominate wild interests as well, and assess whether sustainable captures of such varieties may be possible to boost the economic potential of the trade and practices.

At the same time, professionals, especially exporters and retailers, may also show interest if such forms are improved to high quality standards. For Blue Diamonds, specialist breeders may aim to improve strains so that the fish may exhibit a metallic exterior on the body, a trait known as ‘Reflection D’, which is highly appealing to hobbyists and buyers worldwide (Anon, breeder, pers. comm.). By acquiring these varieties, if made available by the specialist breeder, exporters may be able to obtain a specialized supply, and retailers may be able to sell popular strains that may show greater appeal with an improved characteristic than say a typical Blue Diamond (Anon., breeder, pers. comm.). Particular interest is placed towards discus with markings, such as the spotted Leopard Snakeskins which attract a lot of investment from commercial breeders, as these varieties are extremely popular in the Far East Asian market and are very marketable (Au et al., 2007).

4.2.2 PUBLIC END-USERS

In comparison, the general public seemed to elicit preferences that are more direct than what is observed among professionals. A choice between alternatives tends to be made based on the given attributes in the CE, and CS orders were decided relatively quicker due to simpler explanations and a less extensive mental assessment between images. However, as preferences are subjective to the consumer, a high level of heterogeneity was observed among responses.

HOBBYISTS

Aquarium keeping is one of the most popular hobbies worldwide (Livengood & Chapmen, 2011). Internationally, the ornamental fish trade easily supports over millions of enthusiasts (Livengood & Chapman, 2011). Nevertheless, regardless of what is considered ‘high quality’, every enthusiast is entitled to be led by their own standards, and base choices and quality to their own preferences.

Observations revealed that hobbyists often based their choices, and specifically rank orders for the CS, on an aesthetic judgment of how well the acquired fish would look in an aquarium tank (Anon., hobbyist, pers. comm.). Combining both colour and pattern attributes, the hobbyist seem to be able to construct a mental image of the overall appearance of the tank, and would be able to assess whether their chosen discus is of best fit. Although for different reasons, similar preferences seem to be reflected among professionals as well, revealing the strong overlap of the industry's depiction of the general hobbyist market. Looking at the CE results, specialist hobbyists seemed to carry more specific preferences, whereas the general hobbyist had broader interests (LCM 2, Table 3.7). Nevertheless, a clear favouring towards blue/green discus was observed, which was in line with the CS, where both professional hobbyists and general hobbyists expressed top ranks for Blue Diamond, Blue Snakeskin and Red Spotted Green. As such blue/green characteristics are "marine" colours, it is suggested that hobbyists may tend to favour aquatic colorations, which would be in keeping with their aquarium interests.

Similar to other groups, a preference towards brighter colours was observed with hobbyists expressing their choices for Blue Diamond and Blue Snakeskin due to their "bright", "vibrant", "shimmering", "iridescent" and "metallic" appearances. For the Blue Diamond in particular, its metallic exterior or "Reflection D" trait is highly sought out for due to its elegant appearance on the discus, and the attraction of observing the way the colours accentuate and "shine" in the tank with aquarium lighting (Anon., breeder, pers. comm.; Anon., hobbyist, pers. comm.).

Second to blue/green, hobbyists exhibited a relative fondness for red colorations, as seen with CS results of mid-rank positions for Red Turquoise, Pigeon Blood and Super Marlboro Red. As such colorations are known to be able to "stand out" in a tank, these varieties may be of interest to other hobbyists who are looking to have a more colourful tank (Anon., breeder, pers. comm.). These observations are parallel to the CE results as well, where specialist hobbyists expressed the strongest interest towards red/brown colour characteristics, especially European female hobbyists who may be more interested in Red Turquoise due to its wild-related appearances (LCM 2, Table 3.7). This reveals a strong wild market potential among the hobbyist community in the European market, and that the harvesting of discus with colorations that are nearer to red/brown colorations make appeal more to the group of respondents than others. On the other hand, Far East hobbyists seemed to differ by preferring golden over red/brown, exhibiting a preference which is clear among Hong Kong respondents and the strong artificially cultivated market for indifferent colorations as well (LCM 4, Appendix B2).

With regards to pattern, the CS results revealed a distinct interest for discus with patterning for both professional hobbyists and hobbyists, and a lesser interest towards solid varieties. These results are parallel to observations from previous studies, which indicate that hobbyists may tend to prefer discus with markings over solid varieties (Au et al., 2007). The top four ranked images revealed the greatest preference for multi-patterned discus with

both striations and spots, followed by full striations. Looking at the CE, both specialist and general hobbyists who were European females seemed more likely to exhibit such consumer behaviour, as a greater affinity for striped discus was observed due to the market's wild interests (LCM 2, Table 3.7; LCM 4, Appendix B2). On the other hand, Far East hobbyists were more interested in patterned and spotted discus, which are reflective of the market's cultivated discus interests (LCM 4, Appendix B2). Nevertheless, CS results on both markets placed high rankings for Blue Snakeskin. This is suggested to be related to a greater appeal among hobbyists for its colour and pattern combination, with a "blue" colour and "fine striations", which seems to imitate a "ripple effect" of the waves in the ocean. Considering how hobbyists are attracted to discus that appear to be reminders of a marine environment, it may be interesting to evaluate the extent of interest for the wild Royal Blue discus with both striations and a 'brilliant blue' coloration on the body in different international markets (Baensch, 1997). By identifying what types fit demand the best, as long as sustainability at the source is possible and can be managed and maintained effectively, such identifications will be able to provide further opportunities for ways to boost the economic potential of wild-caught discus and its trade.

For shape, all hobbyists seemed to place a high ranking for high-finned discus. No significant inference on body shape was made on the CE, which is in line with the selected images which included a round, long-bodied and less-defined D-body shapes. Regardless, Far East hobbyists were observed with a slightly greater preference towards high-bodied shapes in the CE, expressing their affinity towards modern cultivated discus.

In addition, it appears that the naming of discus varieties may carry potential influences to respondent choice as well. Breeders, especially those from the Far East Asian markets, tend to name their improved strains to make an introduction into the market, and potentially appeal to newer customers who might seek to acquire the latest strain (Anon., breeder, pers. comm.). This is a marketing strategy, as particular word choice may potentially attract a purchase from certain customers more than others (Anon., breeder, pers. comm.). For example, certain specialist varieties of the Blue Diamond are artistically named as the 'Blue Knight'. This is a high-bodied reflective variety that seems to be given its name due to its majestic outlook, stance and metallic appearance (Anon., breeder, pers. comm.). Such varieties are highly sought out among hobbyists, which were evident with strong significant preferences observed for all related hobbyists in the CE, and top rank positions for the Blue Diamond in CS orderings for colour, pattern and to a majority of respondents for shape.

However, for Yellow Ghost, hobbyists were found to have placed the image at a much lower rank position than others. Despite a clear interest towards golden colour attributes in the CE, the CS revealed that the image was disliked for colour, shape and especially for pattern. Respondents seemed to have described their disinterests in the particular fish with subjective perceptions on its appearance, seemingly "weird", "smoked", "bleached", "fake", "unappealing" and "looks dead". This is reflective of current understandings on the demand for Ghost discus, which quickly dropped and is considered to be one of a few strains that are

more difficult to find in the artificially cultivated market due to its lack of popularity (Anon., breeder, pers. comm.). The drop in demand for the original Ghost discus is believed to be related to its dull appearance, which is often dusted due to side-effects from the mutation (Anon., breeder, pers. comm.). However, its name is also speculated to have influenced its unpopularity in the Far East retail markets, especially to those who are of Chinese descent, as its negative symbolism are said to have warded off a lot of potential customers (Anon., breeder, pers. comm.). Thus, breeders who are using the strain for crossing or are selectively breeding the strain for other markets have now renamed it as the 'Silver Dreamer' (Soh, 2005). Nevertheless, other golden varieties may be of greater interest to the group, and may market well for the cultivated trade in the Far East. In contrast, as certain wild discus colorations can be brighter depending on the source of the colony, it would be interesting to test if consumer interest for wild discus may differ in the Far East if artistic names or appreciation are designated, and brighter colour forms are introduced and given as options for choice. As of now, the wild discus available in markets such as Hong Kong are highly minimal, and often do not display much choice. Considering that brightness and overall display in the tank are the main factors towards discus choice among hobbyists, it seems that there may be potential for a greater interest in the Far East Asian market as well.

GENERAL INTEREST

Amateur beginners or everyday consumers with only general interest and basic knowledge to discus were found to have expressed preferential differences to other public consumer groups, and differed the most substantially with the industry's depiction of the market. No significant associations with colour and shape with trade professionals were evident due to varied levels of experience in keeping and determining between discus varieties. Hence, such respondents seemed more likely to have found the CS ordering for shape of greatest difficulty, and challenging to rank without external influences in their preferences. However, by knowing less, there would be significantly fewer factors for respondents to consider trading off for. Thus, apart from shape, it is observed in the CS that the group elicited clearer and more straight-forward preferences in their rank orders.

For colour, the CS results revealed a stronger preference for the Blue Snakeskin, followed by Red Spotted Green and Pigeon Blood, which are higher than those observed for hobbyists and professionals. Nevertheless, this was in line with the CE results, where the working age demographic with general interest expressed a significantly stronger preference for blue/green, followed by red/brown colorations. Respondents described their attraction to Blue Snakeskin due to its "variety of colours" including "blues [and] silvers", and its "nice turquoise blue" outlook. However, as first impressions for discus seem to be commonly related to discus colour, the group seemed to frequently base their choices on a personal favourite colour or shade. This was observed particularly for Blue Snakeskin, where respondents have repeatedly commented about the colour blue as their favourite.

At the same time, low grade Blue Diamonds and Red Turquoises are types that breeders can sell to local retailers in the marketplace. This is particularly evident for China and some parts of Hong Kong as well, where extremely cheap prices may increase the discus' appeal to the everyday consumer for a one-off purchase. These choices can be based purely on personal preference for its appearance, or are attempted for selection to kick start the beginnings of a discus hobby (Anon, breeder, pers. comm.). This is observed in the CS results with mid-rank positions for Blue Diamond and Red Turquoise, revealing a secondary choice as opposed to the top three. However, it is important to highlight the importance of fishkeeping knowledge and responsible aquarium fish ownership, as many first-time hobbyists may tend to buy fish based on their appearance, and thus may not select species that are easy to keep, such as discus (Tsang, 2001). A lack in keeping experience and preparation may lead to unnecessary stress and early mortality of the fish, which would also in turn lead to disappointment and may drive individuals away from the hobby completely (Tsang, 2001). Thus, it is important for potential aquarists to be prepared by obtaining reliable information on the biology of the species, keeping methods and husbandry techniques, and have selected the right type of fish based on their care knowledge (Livengood & Chapman, 2014). It may also be useful to have labels for fish species based on hardiness and experience level, so that aquarists will be able to have a preliminary idea of the care level required before purchases, though such labels will have to be further evaluated for an assessment on universally agreeable criteria.

In terms of pattern, results were similar between groups and particularly the top ranks, with interest placed on Blue Snakeskin and Red Spotted Green. Some respondents revealed their preferences for Blue Snakeskin with similar thoughts to hobbyists, showing a liking to the fish due to being "fine patterned", "variable" in terms of its patterning, and the fact that "will look good under aquarium light". But for shape, the top rank position was tied between Blue Snakeskin, Red Spotted Green and Golden, which carried distinctively different shapes that ranged from a high-finned round body, a high-finned slightly long-bodied to a spade-shaped discus. This creates a spectrum that actually covers a wide range of the variable shapes in the set, thus suggesting that certain rank orders were placed potentially with incorporations of external influences, i.e. personal preferences rather than a systematic judgement of specific characteristics.

4.2.3 ENVIRONMENTAL EMPLOYMENT

Respondents with environmental related employment were found to have expressed similarities with the general interest group. This is potentially due to the fact that both groups may include people who have lesser knowledge on keeping discus, as well as its specific characteristic differences, than hobbyists or professionals within the discus community. However, this group differs to others in the sense that respondents seemed to have performed their choices in association with environmental valuation. Focuses were placed on the wild type characteristic, which exhibits elements of green consumerism by

basing their choices on perceived sustainability and conservation possibilities (Chen & Chai, 2010).

Results from the CE indicated that respondents with environmental employment may tend to have specialist background and wild interests for discus. The group expressed a significant liking for both wild-caught and cultivated wild types over artificially cultivated varieties. During survey conduction, it was also found that such respondents tend to be from the UK market, and exhibit such behaviour by prioritizing their choices based on discus type (wild-caught) first. In such cases where the wild-caught discus was chosen, respondents were found to have expressed a high environmental appreciation for green products, by considering the potential for community conservation and a sustainable wild ornamental trade in their decision-making (Chen & Chai, 2010). This behaviour is in line with understandings of consumer attitudes towards green products, where such respondents seem to have placed a high value on environmental protection in association with the product attribute (Chen & Chai, 2010). This was also observed in the CS, where wild forms such as Red Spotted Green and Red Turquoise were ranked highly in the set for pattern, and surprisingly for Heckel as well, despite its sparse patterning. Thus, it seems that environmental valuation is above other attributes for this group, and physical characteristics come second to their decision-making, which is the opposite of what was observed from most of the discus community, industry and the wider public. This indicates that perceptions and purchasing behaviour by the conservation community show potential discrepancies to current public consumers of the trade. This highlights the importance of obtaining market information on preferences and demand, as there is always potential for high levels of assumptions and discrepancies between the expected and observed results.

On the other hand, respondents who carry an appreciation for natural aquaria, but are less confident to meet the challenges for keeping a wild discus, seem to select for wild type but cultivated options in the CS. These were also reflected similarly in the CS, with cultivated varieties of the Red Turquoise and Red Spotted Green preferred among respondents. This revealed welfare considerations and elements of responsible aquarium fish ownership in their decision-making, based on confidence levels of care knowledge.

However, environmental valuation was also observed among respondents who selected for a focus on artificially cultivated varieties in the CE as well. In such scenarios, respondents may have incorporated an idea of conservation with perceptions to “leave the wild populations alone” and away from possible threat (Anon., hobbyist, pers. comm.). This was observed among individuals who believe that the wild population for discus should not be touched due to recent claims of potential conservation issues in the Amazon (Livengood et al., 2004). By focusing on the cultured industry, tank-bred varieties that are less sensitive and more adapted to a tank environment may be better alternatives for the trade, and may allow wild populations to recover naturally. This was observed among CE and CS results, where top ranked images were mainly artificially cultivated varieties. However, as wild-caught populations at some localities were found to show prospects of sustainability,

educating and encouraging the wider public on the benefits of supporting sustainable livelihoods and local income generation at traditional markets may be beneficial to minimize the stigma on all wild-caught alternatives.

These observations give rise to the recurring topic on eco-labelling of farmed or harvested origins for ornamental fish. In this case, such results reveal that a label or indication of the species type and source may influence consumer behaviour and choice, and is potentially worth being applied into the end-user markets. This way, consumers will be able to know the species origins before their purchases, and will be able to make considerations based on species type to determine the expected care knowledge and associated challenges, if any, in their upkeep. At the same time, it will provide a chance to increase public exposure to the sustainable forms of the wild-caught trade, provide greater economic potential with increased pathways and consumer base to sustain the trade, and promote local incentives to participate in the practice. But further research on the application and impacts from different types of eco-labelling will be needed to determine the extent of direct influence on consumer behaviour, and to assess the effectiveness of such strategies in promoting conservation and responsible aquarium ownership.

4.3 OTHER INFLUENCES TO CHOICE

4.3.1 QUALITY ASSESSMENT WITH JUDGING STANDARDS

All in all, trade and hobbyist shows that hold discus competitions often attract a large crowd of enthusiasts and potential aquarists of the wider public. These shows provide an important platform for spreading reliable information on care knowledge, and encouraging consumer attitudes and respect for ornamental fish through artistic appreciation, which would hope to increase incentives for welfare considerations. They also do their part in the growth and management of the artificially cultivated market by pointing actors in directions to promote environmentally friendly, ethical and sustainable businesses (Aquarama, 2013). In addition, these events would allow for the establishment of communication between traders to share knowledge of the trade and improve professionalism with updates such as on certification, international standards for aquaculture, and new and improved husbandry techniques that would better the quality and not threaten the vitality of their fish (Aquarama, 2013). Thus, these events have taken part in providing great opportunities to impact public attitudes, enhance interest on ornamental fish, spread conservation awareness, and allow for better management of the industry.

Observations revealed that respondents who are international discus judges, or either professionals or specialized hobbyists that breed for show discus, are often more able to identify specific discus characteristics, and differentiate between images with minimal biases or influences from other characteristics that are not the subject of the CS. This is reflected with detailed comments and systematic explanations of their rank orders, particularly in terms of body shape, where amateur hobbyists or everyday consumers may

find the feature difficult to differentiate between images. This is primarily related to varied levels of understanding on international judging criteria, of which individuals associated with the competition may exhibit greater familiarity and understanding of minute variations. Judges are generally given strict guidelines and are trained to filter and assess each characteristic on their own (Anon., judge, pers. comm.). On the other hand, breeders have developed years of experience in refining and improving strains to meet quality championship standards (Anon., breeder, pers. comm.).

An example of judging standards and criteria used to assess between entries are observed in Table 4.1. The criteria shows greater assessments on factors associated with morphology than other characteristics. Hence, it can be understood that respondents with some familiarity on judging standards may express greater abilities to differentiate between shape, and potentially higher standards on their purchases for discus.

However, judging standards may vary between international competitions due to different organizers and market interests (Au et al., 2007). This was observed at the attended hobby and trade shows, where greater emphasis on the showcase of wild discus was observed in European events with the inclusion of a wild or wild-hybrid discus show class, and lesser to none at events in the Far East with interests primarily in cultivated varieties.

Table 4.1 Judging criteria and assessment for international discus competitions

Criteria	Assessment
Overall impression	Expressiveness of the fish, behaviour in the aquarium tank
Body size	Overall size and mass of the fish
Proportion	Round or high bodied, any bulging forehead or indentation
Fins, tail	Perfect development of fins, tail and gill covers
Eyes	Shape, colour and brightness of eyes
Body marking	Uniform distribution/pattern of stripes/red spots over the body and fins
Colour	Clarity, uniformity and brightness of body colours

The listed criteria were set and derived by the Taiwan Discus Association for the Taiwan International Discus Awards 2011 (TDA, 2011).

Particular differences can be seen with the judging of high-bodied discus, which will often gain higher points in the Far East shows than European shows due to a lack of interest with its significant change away from the “original discus shape” (Anon., breeder, pers. comm.; Anon., hobbyist, pers. comm.). This directly reflects the dichotomy in international consumer preferences and demand for discus, with the former favouring on appreciation of the traditional forms, and the latter on modern forms and genetic artists. With regards to the newly mutated albino Altum Blue Diamond super high fin form, which was entered and showcased in the open class category in Aquarama 2013, despite its revolutionary technique of maintaining a round D-body, such varieties are most likely ineligible in European shows, and were observed to be significantly less accepted among respondents from traditional consumer markets, such as the USA or UK (Anon., exporter, pers. comm.; Anon., hobbyist, pers. comm.).

A review of internationally awarded discus also highlighted a trend in presenting Grand Champion titles to those with patterns, striations or spots, with very few exceptions (Au et al., 2007; Figure 4.2). At Aquarama 2013, judges seem to have placed an exception by awarding a solid red discus as the Grand Champion (Figure 4.2). Yet, as a uniform coloration is much harder to perfect for solid red and yellows than blues, judges may have given allowances to accommodate the level of difficulty that is placed in producing such a fish (Au et al., 2007). Nevertheless, the general trend is still reflected in the CS summary of results, as well as professionals who may be international judges or show fish breeders, with a clear favouring towards discus with patterning and top ranks placed for the Blue Snakeskin, followed by Red spotted Green. These trends are most likely related to an understanding that patternations are often the most difficult for breeders to perfect, particularly in terms of the shape, colour and distribution of markings (Au et al., 2007; Anon., exporter, pers. comm.). Among the most popular are spotted discus, which refers to high-body cultivated forms including the Leopard, Leopard Snakeskin and Ring Leopards for the Far East shows, and a special interest towards Red Spotted Green for the European shows; a wild type with both striations and spots (Au et al., 2007). Both results are in line with preferences observed for the CE, with an overall stronger interest towards spotted discus for Singapore and Hong Kong, and preferences for striations with some interest towards spotted discus in the UK as well.

Figure 4.2 Winning show fish in the UK and Singapore

Ring Leopard (BIDKA)
(Source: Wan, 2012)

Grand Champion (Aquarama)
(Source: Watson, 2013)

However, preferences and valuation for discus can be particularly different between sales and judging (Au et al., 2007). Championship discus would need to fulfil strict criteria and standards, whereas a greater variety of discus are acceptable for retailing purposes, and express greater possibilities to appeal to the wider public due to heterogeneous interests (Anon., breeder, pers. comm.). Thus, extended comparisons among professionals are suggested to examine the distinct differences between discus bred for championship qualities and discus for retail purposes. Observations on the feedback of both types of discus in the wider community would also be of great interest.

4.3.2 WELFARE CONSIDERATION

STRESS INDICATORS

Certain colorations were found to have driven consumers away from choosing particular images. Discus are typically known to show dark and intense coloration when stressed and in poor health, with indicators for health related to dark colorations in the body and enlarged eyes (Au et al., 2007). For wild discus, the melanin bars are also known as 'stress bars', which tends to be an indicator of such situations. However, if the discus is artificially cultivated, the melanin is reduced to an extent that the bars appear to be invisible and the indicator will no longer be effective. Nevertheless, when such dark colorations are observed, respondents may be less inclined to place a higher ranking for images of discus that appear to be darker, or would remind them of signs of bad health. This is often the case for Heckel, where its patchy coloration and enlarged eyes may lead to less interest among respondents. Overall, this indicates an association to welfare considerations by keepers with care knowledge on discus, and reveals elements of responsible aquarium fish ownership. This suggests the presence of a generally well-informed and responsible community for keeping ornamental fish, which reflects well on the sustenance and management of the cultivated trade.

COLOR ENHANCEMENTS

Natural colour enhancements tend to be used by breeders as a tool for selection (Au et al., 2007). Currently, these enhancements are derived from organic sources, and applied with a controlled dosage and effect to aid breeders in performing an earlier selection of better quality discus out of a large brood-stock (Au et al., 2007). As young fish may potentially possess full and complete colour pigmentations seen in an adult, colour enhancements are used to accentuate colour features temporarily, and to be able to sort and identify individuals with greater potential for higher quality discus.

However, the use of hormones is a sensitive and controversial method that is highly frowned upon across the professional industry (Au et al., 2007). Regardless, some breeders may still use hormones for a quick fix and short-term sales, resulting in extreme and unnatural colorations. For example, by treating a discus with testosterone, blue pigmentation on the body is enhanced, but in time the fluorescent blue coloration will fade away, potentially decolorizing the water in the tank if overmedicated, and may even result in the death of the discus (Au et al., 2007).

Thus, certain images such as the Yellow Ghost with an unusual and sharp colour combination seemed to have warded off potential customers, and discouraged particular respondents to place a high ranking for the fish. One respondent from the USA, also a traditional consumer market with an affinity for natural aquaria, expressed that he might actually tend to believe that this is a "hormone fish" as it seemed "too unnatural" to be developed through natural cross-breeding methods. This is directly reflective of consumer

attitudes associated with welfare considerations, where respondents have been observed to show indications of distaste towards the use of such measures, and will generally prefer not to purchase options that would remind them of it. This reveals an evident awareness of such issues, and highlights the regulatory potential of the trade with buyers actively choosing not to purchase associated products and not fuelling demand for such products. However, as many cases of hormone treatments relates to the Far East Asian markets, particularly in China, increased awareness on the impacts of such issues in the related markets will be needed to protect the health and vitality of ornamental fish produced.

4.4 SURVEY EVALUATION

4.4.1 SURVEY VERSION

In this study, surveys were conducted in different language versions and types. Despite variations in sample size, survey language was found to have expressed minimal influences in results, with no strong variations between rank orders. All differences observed were mainly associated with greater representations of particular respondent groups, such as those of Chinese descent to be able to complete the Chinese survey. Thus, this suggests that survey language had minimal impacts to results, and is most likely not related to potential errors related to translation.

However, significant differences were observed for survey type. Greater representations of particular respondent groups and a significant smaller sample size for online surveys could also be the principle sources behind this variation. Yet, for online surveys, display errors were encountered online, and have affected respondents based on reasons unknown. Recommendations to use a particular internet browser were placed on the site to minimize such occurrences, and all incomplete data from the online surveys were excluded from the analyses to prevent biases. Nevertheless, such display errors may have played a part in the variances between online rankings of images as well. Thus, this issue should be taken into account, and made aware for future studies on applying picture sorts online. But with all things considered, the CE results revealed no significant differences based on paper and online surveys apart from differences in representations of respondent groups. Thus, the online survey that was used in the study was deemed more effective as an alternative to paper and face-to-face exercises for the CE than the CS.

4.4.2 PREFERENCE ELICITATION

The study revealed that survey completeness by respondents placed minimal impacts to results. This suggests that the preferential differences observed were not a result of cognitive burden, and respondents were able to elicit their preferences adequately regardless of survey length. The CE and CS also expressed consistent findings that are in line with previous understandings of the market, thus implying that such methods are effective measures to obtain market information for the discus trade.

With regards to monitoring wildlife trade, both approaches can act as a good starting point to obtaining base knowledge information for conservation planning and trade management. Essentially, results from the CE reflect how people prioritize one attribute over another, form an understanding on attribute importance and valuation, and predict choice behaviour by sectors or target groups in more a refined level. As such, these methods could be used to obtain an understanding on demand and behaviour by investigating the main incentives and drivers for groups to act on a particular event. For example, instigators to purchase a highly traded product i.e. shark fin, can be identified by assessing whether Chinese consumers of different socio-demographic groups would choose to purchase options based on e.g. rarity, taste, origin, price or size. By performing latent class modelling approaches, consumer perceptions on shark fin as a product could be understood, and main target groups that drive the demand for particular attributes of concern i.e. rarity can be highlighted to focus conservation actions and potentially behaviour change interventions. In a different perspective, CEs could also be used in policy development to understand the incentives for people to elicit a particular sensitive behaviour. For instance, studies have looked into understanding the behaviour towards hunting or trading bushmeat, with assessments based on factors such as patrolling frequencies, range of fines and daily salaries to identify the main push factors and priorities of concern that act behind their choices to perform an illicit behaviour (Nielson et al. 2013).

On the other hand, results from the CS can help understand individual mindsets on an issue, determine the basis of how people judge and perform their decisions, and identify attribute-specific prioritizations in choice-making. Such methods will allow an understanding of the way groups perceive subjects in reality, and the way trade-offs are performed. For example, consumer groups could be presented with a scenario to make choices between five ivory-based and tagua nut products. By assessing their order of preference based on, for example, the product itself and ivory fluorescence, it would be interesting to see if the ingredient makes a difference in their choices, and assess if such alternatives may work.

Nevertheless, observations revealed certain limitations to both methodologies which should be taken into account for further studies.

LIMITATIONS

The CE is conducted where both choice alternatives are expected to show no health problems and deformations, with discus options expressing optimal or perfect representations of characteristics for each phonotypic attribute. However, unlike an electronic product where specifications are standardized and can only mean one thing or another, i.e. either Windows or Macintosh for computers, the characteristics or expression of physical traits in live animals are often imperfect, more complex in reality, and highly variable for each individual. When consumers are faced with their choices in reality, different trade-offs may be performed and incorporated within their decision-making based on a refined judgment of attributes. For example, between two high-bodied discus,

individuals may prefer one over the other due to specific shape requirements such as a smooth forehead and overall symmetry. Hence, unless the choice set includes a large number of attributes, which may in turn become exhaustive or induce cognitive burden to respondents, heterogeneous preferences for discus can only be investigated to a certain degree.

On the other hand, picture sorts are able to overcome this issue by observing trade-off behaviour between real discus fish, and tracing changes in preference when a particular characteristic is not fully represented or potentially outweighed by other features that appeal more to the consumer. This technique is primarily effective in the sense that it provides a visualization of discus options of which the designed CE and especially unlabelled CEs are less able to offer. However, the use of real photographic images in card sorts can carry limitations that may impact results on elicited preferences. One of the major factors to consider are scan resolution and printing quality, which could alter the colorations and display of the image. In this study, to ensure that images are analysed and exhibited to the best quality possible, scans were made through a photographic printer and images were printed in photographic quality.

Sorting between real discus fish is particularly advantageous in the sense that it directly represents what is being sold or observed in the marketplace, and would allow detailed and extensive inferences to be made on preference elicitation. However, as phenotypic variations among discus can become complex and highly variable, respondents may experience difficulties to focus on rank orders for one specific characteristic without applying subconscious influences or biases from other attributes. Such occurrences were observed in the results, where high associations between rank orders for all three characteristics suggest an overall preference for discus, and correlations between colour and pattern suggest potential incorporations of both characteristics in rank orders. At the same time, this could in fact be a reflection of common consumer behaviour observed in the marketplace, when individuals are met with potential choices of similar interest, and are inclined to make prioritizations and trade-offs based on other characteristics. Nevertheless, when these situations occur, the final decision could either be derived systematically with incorporations of other characteristics, from personal preferences such as a favourite colour, or potentially just randomly due to chance (Anon., hobbyist, pers. comm.). This may induce biases in rank orders, thus impacting results and corresponding inferences on preferable attributes between consumers. Conversely, as the CE is based on specific and labelled attributes, the preference elicitation process is a lot clearer and simpler in comparison. The CE is also in line with economic demand theory, which allows economic valuations of each specific attribute to be expressed (Verissimo et al., 2009). In this sense, the CE has a greater advantage where respondents can focus on factual statements of characteristics, and assess whether a specific attribute has greater importance to them or not.

It was also found that swimming performance and behaviour of the fish carries great importance to customers when making a choice between similar options (Anon., hobbyist, pers. comm.). For discus, this is a factor that is included among international judging criteria, and is also a selection criterion among breeders as they systematically sort and grade between young fish for quality (Au et al., 2007; TDA, 2011). As one of the major appeals of the discus hobby is related to its swimming posture and stance, a 2D image of a discus will be unable to capture this factor that is observed in the marketplace, let alone a specific labelled attribute. Nevertheless, an assessment on swimming performance is ineffective to be included in market surveys as it is very specific, potentially subjective, and are generally of tertiary importance to consumers after all other attributes are considered (Anon., hobbyist, pers. comm.). Moreover, accurate judgments can only be made when respondents are placed face-to-face with their options, and unless the differences are significant, variations are potentially only identifiable to consumers that carry specific requirements for their purchases; primarily those with an extensive knowledge and experience with keeping discus (Anon., breeder, pers. comm.).

4.5 CONCLUSION

The international market demand for discus is generally split between preferences for wild forms and cultivated varieties. CE results suggest that discus colour seemed to be the most influential attribute to consumer choice, followed by discus type. Price seemed to be of least concern to consumers, and is of secondary importance to discus appearance. The most favourable attributes across the international community include blue/green colorations, striated patterning and artificially cultivated varieties. Slight preferences towards high-body shapes were expressed, but heterogeneity was evident among sample populations. The CS observed preferential differences in colour, pattern and shape, with the greatest heterogeneity for Blue Diamond, Blue Snakeskin, Red Turquoise and Yellow Ghost varieties across groups.

Heterogeneous preferences were observed between international markets. The UK, representative of a traditional end-user market, expressed both wild and artificially cultivated interests for discus. However, a strong wild influence is still present in the market, revealing great market potential and potential large consumer base for the trade of sustainably harvested wild-caught discus. Thus, the accepted cultivated forms are generally restricted to varieties that resemble the wild discus, such as Red Spotted Green and Red Turquoise, or early cultivated strains such as the Blue Diamond and Pigeon Blood. Malaysia, a supplier for discus, expressed extensive interests to multiple characteristics and strains, but carried a significant focus on artificially cultivated varieties. Hong Kong, a specialized end-user market, also carried a main focus on artificially cultivated varieties with some room for wild discus to be of interest, though a dichotomy in the demand between highly priced quality discus and cheaper alternatives was observed. Singapore, an end-user market and exporter for discus, expressed interests with elements of preferences from both European and Far East Asian markets, meeting demand to both wild and cultivated trades.

Further differences in consumer preferences were observed between respondents of different socio-economic and cultural backgrounds. Results were significant for gender, age group and fishkeeping experience. Heterogeneous preferences were observed between trade professionals and different public consumer groups. Traders expressed broad interests for discus, and met consumer interests and demand for both wild and cultivated discus by hobbyists within the discus community. The greatest variation was observed between traders and the general consumer, with specific interests for lower priced cultivated varieties. A preferential divide was observed within the conservation community, which exhibited similarities to specialist hobbyists with wild interests, and the general consumer with cultivated interests.

Choice experiments and card sorting results were consistent, and both techniques seem to complement each other to minimize methodological limitations. Survey language and the extent of survey completeness did not impact results. However, significant differences were observed for paper and online versions. Nevertheless, both methods were deemed effective in obtaining an understanding on consumer preferences and market demand for discus. Thus, if used in a wider context, these methods can therefore help in the monitoring of wildlife trade by facilitating the mitigation of factors that could result in over-exploitation of wildlife populations. By obtaining an understanding on consumer attitudes that influence choice behaviour and mindsets behind the decision-making, an assessment on the drivers of consumer demand can highlight the associated factors and target groups that need to be addressed for trade management, and provide base knowledge on the market situation for more effective planning of other management measures.

4.6 RECOMMENDATIONS

Continued research in the observed markets will be beneficial to monitor changes in market preferences, demand and trade levels over time. Larger sample sizes of markets are suggested to obtain greater representations of consumer preferences, and a more reflective portrayal of market interests.

Further research with larger representations between different actors of the supply chain will be needed to identify gaps of knowledge and market information among professionals of the industry – from suppliers in source countries to retailers in end-user markets. Particular interest is placed on defining the market potential for wild varieties, where extensive studies could be conducted from collectors to retailers, to determine the extent of current consumer demand for the species. Consumer interests for particular wild discus varieties between international markets will also need to be measured to identify potential end-user markets, and populous discus varieties of high interest to attract a larger consumer base and meet potential consumer demand. This will provide an evaluation on the effectiveness of using discus collections as a tool for community conservation, and suggest potential ways to improve consumer demand for varieties that are not experiencing population declines and are suitable for the trade.

Further research and focuses in other end-user markets will also be of great interest to observe potential differences in consumer demand, and provide an overview of the international market at a wider aspect between geographical regions. Particular efforts can be placed in monitoring the status and change in demand for longstanding markets, with reference to traditional consumer countries such as the USA and Germany, main consumer markets such as Japan, and especially emerging markets, such as Spain and the Middle Eastern countries, to define the market potential for different discus varieties (Ploeg, 2013a).

CE designs can be improved by incorporating information of consumer preferences observed in the current card sort for the studied markets. A suggestion would be to include traits that were deemed 'less preferable' to consumers as well, such as the long-bodied or mango-shaped discus, to observe the extent of disinterest and potential interest among particular respondent groups. This inclusion will allow the CE to cover a larger range of possibilities, and paint a picture that can provide a relatively more well-rounded review of the present markets. An opt-out option in choice sets will also be beneficial to provide respondents an option to choose the status quo when both choice alternatives are not desired (Kontoleon & Yabe, 2003).

Experimentations on CS exercises that use monochrome outlines of different discus patterns and shapes are also suggested for continued studies. This will provide a clearer portrayal of differences in phenotypic characteristics, and allow respondents to focus on preferences for specific physical features; while minimizing errors and biases sourced from subconscious influences from other visible characteristics of the image. Greater emphases on the qualitative aspects of the CS exercises is also recommended to allow for an extended review and more in-depth analysis of consumer attitudes and perceptions towards particular attributes of the product.

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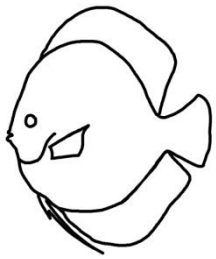
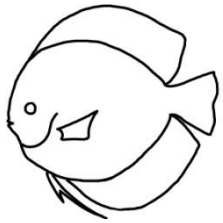
Appendix A Key designed for the reference sheet for choice experiments

<table>
<tr>
<td>WILD DISCUS
 
e.g. Heckel[5]
(Symphysodon discus discus)</td>
<td>PLAIN DISCUS
 
e.g. Blue Diamond[3]
(Solid Blue)</td>
<td>PATTERNED DISCUS
 
e.g. Pearl Pigeon Blood[3]</td>
</tr>
<tr>
<td>STRIATED DISCUS
 
e.g. Red Turquoise[1]</td>
<td>SPOTTED DISCUS
 
e.g. Leopard Snakeskin[3]</td>
<td> 
HIGH BODY
 
ROUND</td>
</tr>
</table>

All photographic images were scanned and referenced from printed books, and edited on Adobe Photoshop CS6. Illustrations for body shape were made on Adobe Photoshop CS6.

Appendix B CE results of other latent class models from the selected set

LCM 4: Market regions – European versus Far East Asian hobbyists

Appendix B1 Measures of model fit from gender, age group, the Far East Asian market and hobbyists

Model	K	LL	AIC	BIC	AIC3	Pseudo R^2
MNL	11	-9082.287	18186.574	9117.129	18230.573	0.084
LCM 2	27	-8247.070	16548.139	8161.546	16332.139	0.168
LCM 3	43	-7973.725	16033.449	7837.521	15689.449	0.196
LCM 4	59	**-7748.603**	**15615.206**	7561.719	15143.206	**0.218**
LCM 5	75	-7752.116	15654.233	**7514.552**	**15054.233**	0.218

Note: K = number of parameters estimated. LL = model log likelihood. Models with information that were most statistically efficient were bolded for each criterion.

Model shows an extended overview on heterogeneity within the international hobbyist community. Marginal improvement further minimized at a delta BIC of 47.2 units ($p < 0.01$) and delta AIC3 of 89.0 ($p < 0.01$) between four and five segments, indicating optimality at five segments.

The five-segment LCM was significantly predicted at: $X^2 = 4382.815$, df = 75, $p < 0.001$.

Appendix B2 Five class LCM on gender, age group, the Far East Asian market and hobbyists

Attribute Levels	Coefficients per segment				
	1 (28.8%) Mix with wild interest	**2 (8.4%) European female hobbyists**	**3 (41.2%) Far East hobbyists**	**4 (11.6%) Young females**	**5 (10.0%) Older male non-hobbyists**
	Utility Function: Discus Attributes				
ASC	0.846*** (0.19)	0.097 (0.31)	-2.262*** (0.16)	-4.035*** (0.31)	0.981** (0.39)
C: Blue / Green	1.243*** (0.11)	2.089*** (0.22)	0.721*** (0.09)	1.578*** (0.27)	0.309 (0.55)
C: Red / Brown	1.393*** (0.09)	0.919*** (0.21)	0.404*** (0.06)	1.025*** (0.22)	0.576 (0.46)
C: Golden	0.755*** (0.13)	0.653*** (0.25)	0.651*** (0.12)	1.048*** (0.25)	0.581 (0.39)
C: White	-	-	-	-	-
P: Plain	0.376*** (0.13)	-0.237 (0.23)	-0.493*** (0.11)	-0.681*** (0.27)	-0.058 (0.39)
P: Patterned	-0.117 (0.14)	0.041 (0.22)	0.031 (0.10)	0.419 (0.24)	-0.208 (0.35)
P: Striped	0.476*** (0.15)	0.357* (0.20)	-0.236* (0.14)	-0.388 (0.15)	0.454 (0.34)
P: Spotted	-	-	-	-	-
S: Round	-0.536*** (0.07)	-0.186 (0.15)	0.145* (0.08)	-0.208 (0.21)	-0.183 (0.23)
S: High Body	-	-	-	-	-
T: Wild Caught	1.071*** (0.10)	-1.262*** (0.30)	-0.277*** (0.08)	-0.245 (0.29)	-1.460*** (0.47)
T: Wild Type, Cultiv.	0.480*** (0.13)	-0.763*** (0.21)	0.032 (0.16)	0.057 (0.005)	-0.857** (0.39)
T: Artificially Cultiv.	-	-	-	-	-
Price	0.005* (0.002)	-0.003 (0.004)	0.002 (0.002)	-0.066*** ()	-0.013** (0.01)
	Segment Membership Function: Consumer Characteristics				
Intercept	1.161 (0.92)	-1.874 (1.19)	1.391 (0.87)	-1.270 (0.99)	-
Gender	0.088 (0.47)	1.150** (0.55)	-0.216 (0.43)	1.572*** (0.47)	-
Age Group	-0.120 (0.16)	-0.063 (0.21)	-0.235 (0.15)	-0.327* (0.18)	-
Far East Market	-0.249 (0.41)	-1.171* (0.62)	1.099*** (0.37)	0.407 (0.45)	-
Hobbyist	0.447 (0.41)	1.040* (0.61)	0.754* (0.39)	0.075 (0.45)	-

*Significance levels are indicated as * for p < 0.10, ** for p < 0.05 and *** for p < 0.01. Standard errors are quoted in parentheses.*

Where () = potential or tendency for a group to be represented in a way:

Segment 1: Mixed (mixed gender) (mixed age) (slight > European) (> hobbyists)

Segment 2: Female, European, hobbyists (mixed age)

Segment 3: Far East, hobbyists (slight > males) (slight > young-mid)

Segment 4: Female, young-mid (> Far East) (mixed classes)

Segment 5: Male, mid-old, non-hobbyist (mixed markets)

Appendix B3 Segment specific valuation (WTA) of discus attributes associated with gender, age group, the Far East Asian market and hobbyists

Attribute Levels	**Coefficients per segment**				
	1 (28.8%) **Mix with wild interest**	**2 (8.4%)** **European female hobbyists**	**3 (41.2%)** **Far East hobbyists**	**4 (11.6%)** **Young females**	**5 (10.0%)** **Older male non-hobbyists**
C: Blue / Green	-260.319* (-551.85, 31.21)	-745.068 (-1303.39, 2793.53)	-333.658 (-1022.82, 355.51)	-23.981*** (16.58, 31.38)	-23.576 (-53.95, 101.10)
C: Red / Brown	-291.768* (-623.23, 39.69)	-327.899 (-578.26, 1234.05)	-187.052 (-618.53, 244.43)	-15.583*** (8.48, 22.69)	-43.964 (-36.76, 124.69)
C: Golden	-158.084* (-339.81, 23.06)	-233.050 (-457.66, 923.76)	-301.191 (-908.17, 305.79)	-15.919*** (9.71, 22.12)	-44.344 (-25.53, 114.22)
C: White	-	-	-	-	-
P: Plain	-78.814 (-195.69, 38.06)	84.536 (-358.37, 189.30)	228.082 (-255.70, 711.87)	10.343*** (-18.05, -2.63)	4.417 (-62.90, 54.07)
P: Patterned	24.460 (-42.06, 90.98)	-14.769 (-151.22, 180.76)	-14.273 (-117.83, 89.28)	-6.365 (-1.83, 14.56)	15.885 (-68.12, 36.35)
P: Striped	-99.640 (-230.59, 31.31)	-127.166 (-246.60, 500.93)	109.220 (-89.98, 308.42)	5.900 (-13.11, 1.31)	-34.651 (-22.66, 91.96)
P: Spotted	-	-	-	-	-
S: Round	112.241* (-12.87, 237.35)	66.440 (-271.39, 138.51)	-67.184 (-261.05, 126.68)	3.168 (-7.65, 1.32)	13.949 (-52.66, 24.77)
S: High Body	-	-	-	-	-
T: Wild Caught	-224.319* (-489.38, 40.74)	449.935 (-1753.03, 853.16)	128.363 (-146.20, 402.93)	3.720 (-10.16, 2.72)	111.391 (-255.38, 32.60)
T: Wild Type, Cultiv.	-100.643 (-223.07, 21.79)	272.213 (-1017.11, 472.68)	-14.771 (-153.61, 124.06)	-0.868 (-7.78, 9.51)	65.337 (-155.21, 24.54)
T: Artificially Cultiv.	-	-	-	-	-

*Significance levels are indicated as * for p < 0.10 (note: considered insignificant for WTA), ** for p < 0.05 and *** for p < 0.01. 95% confidence intervals of the estimates are quoted in brackets.*

LCM 5: Within the European market – United Kingdom

Appendix B4 Measures of model fit for gender, UK residents, discus keepers and survey completeness

Model	K	LL	AIC	BIC	AIC3	Pseudo R^2
MNL	11	-9082.287	18186.574	9117.129	18230.573	0.084
LCM 2	27	-8248.285	16550.571	8162.762	16334.571	0.168
LCM 3	43	-7975,965	16037.929	7839.761	15693.929	0.195
LCM 4	59	**-7747.357**	**15612.715**	7560.473	15140.715	**0.219**
LCM 5	75	-7747.358	15644.716	**7509.793**	**15044.716**	0.219

Note: K = number of parameters estimated. LL = model log likelihood. Models with information that were most statistically efficient were bolded for each criterion.

Marginal improvement minimized further at the fifth segment, with a delta BIC of 50.7 units ($p < 0.01$) and delta AIC3 of 96.0 units ($p < 0.01$) between four and five segments, thus indicating optimal solutions at five segments.

The five-segment LCM was significantly predicted at: $X^2 = 4333.039$, df = 75, $p < 0.001$.

Appendix B5 Five class LCM on gender, UK residents, discus keepers and survey completeness

Attribute Levels	Coefficients per segment				
	1 (22.4%) Males with wild interest	**2 (6.6%) Other fish keepers & non-keepers**	**3 (30.9%) Outside UK 1**	**4 (22.3%) Outside UK 2**	**5 (17.8%) UK discus keepers**
	Utility Function: Discus Attributes				
ASC	0.910*** (0.20)	-11.569 (1.69)	-1.874*** (0.16)	-2.356*** (0.21)	0.589*** (0.20)
C: Blue / Green	1.511*** (0.13)	2.986*** (0.79)	1.902*** (0.16)	-0.046 (0.16)	0.712*** (0.15)
C: Red / Brown	1.492*** (0.10)	2.016*** (0.72)	1.253*** (0.11)	-0.246** (0.10)	0.654*** (0.14)
C: Golden	0.959*** (0.15)	-0.285 (0.60)	1.168*** (0.15)	0.178 (0.17)	0.453*** (0.17)
C: White	-	-	-	-	-
P: Plain	0.460*** (0.13)	-2.074*** (0.57)	-0.660*** (0.16)	-0.360** (0.15)	0.043 (0.17)
P: Patterned	-0.226 (0.16)	-0.108 (0.45)	0.11 (0.15)	0.103 (0.14)	0.038 (0.17)
P: Striped	0.319* (0.17)	-5.852*** (1.23)	0.093 (0.17)	-0.329* (0.18)	0.405** (0.16)
P: Spotted	-	-	-	-	-
S: Round	-0.770*** (0.09)	-2.817*** (0.69)	-0.005 (0.11)	0.249** (0.11)	-0.251*** (0.09)
S: High Body	-	-	-	-	-
T: Wild Caught	1.199*** (0.11)	-1.932** (0.84)	-0.801*** (0.14)	-0.098 (0.11)	-0.572*** (0.13)
T: Wild Type, Cultiv.	0.626*** (0.14)	-1.396** (0.68)	-0.161 (0.19)	-0.098 (0.22)	-0.762*** (0.16)
T: Artificially Cultiv.	-	-	-	-	-
Price	0.011*** (0.002)	-0.158*** (0.02)	-0.012*** (0.003)	0.006* (0.003)	-0.011*** (0.003)
	Segment Membership Function: Consumer Characteristics				
Intercept	0.989 (0.80)	-1.062 (1.34)	1.124 (0.71)	2.683*** (0.80)	-
Gender	-0.788** (0.38)	0.696 (0.56)	-0.126 (0.33)	-0.477 (0.37)	-
United Kingdom	0.226 (0.32)	-0.526 (0.57)	-0.625** (0.30)	-1.680*** (0.36)	-
Discus Keepers	0.127 (0.32)	-1.551*** (0.58)	-0.406 (0.30)	-0.239 (0.33)	-
Surv. Completeness	0.003 (0.33)	-0.066 (0.56)	0.051 (0.31)	-0.739** (0.33)	-

*Significance levels are indicated as * for p < 0.10, ** for p < 0.05 and *** for p < 0.01. Standard errors are quoted in parentheses.*

Where () = potential or tendency for a group to be represented in a way:

Segment 1: Male (> UK) (slight > discus keepers) (mixed completeness)

Segment 2: Discus keepers (> females) (> outside UK) (mixed completeness)

Segment 3: Outside UK (slight > males) (> not kept discus) (mixed completeness)

Segment 4: Outside UK, CE only (> males) (> not kept discus)

Segment 5: Female, UK, Discus keepers (mixed completeness)

Appendix B6 Segment specific valuation (WTA) of discus attributes associated with gender, UK residents, discus keepers and survey completeness

Attribute Levels	**WTA per segment**				
	1 (22.4%) Males with wild interest	**2 (6.6%) Other fish keepers & non-keepers**	**3 (30.9%) Outside UK 1**	**4 (22.3%) Outside UK 2**	**5 (17.8%) discus keepers**
C: Blue / Green	-141.880*** (-218.56, -65.20)	-18.916*** (12.18, 25.65)	-163.176*** (84.35, 242.00)	8.276 (-53.97, 70.53)	-63.419*** (24.56, 102.27)
C: Red / Brown	-140.105*** (-218.54, -61.67)	-12.773*** (4.94, 20.60)	-107.465*** (63.46, 151.47)	44.519* (-6.64, 95.68)	-58.268*** (19.53, 97.01)
C: Golden	-90.011*** (-142.93, -37.09)	1.806 (-9.31, 5.69)	-100.232*** (44.28, 156.18)	-32.308 (-82.65, 18.03)	-40.306** (1.49, 79.12)
C: White	-	-	-	-	-
P: Plain	-43.219** (-81.55, -4.88)	13.136*** (-19.37, -6.91)	56.648*** (-93.34, -19.96)	65.276* (-9.76, 140.31)	-3.802 (-25.82, 33.42)
P: Patterned	21.179 (-10.37, 52.73)	0.684 (-6.25, 4.88)	-9.410 (-16.15, 34.97)	-18.692 (-78.08, 40.70)	-3.423 (-25.96, 32.80)
P: Striped	-29.950 (-66.89, 6.98)	37.072*** (-44.26, -29.88)	-7.943 (-21.42, 37.31)	59.597** (4.68, 114.52)	-36.039** (2.14, 69.94)
P: Spotted	-	-	-	-	-
S: Round	72.333*** (33.23, 111.44)	17.842*** (-22.84, -12.85)	0.408 (-19.47, 18.65)	-45.126 (-121.59, 31.34)	22.308** (-42.69, -1.93)
S: High Body	-	-	-	-	-
T: Wild Caught	-112.547*** (-180.41, -44.68)	12.240** (-22.28, -2.20)	68.686*** (-112.03, -25.34)	17.735 (-23.13, 58.60)	50.940** (-90.11, -11.77)
T: Wild Type, Cultiv.	-58.779*** (-97.46, -20.10)	8.842** (-16.09, -1.59)	13.790 (-45.75, 18.17)	17.752 (-67.78, 103.28)	67.885*** (-108.87, -26.90)
T: Artificially Cultiv.	-	-	-	-	-

*Significance levels are indicated as * for p < 0.10 (note: considered insignificant for WTA), ** for p < 0.05 and *** for p < 0.01. 95% confidence intervals of the estimates are quoted in brackets.*

LCM 6: Within the Far East Asian market – South East Asia

Appendix B7 Measures of model fit for gender, South East Asian residents, survey type and survey completeness

Model	K	LL	AIC	BIC	AIC3	Pseudo R^2
MNL	11	-9082.287	18186.574	9117.129	18230.573	0.084
LCM 2	27	-8244.977	16543.955	8159.454	16327.955	0.168
LCM 3	43	-7973.271	16032.542	7837.067	15688.542	0.196
LCM 4	59	-7744.479	**15606.958**	7557.595	15134.958	0.219
LCM 5	75	**-7732.489**	15614.979	**7494.925**	**15014.979**	**0.220**

Note: K = number of parameters estimated. LL = model log likelihood. Models with information that were most statistically efficient were bolded for each criterion.

Although the AIC is minimized between three and four segments, further marginal improvement is observed with a significantly lower delta BIC of 62.7 units ($p < 0.01$) and delta AIC3 of 120.0 units ($p < 0.01$) between four and five segments. This indicates optimal explanations at five segments.

The five-segment LCM was significantly predicted at: $X^2 = 4362.776$, df = 75, $p < 0.001$.

Appendix B8 Five class LCM on gender, South East Asian residents, survey type and survey completeness

Attribute Levels	Coefficients per segment				
	1 (23.1%) Males with wild interest	**2 (23.8%) South East Asia online**	**3 (6.5%) Online mix**	**4 (28.7%) South East Asia**	**5 (17.9%) Outside South East Asia**
	Utility Function: Discus Attributes				
ASC	0.894*** (0.20)	-1.694*** (0.18)	-8.597*** (1.38)	-2.457*** (0.18)	0.594*** (0.20)
C: Blue / Green	1.502*** (0.13)	2.274*** (0.20)	2.082*** (0.69)	0.155 (0.15)	0.688*** (0.15)
C: Red / Brown	1.520*** (0.10)	1.220*** (0.12)	1.430* (0.77)	0.047 (0.08)	0.664*** (0.14)
C: Golden	1.023*** (0.15)	1.109*** (0.16)	0.502 (0.57)	0.403*** (0.15)	0.441** (0.17)
C: White	-	-	-	-	-
P: Plain	0.481*** (0.13)	-0.594*** (0.19)	-1.825*** (0.58)	-0.480*** (0.13)	0.037 (0.17)
P: Patterned	-0.195 (0.15)	0.301 (0.19)	-0.054 (0.50)	-0.007 (0.13)	0.020 (0.16)
P: Striped	0.353** (0.18)	0.299 (0.22)	-3.640*** (1.05)	-0.397** (0.17)	0.399** (0.16)
P: Spotted	-	-	-	-	-
S: Round	0.755*** (0.09)	0.138 (0.14)	-1.576*** (0.57)	0.075 (0.10)	-0.264*** (0.09)
S: High Body	-	-	-	-	-
T: Wild Caught	1.191*** (0.11)	-0.928*** (0.18)	-1.010 (0.78)	-0.239** (0.10)	-0.553*** (0.13)
T: Wild Type, Cultiv.	0.621*** (0.14)	-0.234 (0.23)	-0.677 (0.65)	-0.082 (0.19)	-0.761*** (0.16)
T: Artificially Cultiv.	-	-	-	-	-
Price	0.011*** (0.003)	-0.015*** (0.003)	-0.125*** (0.02)	0.004 (0.003)	-0.010*** (0.003)
	Segment Membership Function: Consumer Characteristics				
Intercept	1.339* (0.78)	-0.861 (0.73)	-4.586*** (1.30)	0.985 (0.78)	-
Gender	-0.638* (0.38)	0.204 (0.35)	0.187 (0.59)	-0.380 (0.36)	-
South East Asia	0.388 (0.43)	0.903** (0.43)	-3.154 (6.33)	1.874*** (0.40)	-
Survey Type	-0.347 (0.46)	0.671* (0.40)	2.967*** (0.67)	0.299 (0.42)	-
Surv. Completeness	0.019 (0.32)	-0.076 (0.33)	-0.698 (0.53)	-0.582* (0.32)	-

*Significance levels are indicated as * for p < 0.10, ** for p < 0.05 and *** for p < 0.01. Standard errors are quoted in parentheses.*

Where () = potential or tendency for a group to be represented in a way:

Segment 1: Males (> South East Asia) (> paper) (mixed completeness)

Segment 2: South East Asia, Online (slight > females) (mixed completeness)

Segment 3: Online (slight > male) (least South East Asia, > outside South East Asia) (> CE only)

Segment 4: South East Asia, CE only (> males) (slight > online)

Segment 5: Outside South East Asia, Paper, CE+CS (mixed gender)

Appendix B9 Segment specific valuation (WTA) of discus attributes associated with gender, South East Asian residents, survey type and survey completeness

Attribute Levels	**WTA per segment**				
	1 (23.1%) Males with wild interest	**2 (23.8%) South East Asia online**	**3 (6.5%) Online mix**	**4 (28.7%) South East Asia**	**5 (17.9%) Outside South East Asia**
C: Blue / Green	-137.656*** (-209.06, -66.25)	-154.041*** (85.42, 222.66)	-16.708*** (8.99, 24.43)	-38.477 (-106.37, -58.77)	-65.622*** (23.62, 107.63)
C: Red / Brown	-139.312*** (-214.50, -64.12)	-82.660*** (51.66, 113.66)	-11.480** (0.65, 22.31)	-11.698 (-58.77, 35.37)	-63.338*** (20.46, 106.22)
C: Golden	-93.743*** (-145.61, -41.88)	-75.081*** (33.53, 116.64)	-4.028 (-4.89, 12.94)	-100.031* (-213.19, 13.13)	-42.076** (0.32, 83.83)
C: White	-	-	-	-	-
P: Plain	-44.085** (-81.11, -7.06)	40.215*** (-68.52, -11.91)	14.647*** (-23.36, -5.94)	119.058 (-42.84, 280.96)	-3.510 (-27.78, 34.79)
P: Patterned	17.880 (-11.30, 47.06)	-20.393 (-6.62, 47.41)	0.431 (-8.25, 7.39)	1.771 (-59.42, 62.96)	-1.944 (-28.44, 32.33)
P: Striped	-32.358* (-69.95, 5.23)	-20.236 (-10.64, 51.12)	29.213*** (-39.00, -19.42)	98.471* (-7.98, 204.92)	-38.043** (1.47, 74.62)
P: Spotted	-	-	-	-	-
S: Round	69.184*** (32.97, 105.40)	-9.338 (-7.59, 26.27)	12.649*** (-19.12, -6.18)	-18.657 (-82.96, 45.65)	25.158** (-47.58, -2.74)
S: High Body	-	-	-	-	-
T: Wild Caught	-109.132*** (-173.40, -44.86)	62.874*** (-103.11, -22.64)	8.104 (-20.31, 4.10)	59.262 (-28.46, 146.99)	52.760** (-95.78, -9.74)
T: Wild Type, Cultiv.	-56.897*** (-93.69, -20.11)	15.878 (-47.37, 15.61)	5.435 (-14.80, 3.93)	20.367 (-83.64, 124.37)	72.600*** (-118.89, -26.31)
T: Artificially Cultiv.	-	-	-	-	-

*Significance levels are indicated as * for p < 0.10 (note: considered insignificant for WTA), ** for p < 0.05 and *** for p < 0.01. 95% confidence intervals of the estimates are quoted in brackets.*

LCM 7: Within the Far East Asian market – Singapore

Appendix B10 Measures of model fit for age group, Singapore residents, survey type and survey completeness

Model	K	LL	AIC	BIC	AIC3	Pseudo R^2
MNL	11	-9082.287	18186.574	9117.129	18230.573	0.084
LCM 2	27	-8246.786	16547.573	8161.263	16331.573	0.168
LCM 3	43	-7974.564	16035.129	7838.361	15691.129	0.196
LCM 4	59	**-7770.144**	**15658.288**	7583.260	15186.288	**0.216**
LCM 5	75	-7784.520	15719.039	**7546.955**	**15119.039**	0.215

Note: K = number of parameters estimated. LL = model log likelihood. Models with information that were most statistically efficient were bolded for each criterion.

Marginal improvement continues with a lower delta BIC at 36.3 units ($p < 0.01$) and delta AIC3 at 67.2 unites ($p < 0.01$) between four and five segments. This indicates optimality at five segments.

The five-segment LCM was significantly predicted at: $X^2 = 4610.564$, df = 75, $p < 0.001$.

Appendix B11 Five class LCM on age group, Singapore residents, survey type and survey completeness

Attribute Levels	Coefficients per segment				
	1 (19.6%) ***Paper***	**2 (9.7%)** ***Online***	**3 (40.4%)** ***Singapore***	**4 (24.9%)** ***Mix***	**5 (5.4%)** ***Outside Singapore***
Utility Function: Discus Attributes					
ASC	0.690 (0.45)	-5.573*** (0.66)	-2.674*** (0.18)	-0.122 (0.15)	4.539*** (1.18)
C: Blue / Green	1.469*** (0.25)	1.419*** (0.37)	0.868*** (0.11)	0.939*** (0.12)	0.369 (0.67)
C: Red / Brown	1.545*** (0.21)	0.597 (0.45)	0.411*** (0.09)	0.645*** (0.12)	0.901 (0.66)
C: Golden	1.195*** (0.26)	1.116*** (0.34)	0.691*** (0.11)	0.350*** (0.12)	0.522 (0.81)
C: White	-	-	-	-	-
P: Plain	0.465*** (0.18)	-1.006** (0.43)	-0.531*** (0.10)	0.050 (0.10)	0.924 (0.76)
P: Patterned	-0.074 (0.16)	0.134 (0.27)	0.020 (0.09)	0.058 (0.11)	1.042 (0.75)
P: Striped	0.195 (0.22)	-0.640* (0.37)	-0.307** (0.12)	0.346*** (0.11)	1.418* (0.74)
P: Spotted	-	-	-	-	-
S: Round	-0.534*** (0.15)	0.018 (0.18)	0.105 (0.08)	-0.457*** (0.08)	0.545 (0.46)
S: High Body	-	-	-	-	-
T: Wild Caught	1.298*** (0.18)	0.187 (0.39)	-0.426*** (0.10)	-0.262** (0.13)	-1.429 (0.89)
T: Wild Type, Cultiv.	0.771*** (0.19)	0.585 (0.42)	-0.070 (0.13)	-0.505*** (0.11)	-0.199 (0.50)
T: Artificially Cultiv.	-	-	-	-	-
Price	0.016*** (0.003)	-0.090*** (0.01)	-0.001 (0.002)	-0.007*** (0.002)	-0.004 (0.01)
Segment Membership Function: Consumer Characteristics					
Intercept	3.516*** (1.21)	-1.466 (1.52)	3.441*** (1.11)	2.729** (1.15)	-
Age Group	-0.067 (0.18)	-0.442 (0.28)	-0.234 (0.17)	-0.121 (0.17)	-
Singapore	1.308 (1.22)	0.938 (1.42)	2.040* (1.18)	0.472 (1.22)	-
Survey Type	-1.448** (0.65)	2.405*** (0.68)	-0.319 (0.53)	-0.625 (0.55)	-
Surv. Completeness	-0.280 (0.54)	-0.279 (0.65)	-0.366 (0.51)	-0.033 (0.52)	-

*Significance levels are indicated as * for p < 0.10, ** for p < 0.05 and *** for p < 0.01. Standard errors are quoted in parentheses.*

Where () = potential or tendency for a group to be represented in a way:

Segment 1: Paper (mixed ages) (> Singapore) (slight > CE only)

Segment 2: Online (> young-mid) (> Singapore) (slight > CE only)

Segment 3: Singapore (slight > young-mid) (> paper) (> CE only)

Segment 4: Mixed (slight young-mid) (> Singapore) (> paper) (mixed completeness)

Segment 5: Mid-old, Outside Singapore, Online, CE+CS

Appendix B12 Segment specific valuation (WTA) of discus attributes associated with age group, Singapore residents, survey type and survey completeness

Attribute Levels	**WTA per segment**				
	1 (19.6%) Paper	**2 (9.7%) Online**	**3 (40.4%) Singapore**	**4 (24.9%) Mix**	**5 (5.4%) Outside Singapore**
C: Blue / Green	-94.339*** (-139.37, -49.31)	-15.735*** (8.59, 22.88)	-654.388 (-1468.446, 2777.222)	-135.070*** (49.06, 221.08)	-86.866 (-526.11, 699.84)
C: Red / Brown	-99.242*** (-152.44, -46.04)	-6.618 (-2.97, 16.20)	-309.758 (-654.71, 1274.23)	-92.675*** (28.41, 156.94)	-211.850 (-987.23, 1410.93)
C: Golden	-76.713*** (-116.21, -37.21)	-12.369*** (5.88, 18.86)	-520.786 (-1207.11, 2248.68)	-50.368** (4.39, 96.34)	-122.858 (-756.97, 1002.68)
C: White	-	-	-	-	-
P: Plain	-29.873** (-57.64, -2.11)	11.156** (-20.07, -2.24)	400.695 (-1702.41, 901.02)	-7.253 (-21.53, 36.03)	-217.275 (-901.93, 1336.48)
P: Patterned	4.762 (-14.76, 24.29)	-1.486 (-4.58, 7.56)	-15.376 (-116.84, 147.59)	-8.349 (-22.56, 39.26)	-244.995 (-1113.01, 1603.00)
P: Striped	-12.493 (-42.36, 17.38)	7.090* (-14.49, 0.31)	231.671 (-1067.54, 604.20)	-49.809** (4.30, 95.32)	-333.531 (-1496.165, 2163.23)
P: Spotted	-	-	-	-	-
S: Round	34.276*** (16.49, 52.06)	-0.199 (-3.67, 4.06)	-79.258 (-144.46, 302.98)	65.673*** (-114.18, -17.16)	-128.095 (-594.15, 850.34)
S: High Body	-	-	-	-	-
T: Wild Caught	-83.332*** (-126.89, -39.77)	-2.077 (-6.24, 10.39)	321.047 (-1369.25, 727.15)	37.672 (-83.08, 7.73)	336.127 (-2267.65, 1595.40)
T: Wild Type, Cultiv.	-49.491*** (-76.76, -22.23)	-6.484 (-2.48, 15.45)	52.817 (-286.07, 180.43)	72.540*** (-123.05, -22.03)	46.765 (-382.83, 289.30)
T: Artificially Cultiv.	-	-	-	-	-

*Significance levels are indicated as * for p < 0.10 (note: considered insignificant for WTA), ** for p < 0.05 and *** for p < 0.01. 95% confidence intervals of the estimates are quoted in brackets.*

LCM 8: Within the Far East Asian market – Hong Kong

Appendix B13 Measures of model fit for age group, Hong Kong residents, discus keepers and respondents with environmental employment

Model	K	LL	AIC	BIC	AIC3	Pseudo R^2
MNL	11	-9082.287	18186.574	9117.129	18230.573	0.084
LCM 2	27	-8259.152	16572.304	8173.629	16356.304	0.167
LCM 3	43	-7985.322	16056.643	7849.118	15712.643	0.195
LCM 4	59	-7763.140	**15644.279**	7576.255	15172.279	0.217
LCM 5	75	**-7749.420**	15648.840	**7511.856**	**15048.480**	**0.218**

Note: K = number of parameters estimated. LL = model log likelihood. Models with information that were most statistically efficient were bolded for each criterion.

Further improvement with a significantly lower delta BIC at 64.4 units (p <0.01) and delta AIC3 at 123.8 units (p < 0.01) between four and five segments. This indicates the most optimal solutions at five segments.

The five-segment LCM was significantly predicted at: X^2 = 4328.914, df = 75, p < 0.001.

Appendix B14 Five class LCM on age group, Hong Kong residents, discus keepers and respondents with environmental employment

Attribute Levels	Coefficients per Latent Class				
	1 (23.6%) ***Outside Hong Kong***	**2 (21.1%)** ***Young respondents***	**3 (7.2%)** ***Young Hong Kong Non-keepers***	**4 (29.8%)** ***Mix***	**5 (18.3%)** ***Older discus keepers***
	Utility Function: Discus Attributes				
ASC	0.727*** (0.19)	-2.314*** (0.21)	-9.348*** (1.48)	-1.897*** (0.17)	0.591*** (0.19)
C: Blue / Green	1.314*** (0.12)	-0.105 (0.17)	2.561*** (0.73)	1.980*** (0.17)	0.740*** (0.14)
C: Red / Brown	1.338*** (0.10)	-0.378*** (0.10)	1.659** (0.69)	1.367*** (0.14)	0.683*** (0.14)
C: Golden	0.887*** (0.15)	0.089 (0.17)	0.305 (0.48)	1.256*** (0.17)	0.443*** (0.17)
C: White	-	-	-	-	-
P: Plain	0.427*** (0.13)	-0.458*** (0.15)	-1.737*** (0.49)	-0.633*** (0.16)	0.064 (0.17)
P: Patterned	-0.140 (0.15)	0.054 (0.14)	0.057 (0.41)	0.110 (0.15)	0.041 (0.16)
P: Striped	0.297* (0.17)	-0.340* (0.17)	-4.301*** (1.09)	0.063 (0.19)	0.422*** (0.16)
P: Spotted	-	-	-	-	-
S: Round	-0.729*** (0.09)	0.308*** (0.11)	-1.918*** (0.60)	-0.018 (0.11)	-0.268*** (0.09)
S: High Body	-	-	-	-	-
T: Wild Caught	1.203*** (0.11)	-0.251** (0.11)	-1.392** (0.69)	-0.683*** (0.14)	-0.553*** (0.12)
T: Wild Type, Cultiv.	0.616*** (0.14)	-0.133 (0.22)	-0.942 (0.65)	-0.110 (0.21)	-0.745*** (0.15)
T: Artificially Cultiv.	-	-	-	-	-
Price	0.012*** (0.003)	0.005 (0.003)	-0.132*** (0.02)	-0.012*** (0.003)	-0.011*** (0.003)
	Segment Membership Function: Consumer Characteristics				
Intercept	0.319 (0.47)	1.534*** (0.46)	0.721 (0.56)	-0.880** (0.43)	-
Age Group	-0.010 (0.12)	-0.420*** (0.13)	-0.484*** (0.17)	-0.074 (0.11)	-
Hong Kong	-1.375** (0.59)	0.565 (0.40)	1.507*** (0.53)	-0.193 (0.39)	-
Discus Keepers	0.169 (0.32)	-0.268 (0.34)	-1.624*** (0.53)	-0.313 (0.30)	-
Env. Employment	0.059 (0.61)	-20.46 (4.36 E7)	-1.921* (1.14)	0.364 (0.52)	-

*Significance levels are indicated as * for p < 0.10, ** for p < 0.05 and *** for p < 0.01. Standard errors are quoted in parentheses.*

Where () = potential or tendency for a group to be represented in a way:

Segment 1: Outside Hong Kong (mixed ages) (slight > discus keepers) (mixed classes)

Segment 2: Young-mid (> Hong Kong) (slight > not kept discus) (least environmentally employed, > other classes)

Segment 3: Young-mid, Hong Kong, Have not kept discus, Not environmentally employed

Segment 4: Mixed (mixed ages) (slight > Outside Hong Kong) (> not kept discus) (> with environmentally employment)

Segment 5: Mid-old, Discus keepers (mixed markets) (mixed classes)

Appendix B15 Segment specific valuation (WTA) of discus attributes associated with age group, Hong Kong residents, discus keepers and respondents with environmental employment

Attribute Levels	**WTA per segment**				
	1 (23.6%) Outside Hong Kong	**2 (21.1%) Young respondents**	**3 (7.2%) Young Hong Kong Non-keepers**	**4 (29.8%) Mix**	**5 (18.3%) Older discus keepers**
C: Blue / Green	-113.944***	22.945	-19.374***	-171.684***	-68.336***
	(-166.60, -61.29)	(-64.79, 110.68)	(12.00, 26.75)	(84.24, 259.13)	(27.04, 109.64)
C: Red / Brown	-116.001***	82.579	-12.550***	-118.510***	-63.069***
	(-172.33 -59.67)	(-23.00, 188.16)	(3.71, 21.39)	(67.19, 169.83)	(22.58, 103.56)
C: Golden	-76.876***	-19.386	-2.310	-108.920***	-40.881**
	(-116.78, 36.97)	(-84.28, 45.50)	(-4.87, 9.49)	(45.16, 172.69)	(1.82, 79.95)
C: White	-	-	-	-	-
P: Plain					
P: Patterned	-37.037**	100.111	13.139***	54.933***	-5.922
	(-67.97, -6.10)	(-29.51, 229.73)	(-19.83, -6.44)	(-93.85, -16.01)	(-23.91, 35.75)
P: Striped	12.139	-11.913	-0.430	-9.522	-3.805
	(-14.27, 38.54)	(-78.58, 54.75)	(-5.72, 6.58)	(-16.96, 36.00)	(-25.69, 33.30)
P: Spotted	-25.770	74.289*	32.540***	-5.465	-39.021**
	(-60.11, 8.57)	(-7.10, 155.68)	(-41.24, -23.84)	(-26.78, 37.71)	(3.01, 75.04)
	-	-	-	-	-
S: Round					
S: High Body	63.162***	-67.281	14.511***	1.530	24.763**
	(34.68, 91.65)	(-183.10, 48.54)	(-20.33, -8.69)	(-21.15, 18.09)	(-46.17, -3.36)
	-	-	-	-	-
T: Wild Caught					
T: Wild Type, Cultiv.	-104.253***	54.959	10.535**	59.198***	51.064**
	(-158.87, -49.64)	(-22.80, 132.72)	(-20.12, -0.95)	(-101.13, -17.27)	(-90.30, -11.83)
T: Artificially Cultiv.	-53.438***	29.187	7.129	9.505	68.839***
	(-85.32, -21.55)	(-82.24, 140.62)	(-15.64, 1.38)	(-44.87, 25.86)	(-110.81, -26.86)
	-	-	-	-	-

*Significance levels are indicated as * for p < 0.10 (note: considered insignificant for WTA), ** for p < 0.05 and *** for p < 0.01. 95% confidence intervals of the estimates are quoted in brackets.*

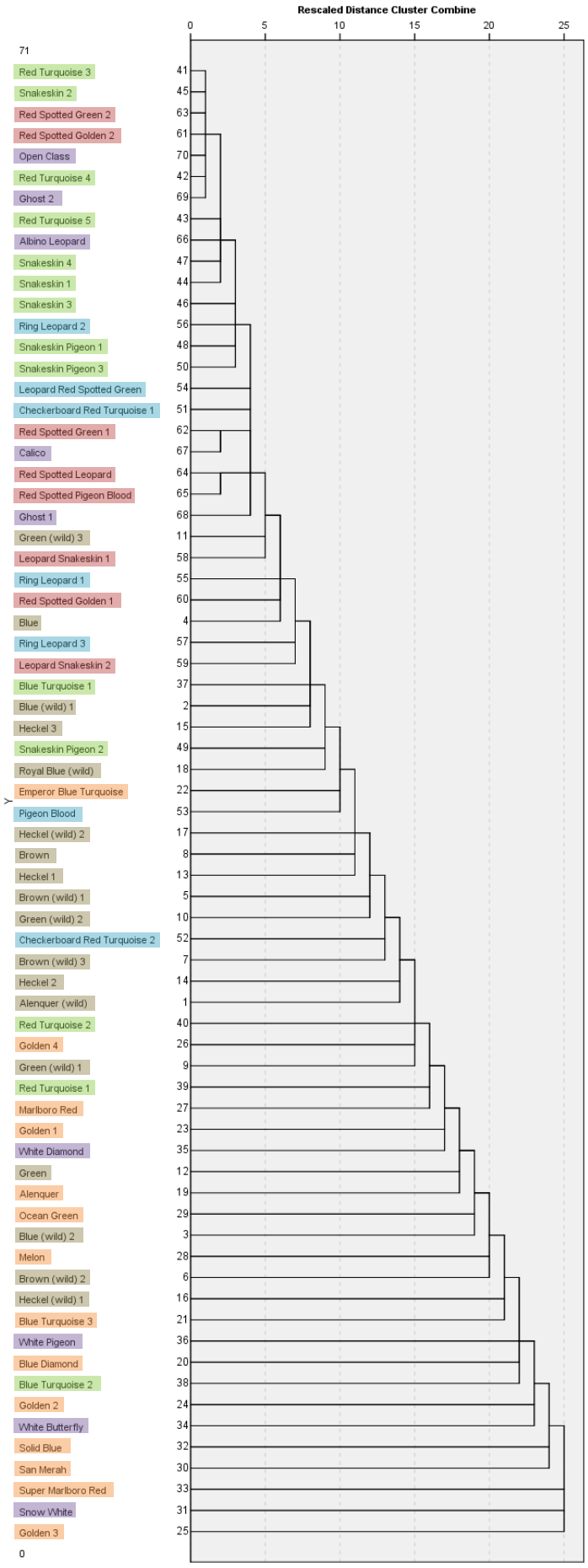
Appendix C PCA results for preliminary analyses of discus images

Appendix C1 Total variance explained for PCA on discus colour between PC 1 and PC 20

Principal Component	*Total of Initial Eigen Values*	Percentage of Total Variance Explained	Cumulative Variance Explained
PC 1	190.848	22.192	22.192
PC 2	123.851	14.401	14.401
PC 3	79.672	9.264	45.857
PC 4	63.696	7.407	53.264
PC 5	51.561	5.996	59.259
PC 6	39.834	4.632	63.891
PC 7	32.694	3.802	67.693
PC 8	30.529	3.550	71.243
PC 9	26.699	3.105	74.347
PC 10	20.754	2.413	76.760
PC 11	18.773	2.183	78.943
PC 12	16.247	1.889	80.832
PC 13	14.332	1.667	82.499
PC 14	12.842	1.493	83.992
PC 15	11.958	1.390	85.383
PC 16	11.254	1.309	86.691
PC 17	10.240	1.191	87.882
PC 18	8.888	1.033	88.915
PC 19	7.659	0.880	89.795
PC 20	**7.376**	**0.858**	**90.653**

Appendix C2 Total variance explained for PCA on discus morphometrics between PC 1 and PC 10

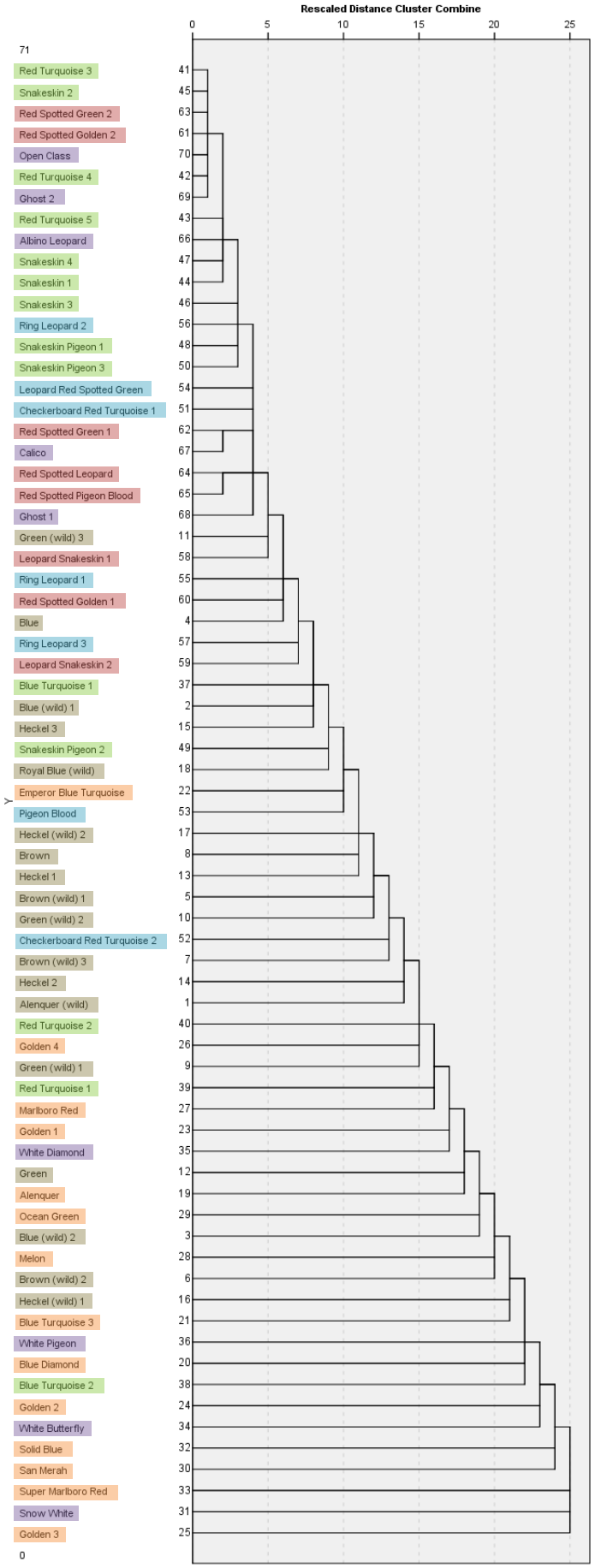
Principal Component	*Eigen Value*	Percentage of Total Variance Explained	Cumulative Variance Explained
PC 1	0.00184	24.950	24.950
PC 2	0.00141	19.108	44.058
PC 3	0.00110	14.858	58.915
PC 4	0.000615	8.333	67.248
PC 5	0.000453	6.135	73.383
PC 6	0.000361	4.894	78.277
PC 7	0.000302	4.096	82.373
PC 8	0.000267	3.620	85.993
PC 9	0.000185	2.503	88.495
PC 10	**0.000153**	**2.072**	**90.567**



Appendix D1

Dendrogram of discus colour with average linkage within groups

CLASS CATEGORIES
Wild form
Solid
Striped
Patterned
Spotted
Open Class

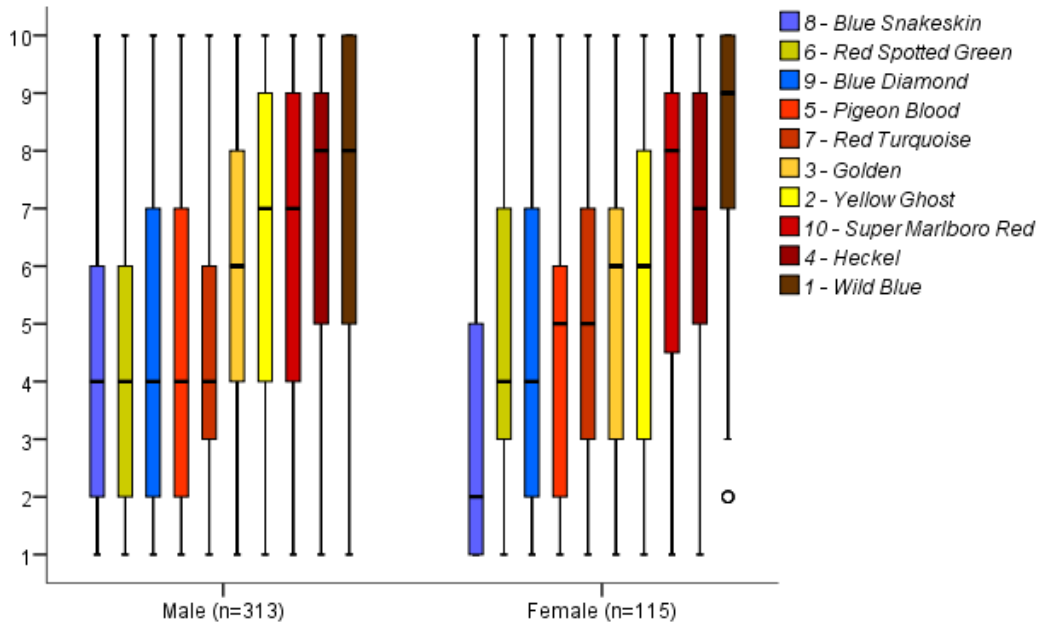


Appendix D2 Dendrogram of both colour and shape with average linkage within groups

CLASS CATEGORIES
Wild form
Solid
Striped
Patterned
Spotted
Open Class

Appendix E Results for CS analyses on gender

Appendix E1 Boxplot of rank scores for images based on colour



Outliers are marked with a circle for 'out' values, and a star for extreme values. This was observed among females for Wild Blue.

Appendix E2 One-way ANOVA between groups based on colour

Image	Source	*d. f.*	*SS*	*MS*	*F*	*p*	Partial η^2
2 - Yellow Ghost	Gender	1	92.590	92.590	11.677***	0.001	0.027
	Residual	426	3377.766	7.929			
	Corrected Total	427	3470.355				
3 – Golden	Gender	1	7.733	7.733	1.093	0.296	0.003
	Residual	426	3012.778	7.072			
	Corrected Total	427	3020.512				
4 – Heckel	Gender	1	12.938	12.938	2.209	0.138	0.005
	Residual	426	2495.483	5.858			
	Corrected Total	427	2508.421				
7 – Red Turquoise	Gender	1	34.910	34.910	5.943**	0.015	0.007
	Residual	426	2502.499	5.874			
	Corrected Total	427	2537.409				
8 – Blue Snakeskin	Gender	1	105.499	105.499	16.382***	< 0.001	0.037
	Residual	426	2743.480	6.440			
	Corrected Total	427	2848.979				
9 – Blue Diamond	Gender	1	8.332	8.332	1.028	0.311	0.002
	Residual	426	3454.350	8.109			
	Corrected Total	427	3462.682				
10 – Super Marlboro Red	Gender	1	36.684	36.864	4.698**	0.031	0.011
	Residual	426	3342.900	7.847			
	Corrected Total	427	3379.764				

*Included are models that have met assumptions on normality. Significance levels are indicated as ** for $p < 0.05$ and *** for $p < 0.01$*

Appendix E3 Parameter estimates for significant models between groups based on colour

Image	Source	B-Effect	Std. Err.	*T*	*p*	Partial η^2
2 - Yellow Ghost	Intercept	5.513***	0.263	20.996	< 0.001	0.509
	Male	1.049***	0.283	-3.267	0.001	0.027
	Female	0				
7 – Red Turquoise	Intercept	5.104***	0.226	22.584	< 0.001	0.545
	Male	-0.644**	0.264	-2.438	0.015	0.014
	Female	0				
8 – Blue Snakeskin	Intercept	3.174***	0.237	13.412	< 0.001	0.297
	Male	1.120***	0.277	4.047	< 0.001	0.037
	Female	0				
10 – Super Marlboro Red	Intercept	6.930***	0.261	26.531	< 0.001	0.623
	Male	-0.662**	0.305	-2.167	0.031	0.011
	Female	0				

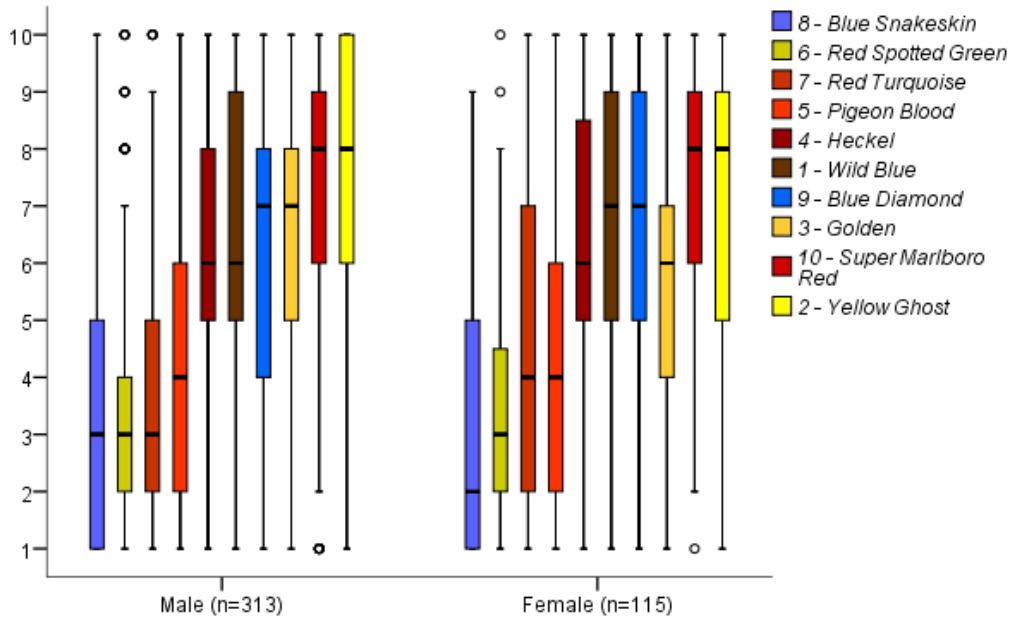
*Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

Appendix E4 Kruskal-Wallis test statistics of images based on colour

Image	*d. f.*	X^2	*P*
1 – Wild Blue	1	8.555***	0.003
5 – Pigeon Blood	1	0.057	0.811
6 – Red Spotted Green	1	1.463	0.226

*Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

Appendix E5 Boxplot of rank scores for images based on pattern



Outliers are marked with a circle for 'out' values, and a star for extreme values. This was observed among males for Red Spotted Green, Pigeon Blood and Super Marlboro Red; and among females for Red Spotted Green and Pigeon Blood.

Appendix E6 One-way ANOVA between groups based on pattern

Image	Source	*d. f.*	*SS*	*MS*	*F*	*p*	Partial η^2
1 – Wild Blue	Gender	1	11.061	11.061	1.666	0.197	0.004
	Residual	426	2827.939	6.638			
	Corrected Total	427	2839.000				
2 – Yellow Ghost	Gender	1	47.313	47.313	7.188***	0.008	0.017
	Residual	426	2804.192	6.583			
	Corrected Total	427	2851.505				
3 - Golden	Gender	1	97.769	97.769	18.705***	< 0.001	0.042
	Residual	426	2226.708	5.227			
	Corrected Total	427	2324.477				
4 - Heckel	Gender	1	0.176	0.176	0.034	0.853	< 0.001
	Residual	426	2178.712	5.114			
	Corrected Total	427	2178.888				
5 – Pigeon Blood	Gender	1	0.099	0.099	0.015	0.904	< 0.001
	Residual	426	2178.712	6.773			
	Corrected Total	427	2178.888				
6 – Red Spotted Green	Gender	1	1.074	1.074	0.271	0.603	0.001
	Residual	426	1687.438	3.961			
	Corrected Total	427	1688.512				
8 – Blue Snakeskin	Gender	1	5.150	5.150	0.952	0.330	0.002
	Residual	426	2303.998	5.408			
	Corrected Total	427	2309.147				
9 – Blue Diamond	Gender	1	24.472	24.472	3.398**	0.066	0.008
	Residual	426	3067.983	7.202			
	Corrected Total	427	3092.456				
10 – Super Marlboro Red	Gender	1	0.655	0.655	0.116	0.734	< 0.001
	Residual	426	2404.567	5.645			
	Corrected Total	427	2405.222				

*Included are models that have met assumptions on normality. Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

Appendix E7 Parameter estimates for significant models between groups based on pattern

Image	Source	B-Effect	Std. Err.	*t*	*p*	Partial η^2
2 - Yellow Ghost	Intercept	6.774***	0.239	28.313	< 0.001	0.653
	Male	0.750***	0.280	2.681	0.008	0.017
	Female	0				
3 - Golden	Intercept	5.609***	0.213	26.308	< 0.001	0.619
	Male	1.078***	0.249	4.325	< 0.001	0.042
	Female	0				
9 – Blue Diamond	Intercept	6.817***	0.250	21.192	< 0.001	0.513
	Male	-0.539	0.293	-4.398	0.066	0.043
	Female	0				

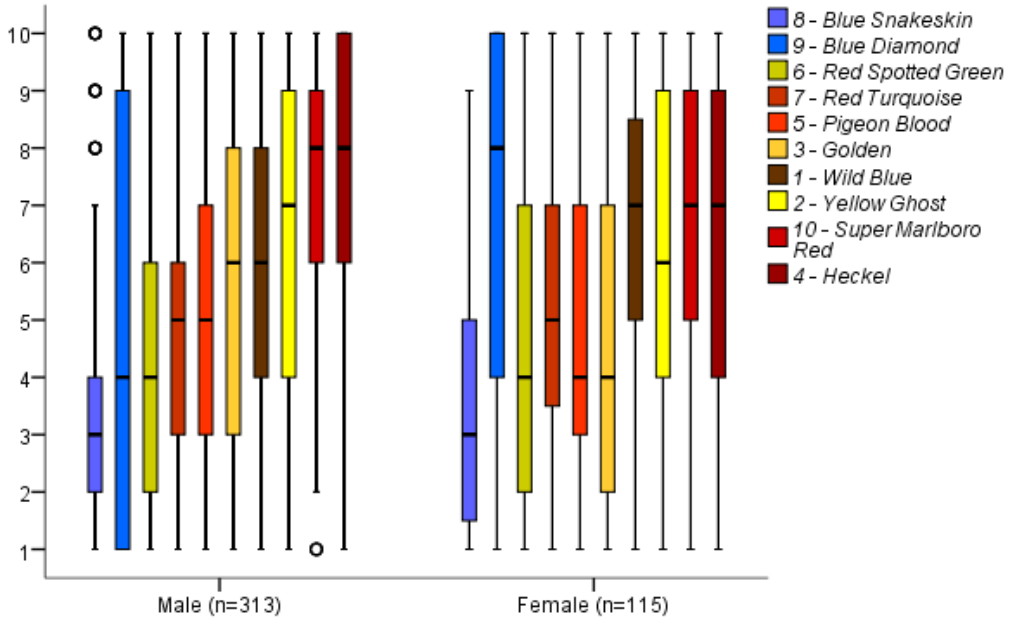
*Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

Appendix E8 Kruskal-Wallis test statistics of images based on pattern

Image	*d. f.*	X^2	*p*
7 – Red Turquoise	1	12.826***	< 0.001

*Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

Appendix E9 Boxplot of rank scores for images based on shape



Outliers are marked with a circle for 'out' values, and a star for extreme values. This was observed among males for Blue Snakeskin and Super Marlboro Red.

Appendix E10 One-way ANOVA between groups based on shape

Image	Source	*d. f.*	*SS*	*MS*	*F*	*p*	Partial η^2
1 – Wild Blue	Gender	1	57.593	57.593	9.112***	0.003	0.021
	Residual	426	2692.545	6.321			
	Corrected Total	427	2750.138				
2 - Yellow Ghost	Gender	1	2.181	2.181	0.319	0.573	0.001
	Residual	426	2914.604	6.842			
	Corrected Total	427	2916.785				
3 – Golden	Gender	1	109.562	109.562	14.739***	< 0.001	0.033
	Residual	426	3166.625	7.433			
	Corrected Total	427	3276.187				
5 – Pigeon Blood	Gender	1	0.079	0.079	0.013	0.911	< 0.001
	Residual	426	2696.061	6.329			
	Corrected Total	427	2696.140				
7 – Red Turquoise	Gender	1	20.164	20.164	3.492	0.062	0.008
	Residual	426	2459.600	5.774			
	Corrected Total	427	2479.764				

Image	Source	*d. f.*	*SS*	*MS*	*F*	*p*	Partial η^2
8 – Blue Snakeskin	Gender	1	< 0.001	< 0.001	< 0.001	0.996	< 0.001
	Residual	426	2110.100	4.953			
	Corrected Total	427	211< 0.001				
10 – Super Marlboro Red	Gender	1	28.167	28.167	5.003**	0.026	0.012
	Residual	426	2398.588	5.630			
	Corrected Total	427	2426.755				

*Included are models that have met assumptions on normality. Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

Appendix E11 Parameter estimates for significant models between groups based on shape

Image	Source	B-Effect	Std. Err.	*t*	*p*	Partial η^2
1 – Wild Blue	Intercept	6.687***	0.234	28.523	< 0.001	0.656
	Male	-0.828***	0.274	-3.019	0.003	0.021
	Female	0				
3 - Golden	Intercept	4.539***	0.254	17.854	< 0.001	0.428
	Male	1.141***	0.297	3.839	< 0.001	0.033
	Female	0				
10 – Super Marlboro Red	Intercept	6.504***	0.221	29.395	< 0.001	0.670
	Male	0.579**	0.259	2.237	0.026	0.012
	Female	0				

*Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

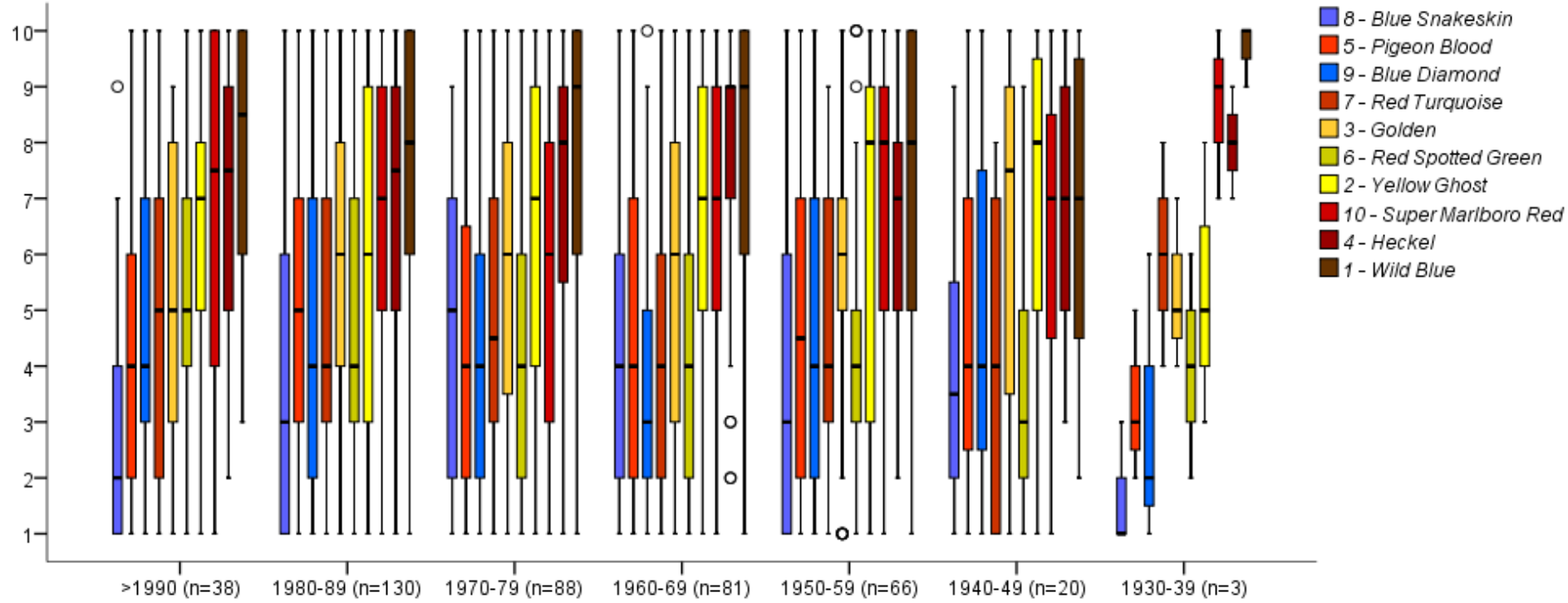
Appendix E12 Kruskal-Wallis test statistics of images based on shape

Image	*d. f.*	X^2	*p*
4 - Heckel	1	18.285***	< 0.001
6 – Red Spotted Green	1	0.092	0.761
9 – Blue Diamond	1	22.136***	< 0.001

*Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

Appendix F Results for CS analyses on age group

Appendix F1 Boxplot of rank scores for images based on colour



Outliers are marked with a circle for 'out' values, and a star for extreme values. This was observed among the >1990 demographic for Blue Snakeskin; 1960-1969 for Blue Diamond and Heckel; and 1950-1959 for Red Spotted Green and Golden.

Appendix F2 One-way ANOVA between groups based on colour

Image	Source	*d. f.*	*SS*	*MS*	*F*	*p*	Partial η^2
1 – Wild Blue	Age Group	6	39.451	6.575	0.949	0.459	0.013
	Residual	419	2902.204	6.927			
	Corrected Total	425	2941.655				
3 – Golden	Age Group	6	19.238	3.206	0.448	0.846	0.006
	Residual	419	2998.086	7.155			
	Corrected Total	425	3017.324				
5 – Pigeon Blood	Age Group	6	45.281	7.547	1.141	0.338	0.016
	Residual	419	2771.351	6.614			
	Corrected Total	425	2816.631				
6 – Red Spotted Green	Age Group	6	45.608	7.601	1.275	0.268	0.018
	Residual	419	2498.807	5.964			
	Corrected Total	425	2544.415				
7 – Red Turquoise	Age Group	6	25.992	4.332	0.724	0.630	0.010
	Residual	419	2505.407	5.979			
	Corrected Total	425	2531.399				
10 – Super Marlboro Red	Age Group	6	121.048	20.175	2.605**	0.017	0.036
	Residual	419	3244.049	7.744			
	Corrected Total	425	3365.739				

*Included are models that have met assumptions on normality. Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

Appendix F3 LSD post-hoc test between groups based on colour

Image	YOB (I)	YOB (J)	Mean Difference (I-J)	Std. Err.	*p*
10 – Super Marlboro Red	>1990	1980-1989	0.478	0.513	0.352
		1970-1979	1.413***	0.540	0.009
		1960-1969	0.293	0.547	0.593
		1950-1959	-0.037	0.567	0.947
		1940-1949	0.297	0.769	0.699
		1930-1939	-1.719	1.669	0.303
	1980-1989	1970-1979	0.935**	0.384	0.015
		1960-1969	-0.185	0.394	0.639
		1950-1959	-0.516	0.421	0.221
		1940-1949	-0.181	0.668	0.787
		1930-1939	-2.197	1.625	0.177
	1970-1979	1960-1969	-1.120***	0.428	0.009
		1950-1959	-1.451***	0.453	0.001
		1940-1949	-1.116	0.689	0.106
		1930-1939	-3.133*	1.634	0.056
	1960-1969	1950-1959	-0.331	0.461	0.474
		1940-1949	0.004	0.695	0.995
		1930-1939	-2.012	1.636	0.219
	1950-1959	1940-1949	0.335	0.710	0.638
		1930-1939	-1.682	1.643	0.307
	1940-1949	1930-1939	-2.017	1.723	0.242

*Significance levels are indicated as * for p < 0.10, ** for p < 0.05 and *** for p < 0.01.*

Appendix F4 Parameter estimates for significant models between groups based on colour

Image	Source	B-Effect	Std. Err.	*t*	*p*	Partial η^2
10 – Super Marlboro Red	Intercept	5.534***	0.297	18.656	< 0.001	0.454
	>1990	1.413***	0.540	2.616	0.009	0.016
	1980-1989	0.935**	0.384	2.434	0.015	0.014
	1960-1969	1.120***	0.428	2.614	0.009	0.016
	1950-1959	1.451***	0.453	3.202	0.001	0.024
	1940-1949	1.116	0.689	1.619	0.106	0.006
	1930-1939	3.133	1.634	1.917	0.056	0.009
	1970-1979	0				

*Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

Appendix F5 Kruskal-Wallis test statistics of images based on colour

Image	*d. f.*	X^2	*p*
2 – Yelloiw Ghost	1	7.362	0.289
4 – Heckel	1	12.014	0.062
8 – Blue Snakeskin	1	22.686***	0.001
9 – Blue Diamond	1	8.239	0.215

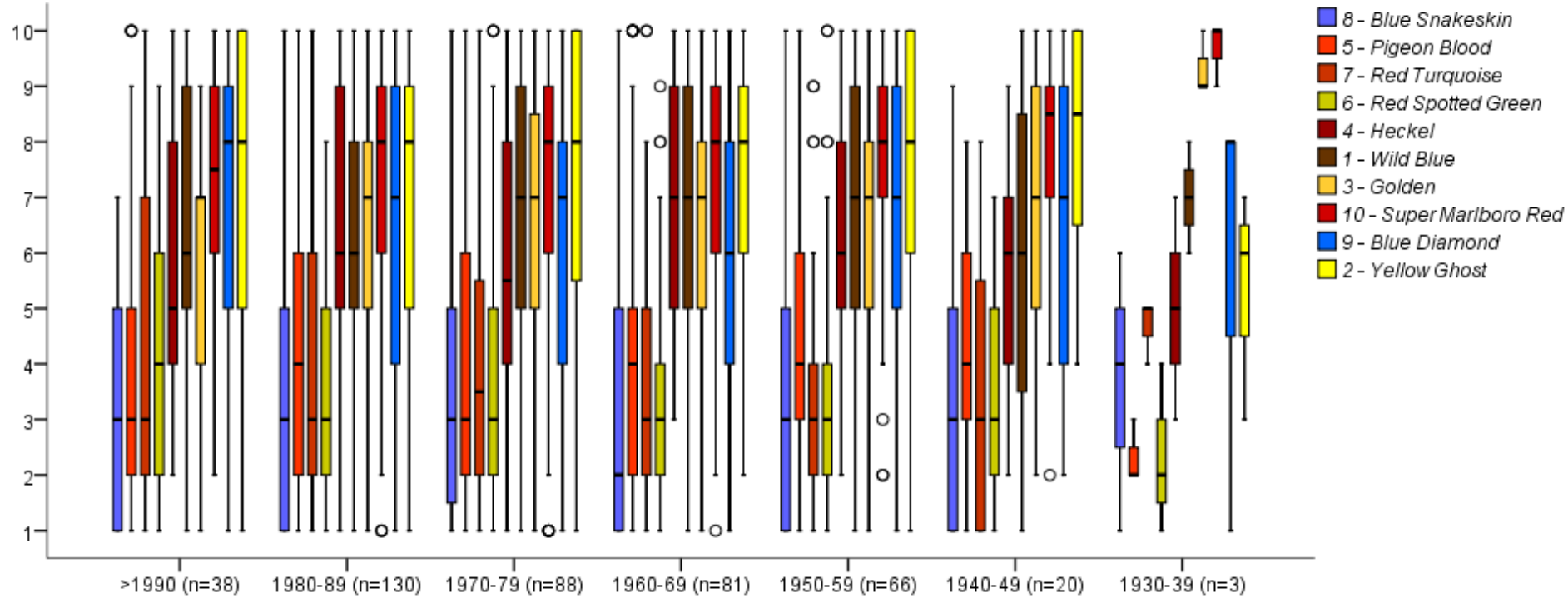
*Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

Appendix F6 Mann-Whitney U post-hoc test between groups based on colour

Image	YOB (I)	YOB (J)	Mann-Whitney U	*Z*	*p*
8 – Blue Snakeskin	>1990	1980-1989	1789.500***	-2.623	0.009
		1970-1979	874.000***	-4.288	< 0.001
		1960-1969	976.000***	-3.251	0.001
		1950-1959	937.000**	-2.183	0.029
		1940-1949	260.000**	-2.011	0.044
		1930-1939	39.000	-0.915	0.360
	1980-1989	1970-1979	4709.000**	-2.232	0.026
		1960-1969	4916.000	-0.818	0.082
		1950-1959	4113.500	-0.476	0.634
		1940-1949	1289.500	-0.059	0.953
		1930-1939	96.500	-1.505	0.132
	1970-1979	1960-1969	3135.000	-1.361	0.174
		1950-1959	2256.000**	-2.387	0.017
		1940-1949	698.500	-1.447	0.148
		1930-1939	53.000	-1.766	0.077
	1960-1969	1950-1959	2375.500	-1.170	0.242
		1940-1949	745.500	-0.554	0.579
		1930-1939	69.500	-1.264	0.206
	1950-1959	1940-1949	636.500	-0.243	0.808
		1930-1939	66.500	-0.968	0.333
	1940-1949	1930-1939	15.500	-1.336	0.182

*Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

Appendix F7 Boxplot of rank scores for images based on pattern



Outliers are marked with a circle for 'out' values, and a star for extreme values. This was observed among the <1990 demographic for Pigeon Blood; 1980-1989 for Super Marlboro Red; 1970-1979 for Red Spotted Green and Super Marlboro Red; 1960-1969 for Pigeon Blood, Red Turquoise, Red Spotted Green and Super Marlboro Red; 1950-1959 for Red Turquoise, Red Spotted Green and Super Marlboro Red; and 1940-1949 for Super Marlboro Red.

Appendix F8 One-way ANOVA between groups based on pattern

Image	Source	*d. f.*	*SS*	*MS*	*F*	*p*	Partial η^2
1 – Wild Blue	Age Group	6	35.725	5.954	0.893	0.500	0.013
	Residual	419	2794.773	6.670			
	Corrected Total	425	2830.498				
2 – Yellow Ghost	Age Group	6	24.776	4.129	0.613	0.720	0.009
	Residual	419	2822.165	6.735			
	Corrected Total	425	2846.941				
3 – Golden	Age Group	6	42.054	7.009	1.288	0.261	0.018
	Residual	419	2279.479	5.440			
	Corrected Total	425	2321.533				
5 – Pigeon Blood	Age Group	6	16.178	2.698	0.394	0.883	0.006
	Residual	419	2119.608	6.844			
	Corrected Total	425	2165.296				
6 – Red Spotted Green	Age Group	6	24.463	4.077	1.031	0.404	0.015
	Residual	419	1656.720	3.954			
	Corrected Total	425	1681.183				
8 – Blue Snakeskin	Age Group	6	10.514	1.752	0.320	0.926	0.005
	Residual	419	2291.477	5.469			
	Corrected Total	425	2301.991				
9 – Blue Diamond	Age Group	6	29.694	4.949	0.680	0.666	0.010
	Residual	419	3047.930	7.274			
	Corrected Total	425	3077.624				

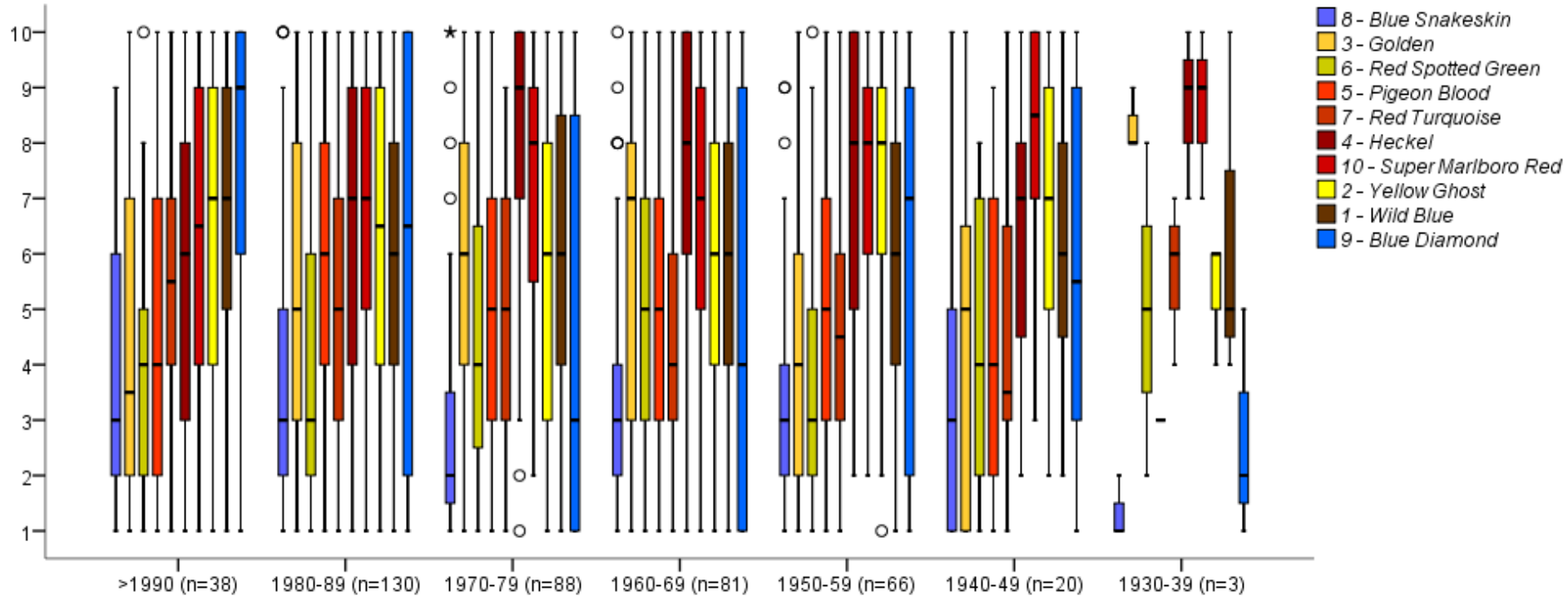
*Included are models that have met assumptions on normality. Significance levels are indicated as ** for $p < 0.05$ and *** for $p < 0.01$.*

Appendix F9 Kruskal-Wallis test statistics of images based on pattern

Image	*d. f.*	X^2	*p*
4 – Heckel	1	9.049	0.107
6 – Red Spotted Green	1	2.623	0.758
9 – Blue Diamond	1	3.921	0.561

*Significance levels are indicated as ** for $p < 0.05$ and *** for $p < 0.01$.*

Appendix F10 Boxplot of rank scores for images based on shape



Outliers are marked with a circle for 'out' values, and a star for extreme values. This was observed among the >1990 demographic for Red Spotted Green; 1980-1989 for Blue Diamond; 1970-1979 for Blue Snakeskin and Heckel; 1960-1969 for Blue Snakeskin; and 1950-1959 for Blue Snakeskin and Red Spotted Green.

Appendix F11 One-way ANOVA between groups based on shape

Image	Source	*d. f.*	*SS*	*MS*	*F*	*p*	Partial η^2
1 – Wild Blue	Age Group	6	22.066	3.678	0.570	0.754	0.008
	Residual	419	2701.364	6.447			
	Corrected Total	425	2723.430				
2 – Yellow Ghost	Age Group	6	94.528	15.755	2.349**	0.030	0.033
	Residual	419	2809.691	6.706			
	Corrected Total	425	2904.218				
3 - Golden	Age Group	6	174.924	29.154	3.963***	0.001	0.054
	Residual	419	3082.475	7.347			
	Corrected Total	425	3257.399				
5 – Pigeon Blood	Age Group	6	60.981	10.164	1.619	0.140	0.023
	Residual	419	2630.918	6.279			
	Corrected Total	425	2691.899				
6 – Red Spotted Green	Age Group	6	42.930	7.155	1.128	0.345	0.016
	Residual	419	2658.095	6.344			
	Corrected Total	425	2701.026				
7 – Red Turquoise	Age Group	6	32.207	5.368	0.919	0.481	0.013
	Residual	419	2447.551	5.841			
	Corrected Total	425	2479.758				
9 – Blue Diamond	Age Group	6	320.362	53.394	4.272***	< 0.001	0.058
	Residual	419	5236.786	12.498			
	Corrected Total	425	5557.148				

*Included are models that have met assumptions on normality. Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

Appendix F12 LSD post-hoc test between groups based on shape

Image	YOB (I)	YOB (J)	Mean Difference (I-J)	Std. Err.	*p*
2 – Yellow Ghost	>1990	1980-1989	0.024	0.478	0.959
		1970-1979	0.743	0.503	0.140
		1960-1969	0.447	0.509	0.380
		1950-1959	-0.674	0.527	0.202
		1940-1949	-0.403	0.715	0.574
		1930-1939	1.114	1.553	0.474
	1980-1989	1970-1979	0.719**	0.357	0.045
		1960-1969	0.423	0.367	0.249
		1950-1959	-0.698	0.391	0.075
		1940-1949	-0.427	0.622	0.493
		1930-1939	1.090	1.512	0.472
	1970-1979	1960-1969	-0.295	0.399	0.459
		1950-1959	-1.417***	0.422	0.001
		1940-1949	-1.145	0.641	0.075
		1930-1939	0.471	1.520	0.807
	1960-1969	1950-1959	-1.121***	0.429	0.009
		1940-1949	-0.850	0.647	0.189
		1930-1939	0.667	1.523	0.662
	1950-1959	1940-1949	0.271	0.661	0.682
		1930-1939	1.788	1.529	0.243
	1940-1949	1930-1939	1.517	1.603	0.345

Image	YOB (I)	YOB (J)	Mean Difference (I-J)	Std. Err.	*p*
3 - Golden	>1990	1980-1989	-1.005**	0.500	0.045
		1970-1979	-1.548	0.526	0.148
		1960-1969	-1.531	0.533	0.171
		1950-1959	-0.166**	0.552	0.041
		1940-1949	-0.105	0.749	0.168
		1930-1939	-3.939	1.627	0.065
	1980-1989	1970-1979	-0.543	0.374	0.148
		1960-1969	-0.526	0.384	0.967
		1950-1959	0.839***	0.410	0.002
		1940-1949	0.900**	0.651	0.032
		1930-1939	-2.933	1.584	0.134
	1970-1979	1960-1969	0.017	0.418	0.967
		1950-1959	1.383***	0.442	0.002
		1940-1949	1.443**	0.672	0.032
		1930-1939	-2.390	1.592	0.133
	1950-1959	1940-1949	0.061	0.692	0.930
		1930-1939	-3.773**	1.601	0.019
	1940-1949	1930-1939	-3.833**	1.679	0.023
9 – Blue Diamond	>1990	1980-1989	1.551**	0.652	0.018
		1970-1979	2.940***	0.686	< 0.001
		1960-1969	2.572***	0.695	< 0.001
		1950-1959	1.534**	0.720	0.034
		1940-1949	1.624	0.977	0.097
		1930-1939	4.807**	2.120	0.024
	1980-1989	1970-1979	1.389***	0.488	0.005
		1960-1969	1.022**	0.500	0.042
		1950-1959	-0.016	0.534	0.976
		1940-1949	0.073	0.849	0.931
		1930-1939	3.256	2.065	0.115
	1970-1979	1960-1969	-0.367	0.544	0.500
		1950-1959	-1.405	0.576	0.015
		1940-1949	-1.316	0.876	0.134
		1930-1939	1.867	2.076	0.369
	1960-1969	1950-1959	-1.038	0.586	0.077
		1940-1949	-0.949	0.883	0.283
		1930-1939	2.235	2.079	0.283
	1950-1959	1940-1949	0.089	0.902	0.921
		1930-1939	3.273	2.087	0.118
	1940-1949	1930-1939	3.183	2.189	0.147

*Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

Appendix F13 Parameter estimates for significant models between groups based on shape

Image	Source	B-Effect	Std. Err.	*t*	*p*	Partial η^2
2 - Yellow Ghost	Intercept	5.705***	0.276	20.665	< 0.001	0.505
	>1990	0.743	0.503	1.478	0.140	0.005
	1980-1989	0.719**	0.357	2.010	0.045	0.010
	1960-1969	0.295	0.399	0.741	0.459	0.001
	1950-1959	1.417***	0.422	3.360	0.001	0.026
	1940-1949	1.145	0.641	1.786	0.075	0.008
	1930-1939	-0.371	1.520	-0.244	0.807	< 0.001
	1970-1979	0				
3 - Golden	Intercept	4.561***	0.334	13.660	< 0.001	0.308
	>1990	-0.166	0.552	-0.300	0.764	< 0.001
	1980-1989	0.839**	0.410	2.048	0.041	0.010
	1970-1979	1.383***	0.442	3.130	0.002	0.023
	1960-1969	1.365***	0.450	3.036	0.003	0.022
	1940-1949	-0.061	0.692	-0.088	0.930	0.000
	1930-1939	3.773**	1.601	2.356	0.019	0.013
	1950-1959	0				
9 – Blue Diamond	Intercept	6.184***	0.384	16.016	< 0.001	0.382
	1980-1989	0.562	0.436	1.287	0.199	0.004
	1970-1979	0.929**	0.459	2.023	0.044	0.010
	1960-1969	0.569	0.465	1.222	0.222	0.004
	1950-1959	1.149**	0.482	2.384	0.018	0.013
	1940-1949	1.716***	0.654	2.624	0.009	0.016
	1930-1939	2.482	1.419	1.749	0.081	0.007
	>1990	0				

*Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

Appendix F14 Kruskal-Wallis test statistics of images based on shape

Image	*d. f.*	X^2	*p*
4 – Heckel	1	41.233***	< 0.001
8 – Blue Snakeskin	1	9.921	0.128
10 – Super Marlboro Red	1	10.753	0.096

*Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

Appendix F15 Mann-Whitney U post-hoc test between groups based on shape

Image	YOB (I)	YOB (J)	Mann-Whitney U	*Z*	*p*
4 - Heckel	>1990	1980-1989	2021.500	-1.713	0.087
		1970-1979	756.500***	-4.930	< 0.001
		1960-1969	830.000***	-4.095	< 0.001
		1950-1959	723.000***	-3.265	< 0.001
		1940-1949	305.000	-1.238	0.216
		1930-1939	18.500	-1.947	0.051
	1980-1989	1970-1979	3749.500***	-4.361	< 0.001
		1960-1969	802.000***	-3.430	0.001
		1950-1959	3250.000***	-2.798	0.005
		1940-1949	1290.000	-0.056	0.956
		1930-1939	104.000	-1.390	0.165

Image	YOB (I)	YOB (J)	Mann-Whitney U	*Z*	*p*
	1970-1979	1960-1969	3405.000	-0.513	0.608
		1950-1959	2643.000	-0.975	0.330
		1940-1949	529.000***	-2.826	0.005
		1930-1939	115.500	-0.376	0.707
	1960-1969	1950-1959	2581.500	-0.365	0.715
		1940-1949	560.000**	-2.171	0.030
		1930-1939	103.000	-0.458	0.647
4 - Heckel	1950-1959	1940-1949	488.500	-1.783	0.075
		1930-1939	78.500	-0.619	0.536
	1940-1949	1930-1939	13.500	-1.520	0.129

*Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

Appendix G Analyses of variance for general linear models based on colour

Appendix G1 One-way ANOVA between groups on fishkeeping

Image	Source	*d. f.*	*SS*	*MS*	*F*	*p*	Partial η^2
1 – Wild Blue	Fishkeeping	2	6.619	3.309	0.478	0.620	0.002
	Residual	424	2936.918	6.927			
	Corrected Total	426	2943.536				
2 – Yellow Ghost	Fishkeeping	2	120.005	60.002	7.610***	0.001	0.035
	Residual	424	3342.937	7.884			
	Corrected Total	426	3462.941				
3 – Golden	Fishkeeping	2	25.327	12.663	1.793	0.168	0.008
	Residual	424	2994.753	7.063			
	Corrected Total	426	3020.080				
5 – Pigeon Blood	Fishkeeping	2	8.836	4.418	0.665	0.515	0.003
	Residual	424	2815.155	6.640			
	Corrected Total	426	2823.991				
6 – Red Spotted Green	Fishkeeping	2	54.370	27.185	4.607**	0.010	0.021
	Residual	424	2502.169	5.901			
	Corrected Total	426	2556.539				
8 – Blue Snakeskin	Fishkeeping	2	12.962	6.481	0.970	0.380	0.005
	Residual	424	2832.036	5.896			
	Corrected Total	426	2844.998				
10 – Super Marlboro Red	Fishkeeping	2	48.818	24.409	3.118**	0.045	0.014
	Residual	424	3319.041	7.828			
	Corrected Total	426	3367.859				

*Included are models that have met assumptions on normality. Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

Appendix G2 LSD post-hoc test between groups on fishkeeping

Image	Fishkeeping (I)	Fishkeeping (J)	Mean Difference (I-J)	Std. Err.	*p*
2 – Yellow Ghost	Discus	Other Tropical Fish	0.530	0.315	0.093
		Other / Don't Keep	1.355***	0.348	< 0.001
	Other Tropical Fish	Other / Don't Keep	0.824**	0.373	0.027
6 – Red Spotted Green	Discus	Other Tropical Fish	-0.633**	0.272	0.021
		Other / Don't Keep	-0.805***	0.301	0.008
	Other Tropical Fish	Other / Don't Keep	-0.172	0.322	0.594
10 – Super Marlboro Red	Discus	Other Tropical Fish	0.069	0.314	0.825
		Other / Don't Keep	-0.772**	0.347	0.026
	Other Tropical Fish	Other / Don't Keep	-0.842**	0.371	0.024

*Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

Appendix G3 One-way ANOVA between groups on respondent class

Image	Source	*d. f.*	*SS*	*MS*	*F*	*p*	Partial η^2
1 – Wild Blue	Class	4	13.365	3.341	0.447	0.775	0.775
	Residual	425	4461.239	7.473			
	Corrected Total	429	4474.605				
2 – Yellow Ghost	Class	4	102.466	25.616	3.148**	0.014	0.014
	Residual	425	4858.637	8.138			
	Corrected Total	429	4961.103				
4 – Heckel	Class	4	59.734	14.934	2.623**	0.034	0.034
	Residual	425	3398.414	5.692			
	Corrected Total	429	3458.148				
5 – Pigeon Blood	Class	4	24.094	6.023	0.918	0.453	0.453
	Residual	425	3917.043	6.561			
	Corrected Total	429	3941.136				
7 – Red Turquoise	Class	4	34.551	8.638	1.474	0.208	0.208
	Residual	425	3497.581	5.859			
	Corrected Total	429	3532.133				
8 – Blue Snakeskin	Class	4	40.628	10.157	1.538	0.190	0.190
	Residual	425	3942.975	6.605			
	Corrected Total	429	3983.603				
9 – Blue Diamond	Class	4	138.225	34.556	4.392***	0.002	0.002
	Residual	425	4696.900	7.868			
	Corrected Total	429	4835.125				
10 – Super Marlboro Red	Class	4	71.734	17.934	2.319	0.056	0.056
	Residual	425	4615.809	7.732			
	Corrected Total	429	4687.543				

*Included are models that have met assumptions on normality. Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

Appendix G4 LSD post-hoc test between groups on respondent class

Image	Class (I)	Class (J)	Mean Difference (I-J)	Std. Err.	*p*
2 – Yellow Ghost	Professional	Prof. + Hobbyist	0.142	0.435	0.744
		Hobbyist	0.296	0.309	0.338
		General Interest	1.301***	0.431	0.003
		Env. Employment	-0.481	0.562	0.393
	Prof. + Hobbyist	Hobbyist	0.154	0.382	0.686
		General Interest	1.159**	0.486	0.017
		Env. Employment	-0.623	0.605	0.304
	Hobbyist	General Interest	1.004***	0.377	0.008
		Env. Employment	-0.777	0.522	0.137
	General Interest	Env. Employment	-1.782***	0.602	0.003
4 – Heckel	Professional	Prof. + Hobbyist	0.020	0.364	0.955
		Hobbyist	0.334	0.258	0.196
		General Interest	0.976***	0.361	0.007
		Env. Employment	0.916*	0.470	0.052
	Prof. + Hobbyist	Hobbyist	0.314	0.319	0.326
		General Interest	0.955**	0.406	0.019
		Env. Employment	0.896*	0.506	0.077

Appendix G5 LSD post-hoc test between groups on respondent class

Image	Class (I)	Class (J)	Mean Difference (I-J)	Std. Err.	*p*
4 – Heckel	Hobbyist	General Interest	0.642**	0.315	0.042
		Env. Employment	0.582	0.437	0.183
	General Interest	Env. Employment	-0.060	0.504	0.906
9 – Blue Diamond	Professional	Prof. + Hobbyist	-0.055	0.428	0.897
		Hobbyist	-0.568*	0.304	0.062
		General Interest	-1.633***	0.424	< 0.001
		Env. Employment	-0.897	0.553	0.105
	Prof+ Hobbyist	Hobbyist	-0.512	0.375	0.173
		General Interest	-1.578***	0.478	0.001
		Env. Employment	-0.841	0.595	0.158
	Hobbyist	General Interest	-1.066***	0.371	0.004
		Env. Employment	-0.329	0.513	0.522
	General Interest	Env. Employment	0.737	0.592	0.214

*Significance levels are indicated as * for p < 0.10, for ** for p < 0.05 and *** for p < 0.01.*

Appendix G6 One-way ANOVA between resident countries

Image	Source	*d. f.*	*SS*	*MS*	*F*	*p*	Partial η^2
2 – Yellow Ghost	Resident Country	3	253.093	84.364	11.467**	< 0.001	0.095
	Residual	329	2420.426	7.357	*		
	Corrected Total	332	2673.520				
3 – Golden	Resident Country	3	84.442	28.147	4.004***	0.008	0.035
	Residual	329	2312.843	7.030			
	Corrected Total	332	2397.285				
4 – Heckel	Resident Country	3	8.800	2.933	0.522	0.667	0.005
	Residual	329	1847.836	5.617			
	Corrected Total	332	1856.637				
5 – Pigeon Blood	Resident Country	3	22.588	7.529	1.132	0.336	0.010
	Residual	329	2188.697	6.653			
	Corrected Total	332	2211.285				
7 – Red Turquoise	Resident Country	3	56.659	18.886	3.110**	0.027	0.028
	Residual	329	1998.085	6.073			
	Corrected Total	332	2054.745				
8 – Blue Snakeskin	Resident Country	3	21.328	7.109	1.083	0.357	0.010
	Residual	329	2160.336	6.566			
	Corrected Total	332	2181.664				
9 – Blue Diamond	Resident Country	3	15.374	5.125	0.607	0.607	0.006
	Residual	329	2775.479	8.436			
	Corrected Total	332	2790.853				
10 – Super Marlboro Red	Resident Country	3	13.903	4.634	0.556	0.556	0.005
	Residual	329	2744.175	8.341			
	Corrected Total	332	2758.078				

*Included are models that have met assumptions on normality. Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

Appendix G7 LSD post-hoc test between resident countries

Image	Res. Country (I)	Res. Country (J)	Mean Difference (I-J)	Std. Err.	*p*
2 – Yellow Ghost	United Kingdom	Singapore	0.147	0.345	0.671
		Malaysia	2.042***	0.655	0.002
		Hong Kong	2.383***	0.461	< 0.001
	Singapore	Malaysia	1.895***	0.682	0.006
		Hong Kong	2.236***	0.499	< 0.001
	Malaysia	Hong Kong	0.341	0.747	0.648
3 – Golden	United Kingdom	Singapore	0.453	0.338	0.180
		Malaysia	0.485	0.640	0.449
		Hong Kong	1.546***	0.451	0.001
	Singapore	Malaysia	0.032	0.666	0.962
		Hong Kong	1.093**	0.487	0.026
	Malaysia	Hong Kong	1.061	0.730	0.147
7 – Red Turquoise	United Kingdom	Singapore	-0.702**	0.314	0.026
		Malaysia	-0.828	0.595	0.165
		Hong Kong	-1.019**	0.419	0.016
	Singapore	Malaysia	-0.126	0.619	0.839
		Hong Kong	-0.317	0.453	0.484
	Malaysia	Hong Kong	-0.191	0.679	0.779

*Significance levels are indicated as * for p < 0.10, for ** for p < 0.05 and *** for p < 0.01.*

Appendix G8 One-way ANOVA between survey types

Image	Source	*d. f.*	*SS*	*MS*	*F*	*p*	Partial η^2
3 – Golden	Survey Type	1	29.446	29.446	4.198**	0.041	0.010
	Residual	428	3002.331	7.015			
	Corrected Total	429	3031.777				
5 – Pigeon Blood	Survey Type	1	0.199	0.199	0.030	0.863	< 0.001
	Residual	428	2847.419	6.653			
	Corrected Total	429	2847.619				
7 – Red Turquoise	Survey Type	1	12.873	12.873	2.171	0.141	0.005
	Residual	428	2451.906	5.931			
	Corrected Total	429	2575.219				
8 – Blue Snakeskin	Survey Type	1	14.795	14.795	2.226	0.136	0.005
	Residual	428	2844.146	6.645			
	Corrected Total	429	2858.942				
10 – Super Marlboro Red	Survey Type	1	27.107	27.107	3.456	0.064	0.008
	Residual	428	3357.463	7.845			
	Corrected Total	429	3384.570				

*Included are models that have met assumptions on normality. Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

Appendix H Analyses of variance for general linear models based on pattern

Appendix H1 One-way ANOVA between groups on fishkeeping

Image	Source	*d. f.*	*SS*	*MS*	*F*	*p*	Partial η^2
1 – Wild Blue	Fishkeeping	2	22.499	11.249	1.695	0.185	0.008
	Residual	424	2814.246	6.637			
	Corrected Total	426	2836.745				
2 – Yellow Ghost	Fishkeeping	2	23.834	11.917	1.789	0.168	0.008
	Residual	424	2824.850	6.662			
	Corrected Total	426	2848.684				
3 – Golden	Fishkeeping	2	28.695	14.348	2.653	0.072	0.012
	Residual	424	2293.206	5.409			
	Corrected Total	426	2321.902				
4 – Heckel	Fishkeeping	2	43.078	21.539	4.276**	0.015	0.020
	Residual	424	2135.700	5.037			
	Corrected Total	426	2178.778				
5 – Pigeon Blood	Fishkeeping	2	30.336	15.168	2.254	0.106	0.011
	Residual	424	2853.491	6.730			
	Corrected Total	426	2883.827				
6 – Red Spotted Green	Fishkeeping	2	3.099	1.550	0.391	0.677	0.002
	Residual	424	1679.908	3.962			
	Corrected Total	426	1683.007				
8 – Blue Snakeskin	Fishkeeping	2	5.914	2.957	0.545	0.580	0.003
	Residual	424	2301.486	5.428			
	Corrected Total	426	2307.400				
9 – Blue Diamond	Fishkeeping	2	199.398	99.699	14.677***	< 0.001	0.065
	Residual	424	2880.232	6.793			
	Corrected Total	426	3079.630				
10 – Super Marlboro Red	Fishkeeping	2	5.146	2.573	0.455	0.635	0.002
	Residual	424	2399.964	5.660			
	Corrected Total	426	2405.110				

*Included are models that have met assumptions on normality. Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

Appendix H2 LSD post-hoc test between groups on fishkeeping

Image	Fishkeeping (I)	Fishkeeping (J)	Mean Difference (I-J)	Std. Err.	*p*
4 – Heckel	Discus	Other Tropical Fish	0.651**	0.252	0.010
		Other / Don't Keep	0.619**	0.278	0.027
	Other Tropical Fish	Other / Don't Keep	-0.032	0.298	0.916
9 – Blue Diamond	Discus	Other Tropical Fish	-1.124***	0.292	< 0.001
		Other / Don't Keep	-1.605***	0.323	< 0.001
	Other Tropical Fish	Other / Don't Keep	-0.481	0.346	0.165

*Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

Appendix H3 One-way ANOVA between groups on respondent class

Image	Source	*d. f.*	*SS*	*MS*	*F*	*p*	Partial η^2
1 – Wild Blue	Class	4	24.604	6.151	0.879	0.476	0.006
	Residual	597	4175.854	6.995			
	Corrected Total	601	4200.458				
2 – Yellow Ghost	Class	4	46.150	11.537	1.802	0.127	0.012
	Residual	597	3822.065	6.402			
	Corrected Total	601	3868.214				
4 – Heckel	Class	4	25.977	6.494	1.295	0.271	0.009
	Residual	597	2994.077	5.015			
	Corrected Total	601	3020.055				
5 – Pigeon Blood	Class	4	16.672	4.168	0.631	0.640	0.004
	Residual	597	3942.883	6.604			
	Corrected Total	601	3959.555				
7 – Red Turquoise	Class	4	119.834	29.958	5.273***	< 0.001	0.034
	Residual	597	3392.008	5.682			
	Corrected Total	601	3511.842				

*Included are models that have met assumptions on normality. Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

Appendix H4 LSD post-hoc test between groups on respondent class

Image	Class (I)	Class (J)	Mean Difference (I-J)	Std. Err.	*p*
7 – Red Turquoise	Professional	Prof. + Hobbyist	-0.162	0.363	0.656
		Hobbyist	0.111	0.258	0.668
		General Interest	-1.322***	0.360	< 0.001
		Env. Employment	-0.053	0.470	0.910
	Prof+ Hobbyist	Hobbyist	0.273	0.319	0.392
		General Interest	-1.160***	0.406	0.004
		Env. Employment	0.109	0.506	0.829
	Hobbyist	General Interest	-1.433***	0.315	< 0.001
		Env. Employment	-0.164	0.436	0.708
	General Interest	Env. Employment	1.269**	0.503	0.012

*Significance levels are indicated as * for p < 0.10, for ** for p < 0.05 and *** for p < 0.01.*

Appendix H5 One-way ANOVA between resident countries

Image	Source	*d. f.*	*SS*	*MS*	*F*	*p*	Partial η^2
1 – Wild Blue	Resident Country	3	5.284	1.761	0.273	0.845	0.002
	Residual	329	2125.929	6.462			
	Corrected Total	332	2131.213				
2 – Yellow Ghost	Resident Country	3	148.815	49.605	7.418***	< 0.001	0.063
	Residual	329	2199.930	6.687			
	Corrected Total	332	2345.745				
4 – Heckel	Resident Country	3	12.650	4.217	0.871	0.457	0.008
	Residual	329	1593.609	4.844			
	Corrected Total	332	1606.258				
5 – Pigeon Blood	Resident Country	3	20.803	6.934	1.036	0.377	0.009
	Residual	329	2201.113	6.690			
	Corrected Total	332	2221.916				

Image	Source	*d. f.*	*SS*	*MS*	*F*	*p*	Partial η^2
6 – Red Spotted Green	Resident Country	3	28.936	9.645	2.569	0.054	0.023
	Residual	329	1235.389	3.755			
	Corrected Total	332	1264.324				
7 – Red Turquoise	Resident Country	3	84.630	9.645	2.569	0.054	0.043
	Residual	329	1877.034	3.755			
	Corrected Total	332	1961.664				
8 – Blue Snakeskin	Resident Country	3	84.630	28.210	4.945***	0.002	0.020
	Residual	329	1877.034	5.705			
	Corrected Total	332	1961.664				

*Included are models that have met assumptions on normality. Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

Appendix H6 LSD post-hoc test between resident countries

Image	Res. Country (I)	Res. Country (J)	Mean Difference (I-J)	Std. Err.	*p*
2 – Yellow Ghost	United Kingdom	Singapore	0.238	0.329	0.470
		Malaysia	0.606	0.624	0.332
		Hong Kong	2.054***	0.440	< 0.001
	Singapore	Malaysia	0.368	0.650	0.571
		Hong Kong	1.816***	0.475	< 0.001
	Malaysia	Hong Kong	1.448**	0.712	0.043
7 – Red Turquoise	United Kingdom	Singapore	-0.408	0.304	0.181
		Malaysia	-0.513	0.577	0.375
		Hong Kong	-1.553***	0.406	< 0.001
	Singapore	Malaysia	-0.105	0.600	0.861
		Hong Kong	-1.146***	0.439	0.009
	Malaysia	Hong Kong	-1.040	0.658	0.115

*Significance levels are indicated as * for p < 0.10, for ** for p < 0.05 and *** for p < 0.01.*

Appendix H7 One-way ANOVA between survey types

Image	Source	*d. f.*	*SS*	*MS*	*F*	*p*	Partial η^2
2 – Yellow Ghost	Survey Type	1	258.815	258.815	42.491***	< 0.001	0.090
	Residual	428	2606.961	6.091			
	Corrected Total	429	2865.777				
4 – Heckel	Survey Type	1	83.667	83.667	16.939***	< 0.001	0.038
	Residual	428	2114.045	4.939			
	Corrected Total	429	2197.712				
6 – Red Spotted Green	Survey Type	1	37.534	37.534	3.545***	0.002	0.022
	Residual	428	1683.026	3.932			
	Corrected Total	429	1720.560				
8 – Blue Snakeskin	Survey Type	1	73.751	73.751	14.069***	< 0.001	0.032
	Residual	428	2243.600	5.242			
	Corrected Total	429	2317.351				
9 – Blue Diamond	Survey Type	1	2.926	2.927	0.405	0.525	0.001
	Residual	428	3091.885	7.224			
	Corrected Total	429	3094.812				

*Included are models that have met assumptions on normality. Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

Appendix I Analyses of variance for general linear models based on shape

Appendix I1 One-way ANOVA between groups on fishkeeping

Image	Source	*d. f.*	*SS*	*MS*	*F*	*p*	Partial η^2
1 – Wild Blue	Fishkeeping	2	4.587	2.294	0.354	0.702	0.002
	Residual	424	2744.706	6.473			
	Corrected Total	426	2749.293				
2 – Yellow Ghost	Fishkeeping	2	86.783	43.391	6.513***	0.002	0.030
	Residual	424	2824.618	6.662			
	Corrected Total	426	2911.400				
3 – Golden	Fishkeeping	2	210.210	105.105	14.598***	< 0.001	0.064
	Residual	424	3052.797	7.200			
	Corrected Total	426	3263.007				
5 – Pigeon Blood	Fishkeeping	2	4.798	2.399	0.378	0.685	0.002
	Residual	424	2690.593	6.346			
	Corrected Total	426	2695.391				
6 – Red Spotted Green	Fishkeeping	2	56.560	28.280	4.529**	0.011	0.021
	Residual	424	2647.468	6.244			
	Corrected Total	426	2704.028				
7 – Red Turquoise	Fishkeeping	2	33.149	16.575	2.872	0.058	0.013
	Residual	424	2446.612	5.770			
	Corrected Total	426	2479.761				

*Included are models that have met assumptions on normality. Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

Appendix I2 LSD post-hoc test between groups on fishkeeping

Image	Fishkeeping (I)	Fishkeeping (J)	Mean Difference (I-J)	Std. Err.	*p*
2 – Yellow Ghost	Discus	Other Tropical Fish	-0.933***	0.289	0.001
		Other / Don't Keep	-0.864***	0.320	0.007
	Other Tropical Fish	Other / Don't Keep	0.069	0.343	0.840
3 – Golden	Discus	Other Tropical Fish	1.153***	0.301	< 0.001
		Other / Don't Keep	1.649***	0.333	< 0.001
	Other Tropical Fish	Other / Don't Keep	0.496	0.356	0.164
6 – Red Spotted Green	Discus	Other Tropical Fish	0.521	0.282	0.064
		Other / Don't Keep	-0.894***	0.310	0.004
	Other Tropical Fish	Other / Don't Keep	0.374	0.332	0.261

*Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

Appendix I3 One-way ANOVA between groups on respondent class

Image	Source	*d. f.*	*SS*	*MS*	*F*	*p*	Partial η^2
1 – Wild Blue	Class	4	19.325	4.831	0.746	0.561	0.005
	Residual	597	3868.250	6.479			
	Corrected Total	601	3887.575				
3 – Golden	Class	4	260.083	65.021	9.141***	< 0.001	0.058
	Residual	597	4246.417	7.113			
	Corrected Total	601	4506.500				

Image	Source	*d. f.*	*SS*	*MS*	*F*	*p*	Partial η^2
5 – Pigeon Blood	Class	4	9.159	2.290	0.372	0.828	0.002
	Residual	597	3671.159	6.149			
	Corrected Total	601	3680.319				
6 – Red Spotted Green	Class	4	11.795	2.949	0.483	0.748	0.003
	Residual	597	3645.981	6.107			
	Corrected Total	601	3657.776				
7 – Red Turquoise	Class	4	51.983	12.996	2.235	0.064	0.015
	Residual	597	3471.353	5.815			
	Corrected Total	601	3523.336				
8 – Blue Snakeskin	Class	4	39.551	9.888	2.020	0.090	0.013
	Residual	597	2921.725	4.894			
	Corrected Total	601	2961.276				
9 – Blue Diamond	Class	4	549.769	137.442	10.934***	< 0.001	0.068
	Residual	597	7504.120	12.570			
	Corrected Total	601	8053.889				

*Included are models that have met assumptions on normality. Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

Appendix I4 LSD post-hoc test between groups on respondent class

Image	Class (I)	Class (J)	Mean Difference (I-J)	Std. Err.	*p*
3 – Golden	Professional	Prof. + Hobbyist	0.009	0.407	0.982
		Hobbyist	0.645**	0.289	0.026
		General Interest	2.157***	0.403	< 0.001
		Env. Employment	1.504***	0.526	0.004
	Prof. + Hobbyist	Hobbyist	0.636	0.357	0.075
		General Interest	2.147***	0.454	< 0.001
		Env. Employment	1.495***	0.566	0.008
	Hobbyist	General Interest	1.511***	0.488	< 0.001
		Env. Employment	0.859	0.357	0.079
	General Interest	Env. Employment	-0.652	0.563	0.247
9 – Blue Diamond	Professional	Prof. + Hobbyist	-0.026	0.541	0.962
		Hobbyist	-1.037***	0.384	0.007
		General Interest	-2.930***	0.536	< 0.001
		Env. Employment	-2.810***	0.699	< 0.001
	Prof+ Hobbyist	Hobbyist	-1.011**	0.474	0.033
		General Interest	-2.904***	0.604	< 0.001
		Env. Employment	-2.784***	0.752	< 0.001
	Hobbyist	General Interest	-1.892***	0.469	< 0.001
		Env. Employment	-1.773***	0.649	0.006
	General Interest	Env. Employment	0.120	0.749	0.873

*Significance levels are indicated as * for p < 0.10, for ** for p < 0.05 and *** for p < 0.01.*

Appendix I5 One-way ANOVA between resident countries

Image	Source	*d. f.*	*SS*	*MS*	*F*	*p*	Partial η^2
2 – Yellow Ghost	Resident Country	3	37.763	12.588	1.950	0.121	0.017
	Residual	329	2123.216	6.454			
	Corrected Total	332	2160.979				
3 – Golden	Resident Country	3	90.937	30.312	3.942***	0.009	0.035
	Residual	329	2530.060	7.690			
	Corrected Total	332	2620.997				
4 – Heckel	Resident Country	3	37.087	12.362	1.815	0.144	0.016
	Residual	329	2241.045	6.812			
	Corrected Total	332	2278.132				
6 – Red Spotted Green	Resident Country	3	9.560	3.187	0.521	0.668	0.005
	Residual	329	2013.887	6.121			
	Corrected Total	332	2023.447				
7 – Red Turquoise	Resident Country	3	67.960	22.653	3.895***	0.009	0.034
	Residual	329	1913.608	5.816			
	Corrected Total	332	1981.568				
8 – Blue Snakeskin	Resident Country	3	5.720	1.907	0.377	0.770	0.003
	Residual	329	1663.565	5.056			
	Corrected Total	332	1669.285				
9 – Blue Diamond	Resident Country	3	273.020	91.007	7.373***	< 0.001	0.063
	Residual	329	4060.788	12.343			
	Corrected Total	332	4333.808				
10 – Super Marlboro Red	Resident Country	3	1.517	0.506	0.086	0.968	0.001
	Residual	329	1944.399	5.910			
	Corrected Total	332	1945.916				

*Included are models that have met assumptions on normality. Significance levels are indicated as * for p < 0.10, for ** for p < 0.05 and *** for p < 0.01*

Appendix I6 LSD post-hoc test between resident countries

Image	Res. Country (I)	Res. Country (J)	Mean Difference (I-J)	Std. Err.	*p*
2 – Yellow Ghost	United Kingdom	Singapore	-0.030	0.353	0.933
		Malaysia	-0.409	0.670	0.542
		Hong Kong	1.497***	0.472	0.002
	Singapore	Malaysia	-0.379	0.697	0.587
		Hong Kong	1.527***	0.510	0.003
	Malaysia	Hong Kong	1.906**	0.764	0.013
7 – Red Turquoise	United Kingdom	Singapore	-0.450	0.307	0.144
		Malaysia	-0.965	0.582	0.098
		Hong Kong	-1.293***	0.410	0.002
	Singapore	Malaysia	-0.516	0.616	0.395
		Hong Kong	-0.844	0.443	0.058
	Malaysia	Hong Kong	0.516	0.606	0.395
9 – Blue Diamond	United Kingdom	Singapore	1.006**	0.447	0.025
		Malaysia	2.974***	0.848	0.001
		Hong Kong	-1.013	0.598	0.091
	Singapore	Malaysia	1.968**	0.883	0.026
		Hong Kong	-2.019***	0.646	0.002
	Malaysia	Hong Kong	-3.988***	0.968	< 0.001

*Significance levels are indicated as * for p < 0.10, for ** for p < 0.05 and *** for p < 0.01.*

Appendix I7 One-way ANOVA between survey types

Image	Source	*d. f.*	*SS*	*MS*	*F*	*p*	Partial η^2
2 – Yellow Ghost	Survey Type	1	25.590	25.590	3.775	0.053	0.009
	Residual	428	2901.175	6.778			
	Corrected Total	429	2926.765				
7 – Red Turquoise	Survey Type	1	42.153	42.153	7.308***	0.007	0.017
	Residual	428	2468.612	5.768			
	Corrected Total	429	2510.765				
8 – Blue Snakeskin	Survey Type	1	29.958	29.958	6.142**	0.014	0.014
	Residual	428	2087.661	4.878			
	Corrected Total	429	2117.619				
10 – Super Marlboro Red	Survey Type	1	131.922	131.922	24.492***	< 0.001	0.054
	Residual	428	2305.383	5.386			
	Corrected Total	429	2437.305				

*Included are models that have met assumptions on normality. Significance levels are indicated as * for p < 0.10, for ** for p < 0.05 and *** for p < 0.01.*

Appendix J Non-parametric analyses of variance on image data

Appendix J1 Kruskal-Wallis test statistics of images between groups on fishkeeping, based on colour

Image	*d. f.*	X^2	*p*
4 – Heckel	2	19.151***	< 0.001
7 – Red Turquoise	2	5.851	0.054
9 – Blue Diamond	2	21.339***	< 0.001

*Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

Appendix J2 Mann-Whitney U post-hoc test between groups on fishkeeping, based on colour

Image	Fishkeeping (I)	Fishkeeping (J)	Mann-Whitney U	*Z*	*p*
4 - Heckel	Discus	Other Tropical Fish	10581.500***	-3.004	0.003
		Other / Don't Keep	6737.500***	-4.119	< 0.001
	Other Tropical Fish	Other / Don't Keep	6054.000	-1.112	0.266
9 – Blue Diamond	Discus	Other Tropical Fish	10576.500***	-2.998	0.003
		Other / Don't Keep	11588.500***	-4.376	< 0.001
	Other Tropical Fish	Other / Don't Keep	5823.500	-1.569	0.117

*Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

Appendix J3 Kruskal-Wallis test statistics of images between groups on fishkeeping, based on pattern

Image	*d. f.*	X^2	*p*
7 – Red Turquoise	2	8.060**	0.018

*Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

Appendix J4 Mann-Whitney U post-hoc test between groups on fishkeeping, based on pattern

Image	Fishkeeping (I)	Fishkeeping (J)	Mann-Whitney U	*Z*	*p*
7 – Red Turquoise	Discus	Other Tropical Fish	12823.500	-0.324	0.746
		Other / Don't Keep	7746.000***	-2.616	0.009
	Other Tropical Fish	Other / Don't Keep	5379.500**	-2.458	0.014

*Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

Appendix J5 Kruskal-Wallis test statistics of images between groups on fishkeeping, based on shape

Image	*d. f.*	X^2	*p*
4 – Heckel	2	66.652***	< 0.001
8 – Blue Snakeskin	2	11.287***	0.004
9 – Blue Diamond	2	57.196***	< 0.001
10 – Super Marlboro Red	2	7.151**	0.028

*Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

Appendix J6 Mann-Whitney U post-hoc test between groups on fishkeeping, based on shape

Image	Fishkeeping (I)	Fishkeeping (J)	Mann-Whitney U	*Z*	*p*
4 – Heckel	Discus	Other Tropical Fish	8000.000***	-6.109	< 0.001
		Other / Don't Keep	4656.500***	-7.312	< 0.001
	Other Tropical Fish	Other / Don't Keep	5675.500	-1.862	0.063
8 – Blue Snakeskin	Discus	Other Tropical Fish	11304.000**	-2.157	0.031
		Other / Don't Keep	7351.500***	-3.229	0.001
	Other Tropical Fish	Other / Don't Keep	6080.000	-1.067	0.286
9 – Blue Diamond	Discus	Other Tropical Fish	8793.500***	-5.169	< 0.001
		Other / Don't Keep	4760.000***	-7.083	< 0.001
	Other Tropical Fish	Other / Don't Keep	5536.000**	-2.164	0.030

Image	Fishkeeping (I)	Fishkeeping (J)	Mann-Whitney U	*Z*	*p*
10 – Super	Discus	Other Tropical Fish	11896.000	-1.428	0.153
Marlboro		Other / Don't Keep	7727.500***	-2.636	0.008
Red	Other Tropical Fish	Other / Don't Keep	10845.000	-1.232	0.218

*Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

Appendix J7 Kruskal-Wallis test statistics of images between respondent class, based on colour

Image	*d. f.*	X^2	*p*
6 – Red Spotted Green	4	8.649	0.071

*Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

Appendix J8 Mann-Whitney U post-hoc test between respondent class, based on colour

Image	Class (I)	Class (J)	Mann-Whitney U	*Z*	*p*
3 – Golden	Professional	Prof. + Hobbyist	3928.000	-0.144	0.886
		Hobbyist	15891.000**	-2.169	0.030
		General Interest	3074.000***	-2.871	0.004
		Env. Employment	1572.000	-1.640	0.101
	Prof. + Hobbyist	Hobbyist	9276.000	-1.707	0.088
		General Interest	1786.500**	-2.546	0.011
		Env. Employment	913.500	-1.524	0.128
	Hobbyist	General Interest	9741.000	-1.496	0.135
		Env. Employment	4984.500	-0.361	0.718
	General Interest	Env. Employment	1059.500	-0.680	0.497

*Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

Appendix J9 Kruskal-Wallis test statistics of images between respondent class, based on pattern

Image	*d. f.*	X^2	*p*
7 – Red Turquoise	4	12.760**	0.013

*Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

Appendix J10 Mann-Whitney U post-hoc test between respondent class, based on pattern

Image	Class (I)	Class (J)	Mann-Whitney U	*Z*	*p*
3 – Golden	Professional	Prof. + Hobbyist	3825.000	-0.442	0.659
		Hobbyist	17386.500	-0.864	0.388
		General Interest	2958.000***	-3.208	0.001
		Env. Employment	1490.000**	-2.024	0.043
	Prof. + Hobbyist	Hobbyist	9707.000	-1.187	0.235
		General Interest	1636.500***	-3.200	0.001
		Env. Employment	826.500**	-2.170	0.030
	Hobbyist	General Interest	8505.500***	-2.989	0.003
		Env. Employment	4272.000	-1.677	0.094
	General Interest	Env. Employment	1079.000	-0.543	0.587

*Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

Appendix J11 Kruskal-Wallis test statistics of images between respondent class, based on shape

Image	*d. f.*	X^2	*p*
2 – Yellow Ghost	4	11.541**	0.021
4 – Heckel	4	37.767***	< 0.001
9 – Blue Diamond	4	46.211***	< 0.001

*Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

Appendix J12 Mann-Whitney U post-hoc test between respondent class, based on shape

Image	Class (I)	Class (J)	Mann-Whitney U	*Z*	*p*
4 – Heckel	Professional	Prof. + Hobbyist	3789.500	-0.551	0.582
		Hobbyist	15446.000**	-2.583	0.010
		General Interest	2251.000***	-5.220	< 0.001
		Env. Employment	1021.500***	-4.197	< 0.001
	Prof. + Hobbyist	Hobbyist	9507.500	-1.436	0.151
		General Interest	1428.500***	-4.093	< 0.001
		Env. Employment	652.000***	-3.444	0.001
	Hobbyist	General Interest	7586.000***	-4.097	< 0.001
		Env. Employment	3563.000***	-2.986	0.003
	General Interest	Env. Employment	1098.000	-0.406	0.685

*Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

Appendix J13 Kruskal-Wallis test statistics of images between resident countries, based on colour

Image	*d. f.*	X^2	*p*
1 – Wild Blue	3	9.836**	0.020
6 – Red Spotted Green	3	5.099	0.165

*Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

Appendix J14 Mann-Whitney U post-hoc test between resident countries based on colour

Image	Res. Country (I)	Res. Country (J)	Mann-Whitney U	*Z*	*p*
1 – Wild Blue	United Kingdom	Singapore	7940.000	-0.693	0.488
		Malaysia	1021.500***	-2.834	0.005
		Hong Kong	3564.500	-0.597	0.550
	Singapore	Malaysia	573.000**	-2.568	0.010
		Hong Kong	1831.500	-0.986	0.324
	Malaysia	Hong Kong	204.000***	-3.190	0.001

*Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

Appendix J15 Kruskal-Wallis test statistics of images between resident countries, based on pattern

Image	*d. f.*	X^2	*p*
3 – Golden	3	13.123***	0.004
9 – Blue Diamond	3	0.566	0.904
10 – Super Marlboro Red	3	1.457	0.692

*Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

Appendix J16 Mann-Whitney U post-hoc test between resident countries based on pattern

Image	Res. Country (I)	Res. Country (J)	Mann-Whitney U	*Z*	*p*
3 – Golden	United Kingdom	Singapore	8248.000	-0.184	0.854
		Malaysia	1420.500	-1.090	0.276
		Hong Kong	2485.500***	-3.527	< 0.001
	Singapore	Malaysia	784.000	-0.909	0.363
		Hong Kong	1407.500***	-2.941	0.003
	Malaysia	Hong Kong	321.500	-1.347	0.178

*Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

Appendix J17 Kruskal-Wallis test statistics of images between resident countries, based on shape

Image	*d. f.*	X^2	*p*
1 – Wild Blue	3	18.779***	< 0.001
5 – Pigeon Blood	3	0.247	0.970

*Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

Appendix J18 Mann-Whitney U post-hoc test between resident countries based on shape

Image	Res. Country (I)	Res. Country (J)	Mann-Whitney U	*Z*	*p*
1 – Wild Blue	United Kingdom	Singapore	6006.500***	-3.845	< 0.001
		Malaysia	1144.000**	-2.273	0.023
		Hong Kong	3544.500	-0.647	0.517
	Singapore	Malaysia	894.500	-0.061	0.951
		Hong Kong	1481.500***	-2.599	0.009
	Malaysia	Hong Kong	283.500	-1.927	0.054

*Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

Appendix J19 Kruskal-Wallis test statistics of images between survey types, based on colour

Image	*d. f.*	X^2	*p*
1 – Wild Blue	1	3.482	0.062
2 – Yellow Ghost	1	40.996***	< 0.001
4 – Heckel	1	4.220**	0.040
6 – Red Spotted Green	1	13.316	< 0.001
9 – Blue Diamond	1	8.274***	0.004

*Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

Appendix J20 Kruskal-Wallis test statistics of images between survey types, based on pattern

Image	*d. f.*	X^2	*p*
1 – Wild Blue	1	10.389***	0.001
3 – Golden	1	8.383***	0.004
5 – Pigeon Blood	1	1.013	0.314
7 – Red Turquoise	1	20.301***	< 0.001
10 – Super Marlboro Red	1	10.802***	0.001

*Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

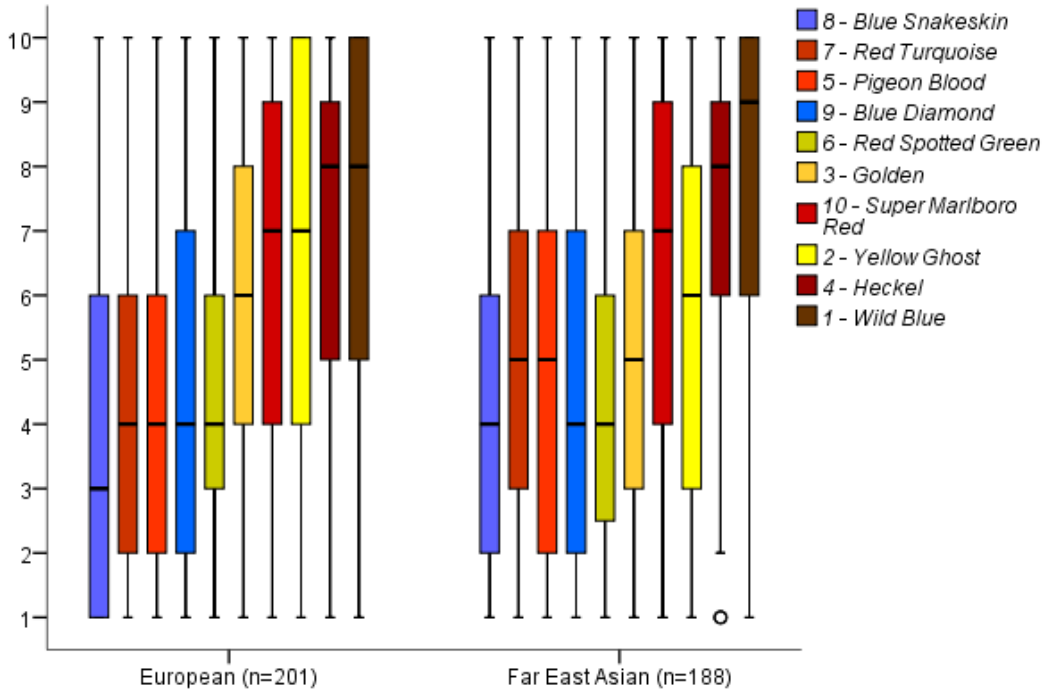
Appendix J21 Kruskal-Wallis test statistics of images between survey types, based on shape

Image	*d. f.*	X^2	*p*
1 – Wild Blue	1	0.342	0.559
3 – Golden	1	18.115***	< 0.001
4 – Heckel	1	30.852***	< 0.001
5 – Pigeon Blood	1	10.220***	0.001
6 – Red Spotted Green	1	0.279	0.597
9 – Blue Diamond	1	38.264***	< 0.001

*Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

Appendix K Results for CS analyses on overall market regions

Appendix K1 Boxplot of rank scores for images based on colour



Outliers are marked with a circle for 'out' values, and a star for extreme values. This was observed among respondents from the Far East Asian market for Heckel.

Appendix K2 One-way ANOVA between groups based on colour

Image	Source	*d. f.*	*SS*	*MS*	*F*	*p*	Partial η^2
2 – Yellow Ghost	Market Region	1	89.217	892.217	11.345***	0.001	0.028
	Residual	387	3043.374	7.864			
	Corrected Total	388	3132.591				
3 – Golden	Market Region	1	54.319	54.319	7.618***	0.006	0.019
	Residual	387	2759.507	7.131			
	Corrected Total	388	2813.825				
4 – Heckel	Market Region	1	3.177	3.177	0.556	0.456	0.001
	Residual	387	2211.851	5.715			
	Corrected Total	388	2215.028				
5 – Pigeon Blood	Market Region	1	0.475	0.475	0.071	0.790	< 0.001
	Residual	387	2596.733	6.710			
	Corrected Total	388	2597.208				
6 – Red Spotted Green	Market Region	1	5.959	5.959	1.028	0.311	0.003
	Residual	387	2242.411	5.794			
	Corrected Total	388	2248.370				
7 – Red Turquoise	Market Region	1	60.531	50.531	8.604***	0.004	0.022
	Residual	387	2272.878	5.873			
	Corrected Total	388	2323.409				
8 – Blue Snakeskin	Market Region	1	6.967	6.967	1.057	0.304	0.003
	Residual	387	2549.971	6.589			
	Corrected Total	388	2556.838				

Image	Source	*d. f.*	*SS*	*MS*	*F*	*p*	Partial η^2
9 – Blue Diamond	Market Region	1	1.379	1.379	0.171	0.680	< 0.001
	Residual	387	3130.893	8.090			
	Corrected Total	388	3132.272				

*Significance levels are indicated as * for p < 0.10, for ** for p < 0.05 and *** for p < 0.01.*

Appendix K3 Parameter estimates for significant models between groups based on colour

Image	Source	B-Effect	Std. Err.	*t*	*p*	Partial η^2
2 – Yellow Ghost	Intercept	5.798***	0.205	28.348	< 0.001	0.675
	European	0.958***	0.285	3l368	0.001	0.028
	Far East Asian	0				
3 – Golden	Intercept	5.207***	0.195	26.739	< 0.001	0.649
	European	0.748***	0.271	2.760	0.006	0.019
	Far East Asian	0				
7 – Red Turquoise	Intercept	5.074***	0.177	28.710	< 0.001	0.681
	European	-0.721***	0.246	-2.933	0.004	0.022
	Far East Asian	0				

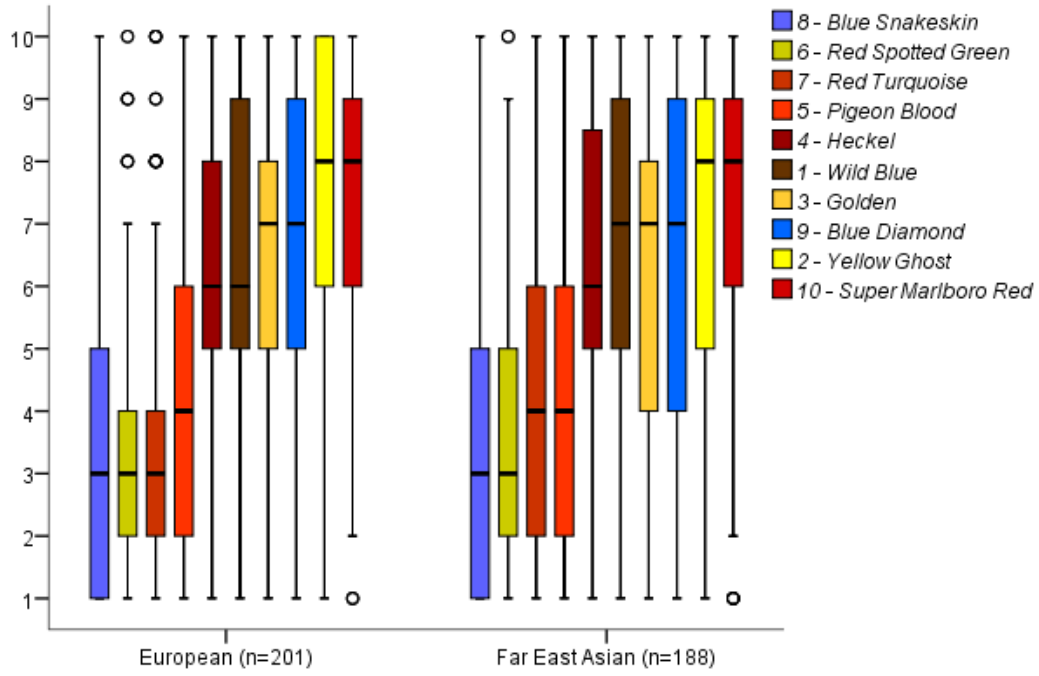
*Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

Appendix K4 Kruskal-Wallis test statistics of images based on colour

Image	*d. f.*	X^2	*p*
1 – Wild Blue	1	1.292	0.256
10 – Super Marlboro Red	1	3.080	0.079

*Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

Appendix K5 Boxplot of rank scores for images based on pattern



Outliers are marked with a circle for 'out' values, and a star for extreme values. This was observed among respondents from the European market for Red Spotted Green, Red Turquoise and Super Marlboro Red; and respondents from the Far East Asian market for Red Spotted Green and Super Marlboro Red.

Appendix K6 One-way ANOVA between groups based on pattern

Image	Source	*d. f.*	*SS*	*MS*	*F*	*p*	Partial η^2
1 – Wild Blue	Market Region	1	4.763	4.763	0.743	0.389	0.002
	Residual	387	2479.870	6.408			
	Corrected Total	388	2484.632				
2 – Yellow Ghost	Market Region	1	38.570	38.570	5.826**	0.016	0.015
	Residual	387	2562.180	6.621			
	Corrected Total	388	2600.751				
4 – Heckel	Market Region	1	10.391	10.391	2.059	0.152	0.005
	Residual	387	1952.725	5.046			
	Corrected Total	388	1963.116				
5 – Pigeon Blood	Market Region	1	4.533	4.533	0.688	0.407	0.002
	Residual	387	2548.305	6.585			
	Corrected Total	388	2552.838				
6 – Red Spotted Green	Market Region	1	0.023	0.023	0.006	0.940	< 0.001
	Residual	387	1542.136	3.985			
	Corrected Total	388	1542.159				
7 – Red Turquoise	Market Region	1	44.049	44.049	7.713***	0.006	0.020
	Residual	387	2210.090	5.711			
	Corrected Total	388	2254.139				
8 – Blue Snakeskin	Market Region	1	2.328	2.328	0.434	0.511	0.001
	Residual	387	2077.410	5.368			
	Corrected Total	388	2079.738				
9 – Blue Diamond	Market Region	1	2.622	2.622	0.357	0.551	0.001
	Residual	387	2842.227	7.344			
	Corrected Total	388	2844.858				

*Significance levels are indicated as * for p < 0.10, for ** for p < 0.05 and *** for p < 0.01.*

Appendix K7 Parameter estimates for significant models between groups, based on pattern

Image	Source	B-Effect	Std. Err.	*t*	*p*	Partial η^2
2 – Yellow Ghost	Intercept	7.027***	0.188	37.443	< 0.001	0.784
	European	0.630**	0.261	2.414	0.016	0.015
	Far East Asian	0				
7 – Red Turquoise	Intercept	4.181***	0.174	23.988	< 0.001	0.598
	European	-0.673***	0.242	-2.777	0.006	0.020
	Far East Asian	0				

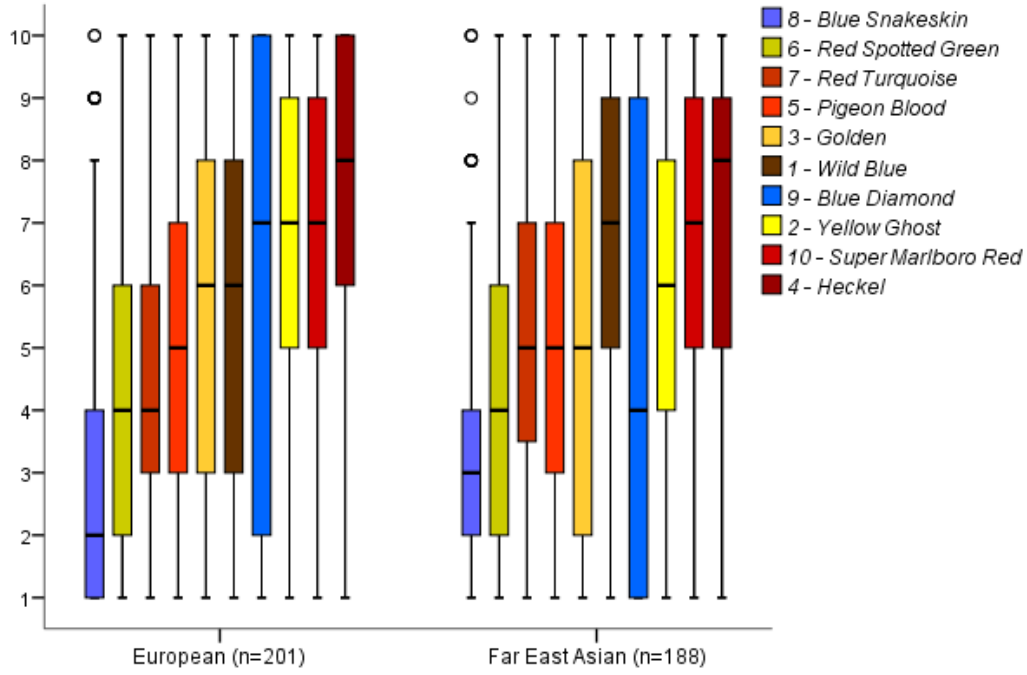
*Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

Appendix K8 Kruskal-Wallis test statistics of images based on pattern

Image	*d. f.*	X^2	*p*
3 – Golden	1	2.474	0.116
10 – Super Marlboro Red	1	0.253	0.615

*Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

Appendix K9 Boxplot of rank scores for images based on shape



Outliers are marked with a circle for 'out' values, and a star for extreme values. This was observed for Blue Snakeskin among respondents from the European market and the Far East Asian market.

Appendix K10 One-way ANOVA between groups based on shape

Image	Source	*d. f.*	*SS*	*MS*	*F*	*p*	Partial η^2
2 – Yellow Ghost	Market Region	1	41.783	41.783	6.459**	0.011	0.016
	Residual	387	2503.522				
	Corrected Total	388	2545.306				
4 – Heckel	Market Region	1	11.425	11.425	1.720	0.190	0.004
	Residual	387	2570.617	6.642			
	Corrected Total	388	2582.041				
5 – Pigeon Blood	Market Region	1	1.600	1.600	0.254	0.614	0.001
	Residual	387	2436.384	6.296			
	Corrected Total	388	2437.985				
6 – Red Spotted Green	Market Region	1	6.147	6.147	0.996	0.319	0.003
	Residual	387	2388.840	6.173			
	Corrected Total	388	2394.987				
7 – Red Turquoise	Market Region	1	47.414	47.414	8.249***	0.004	0.021
	Residual	387	2224.422	5.748			
	Corrected Total	388	2271.835				
8 – Blue Snakeskin	Market Region	1	3.537	3.537	0.742	0.390	0.002
	Residual	387	1844.704	4.767			
	Corrected Total	388	1848.242				

*Significance levels are indicated as * for p < 0.10, for ** for p < 0.05 and *** for p < 0.01.*

Appendix K12 Parameter estimates for significant models between groups, based on shape

Image	Source	B-Effect	Std. Err.	*t*	*p*	Partial η^2
2 – Yellow Ghost	Intercept	6.090***	0.185	32.833	< 0.001	0.736
	European	0.656**	0.258	2.541	0.011	0.016
	Far East Asian	0				
7 – Red Turquoise	Intercept	5.340***	0.175	30.542	< 0.001	0.707
	European	-0.699***	0.243	-2.872	0.004	0.021
	Far East Asian	0				

*Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

Appendix K13 Kruskal-Wallis test statistics of images based on shape

Image	*d. f.*	X^2	*p*
1 – Wild Blue	1	13.588***	< 0.001
3 – Golden	1	0.217	0.641
9 – Blue Diamond	1	10.755***	0.001
10 – Super Marlboro Red	1	0.490	0.484

*Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

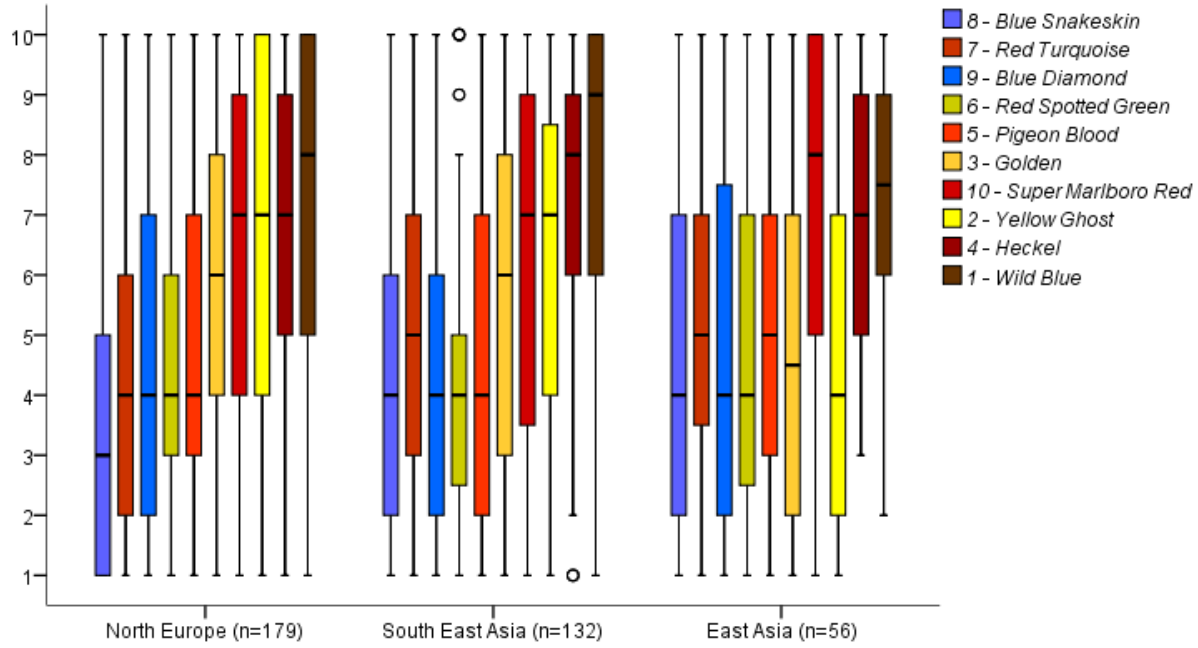
Appendix K14 Spearman's rank correlation coefficients of associations between and within groups

Association		*N*	r_s	*p*
Between groups	c_European * c_FarEast	10	0.903***	< 0.001
	p_European * p_FarEast	10	0.867***	0.001
	s_European * s_FarEast	10	0.818***	0.004
Within groups	c_European * p_European	10	0.600	0.067
	c_European * s_European	10	0.733**	0.016
	p_European * s_European	10	0.770***	0.009
	c_FarEast * p_FarEast	10	0.806***	0.005
	c_FarEast * s_FarEast	10	0.952***	< 0.001
	p_FarEast * s_FarEast	10	0.794***	0.006

*Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

Appendix L Results for CS analyses on geographical sub-region

Appendix L1 Boxplot of rank scores for images based on colour



Outliers are marked with a circle for 'out' values, and a star for extreme values. This was observed among respondents from South East Asia for Red Spotted Green and Heckel.

Appendix L2 One-way ANOVA between groups based on colour

Image	Source	*d. f.*	*SS*	*MS*	*F*	*p*	Partial η^2
2 – Yellow Ghost	Sub-Region	2	201.913	100.956	13.374***	< 0.001	0.068
	Residual	364	2747.739	78.549			
	Corrected Total	366	2949.651				
3 – Golden	Sub-Region	2	89.633	44.816	6.412***	0.002	0.034
	Residual	364	2544.078	6.989			
	Corrected Total	366	2633.711				
4 – Heckel	Sub-Region	2	4.913	2.457	0.438	0.646	0.002
	Residual	364	2043.245	5.613			
	Corrected Total	366	2048.158				
5 – Pigeon Blood	Sub-Region	2	15.877	7.939	1.194	0.304	0.007
	Residual	364	2420.330	6.649			
	Corrected Total	366	2436.207				
6 – Red Spotted Green	Sub-Region	2	16.301	8.151	1.422	0.243	0.008
	Residual	364	2086.615	5.732			
	Corrected Total	366	2102.916				
7 – Red Turquoise	Sub-Region	2	47.952	23.976	4.026**	0.019	0.022
	Residual	364	2167.699	5.955			
	Corrected Total	366	2215.651				
8 – Blue Snakeskin	Sub-Region	2	23.925	11.962	1.832	0.162	0.010
	Residual	364	2377.268	6.531			
	Corrected Total	366	2401.193				

Image	Source	*d. f.*	*SS*	*MS*	*F*	*p*	Partial η^2
9 – Blue Diamond	Sub-Region	2	5.947	2.973	0.364	0.695	0.002
	Residual	364	2974.167	8.171			
	Corrected Total	366	2980.114				
10 – Super Marlboro Red	Sub-Region	2	45.769	22.884	2.807	0.062	0.015
	Residual	364	2967.681	8.153			
	Corrected Total	366	3013.450				

*Significance levels are indicated as * for p < 0.10, for ** for p < 0.05 and *** for p < 0.01.*

Appendix L3 LSD post-hoc test between groups based on colour

Image	Sub-Region (I)	Sub-Region (J)	Mean Difference (I-J)	Std. Err.	*p*
2 – Yellow Ghost	North Europe	South East Asia	0.479	0.315	0.129
		East Asia	2.175***	0.421	< 0.001
	South East Asia	East Asia	1.696***	0.438	< 0.001
3 – Golden	North Europe	South East Asia	0.560	0.303	0.066
		East Asia	1.415***	0.405	0.001
	South East Asia	East Asia	0.855**	0.422	0.043
7 – Red Turquoise	North Europe	South East Asia	-0.709**	0.280	0.012
		East Asia	-0.755**	0.374	0.044
	South East Asia	East Asia	-0.047	0.389	0.905

*Significance levels are indicated as * for p < 0.10, for ** for p < 0.05 and *** for p < 0.01.*

Appendix L4 Parameter estimates for significant models between groups, based on colour

Image	Source	B-Effect	Std. Err.	t	*p*	Partial η^2
2 – Yellow Ghost	Intercept	4.607***	0.367	12.548	< 0.001	0.302
	North Europe	2.175***	0.421	5.170	< 0.001	0.068
	South East Asia	1.696***	0.438	3.870	< 0.001	0.040
	East Asia	0				
3 - Golden	Intercept	4.607***	0.353	13.041	< 0.001	0.318
	North Europe	1.415***	0.405	3.496	0.001	0.032
	South East Asia	0.855**	0.422	2.028	0.043	0.011
	East Asia	0				
7 – Red Turquoise	Intercept	4.352***	0.182	23.860	< 0.001	0.610
	South East Asia	0.709**	0.280	2.531	0.012	0.017
	East Asia	0.755**	0.374	2.021	0.044	0.011
	North Europe	0				

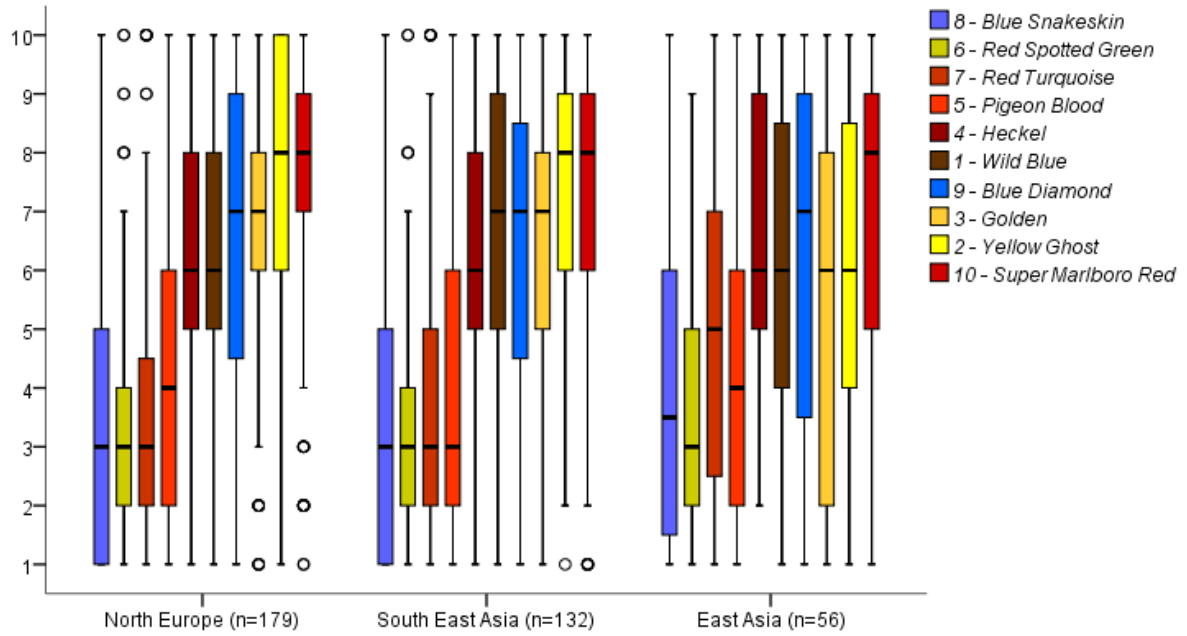
*Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

Appendix L5 Kruskal-Wallis test statistics of images based on colour

Image	*d. f.*	X^2	*p*
1 – Wild Blue	2	4.597	0.100

*Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

Appendix L6 Boxplot of rank scores for images based on pattern



Outliers are marked with a circle for 'out' values, and a star for extreme values. This was observed among respondents from North Europe for Red Spotted Green, Red Turquoise, Golden and Super Marlboro Red; and South East Asia for Red Spotted Green, Red Turquoise, Golden and Super Marlboro Red.

Appendix L7 One-way ANOVA between groups based on pattern

Image	Source	*d. f.*	*SS*	*MS*	*F*	*p*	Partial η^2
1 – Wild Blue	Sub-Region	2	11.788	5.894	0.918	0.400	0.005
	Residual	364	2337.536	6.422			
	Corrected Total	366	2349.324				
2 – Yellow Ghost	Sub-Region	2	112.776	56.388	8.651***	< 0.001	0.045
	Residual	364	2372.581	6.518			
	Corrected Total	366	2485.357				
4 – Heckel	Sub-Region	2	17.285	8.642	1.725	0.180	0.009
	Residual	364	1824.078	5.011			
	Corrected Total	366	1841.362				
5 – Pigeon Blood	Sub-Region	2	6.831	6.831	1.725	0.595	0.003
	Residual	364	2387.551	5.011			
	Corrected Total	366	2394.381				
6 – Red Spotted Green	Sub-Region	2	18.658	0.329	2.477	0.085	0.013
	Residual	364	1370.699	3.766			
	Corrected Total	366	1389.357				
7 – Red Turquoise	Sub-Region	2	79.189	39.595	7.093***	0.001	0.038
	Residual	364	2031.999	5.582			
	Corrected Total	366	2111.188				
8 – Blue Snakeskin	Sub-Region	2	23.908	11.954	2.238	0.108	0.012
	Residual	364	1944.517	5.342			
	Corrected Total	366	1968.425				
9 – Blue Diamond	Sub-Region	2	1.585	0.793	0.106	0.899	0.001
	Residual	364	2718.660	7.469			
	Corrected Total	366	2720.245				

*Significance levels are indicated as * for p < 0.10, for ** for p < 0.05 and *** for p < 0.01.*

Appendix L8 LSD post-hoc test between groups based on pattern

Image	Sub-Region (I)	Sub-Region (J)	Mean Difference (I-J)	Std. Err.	*p*
2 – Yellow Ghost	North Europe	South East Asia	0.255	0.293	0.384
		East Asia	1.616***	0.391	< 0.001
	South East Asia	East Asia	1.360***	0.407	0.001
7 – Red Turquoise	North Europe	South East Asia	-0.348	0.271	0.200
		East Asia	-1.362***	0.362	< 0.001
	South East Asia	East Asia	-1.014***	0.377	0.007

*Significance levels are indicated as * for p < 0.10, for ** for p < 0.05 and *** for p < 0.01.*

Appendix L9 Parameter estimates for significant models between groups, based on pattern

Image	Source	B-Effect	Std. Err.	t	*p*	Partial η^2
2 – Yellow Ghost	Intercept	6.071***	0.341	17.796	< 0.001	0.465
	North Europe	1.616***	0.391	4.133	< 0.001	0.045
	South East Asia	1.360***	0.407	3.41	0.001	0.030
	East Asia	0				
7 – Red Turquoise	Intercept	4.893***	0.316	15.497	< 0.001	0.398
	North Europe	-1.362***	0.362	-3.765	< 0.001	0.037
	South East Asia	-1.014***	0.377	-2.691	0.007	0.020
	East Asia	0				

*Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

Appendix L10 Kruskal-Wallis test statistics of images based on pattern

Image	*d. f.*	X^2	*p*
3 - Golden	2	7.291**	0.026
10 – Super Marlboro Red	2	0.626	0.731

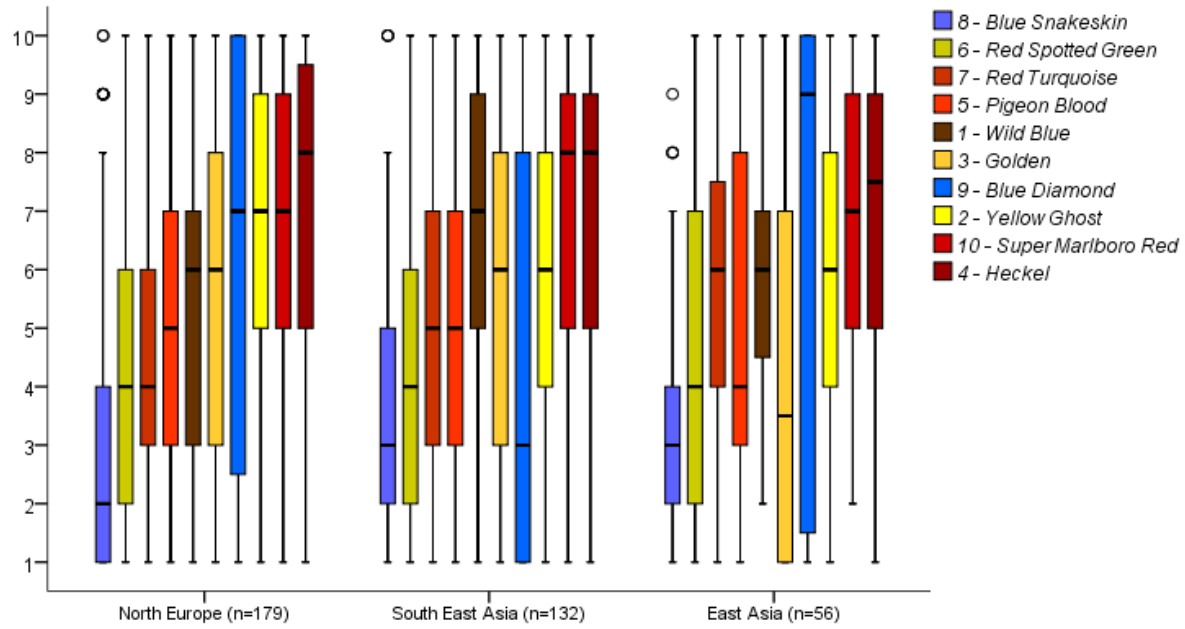
*Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

Appendix L11 Mann-Whitney U post-hoc test between groups based on pattern

Image	Sub-Region (I)	Sub-Region (J)	Mann-Whitney U	*Z*	*p*
3 – Golden	North Europe	South East Asia	11225.000	-0.760	0.447
		East Asia	3840.000***	-2.670	0.008
	South East Asia	East Asia	2990.000**	-2.086	0.037

*Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

Appendix L12 Boxplot of rank scores for images based on shape



Outliers are marked with a circle for 'out' values, and a star for extreme values. This was observed for Blue Snakeskin among respondents from North Europe, South East Asia and East Asia.

Appendix L13 One-way ANOVA between groups based on shape

Image	Source	*d. f.*	*SS*	*MS*	*F*	*p*	Partial η^2
2 – Yellow Ghost	Sub-Region	2	60.447	30.223	4.656**	0.010	0.025
	Residual	364	2363.057	6.492			
	Corrected Total	366	2423.504				
4 – Heckel	Sub-Region	2	13.162	6.581	0.977	0.377	0.005
	Residual	364	2451.072	6.734			
	Corrected Total	366	2464.234				
6 – Red Spotted Green	Sub-Region	2	11.739	5.870	0.941	0.391	0.005
	Residual	364	2271.035	6.239			
	Corrected Total	366	2282.774				
7 – Red Turquoise	Sub-Region	2	62.496	31.248	5.467***	0.005	0.029
	Residual	364	2080.501	5.716			
	Corrected Total	366	2142.997				
8 – Blue Snakeskin	Sub-Region	2	1.384	0.692	0.141	0.868	0.001
	Residual	364	1783.820	4.901			
	Corrected Total	366	1785.204				
9 – Blue Diamond	Sub-Region	2	276.064	138.032	10.948***	< 0.001	0.057
	Residual	364	4589.189	12.608			
	Corrected Total	366	4865.253				
10 – Super Marlboro Red	Sub-Region	2	0.372	186	0.032	0.969	< 0.001
	Residual	364	2121.290	5.828			
	Corrected Total	366	2121.662				

*Significance levels are indicated as * for p < 0.10, for ** for p < 0.05 and *** for p < 0.01.*

Appendix L14 LSD post-hoc test between groups based on shape

Image	Sub-Region (I)	Sub-Region (J)	Mean Difference (I-J)	Std. Err.	*p*
2 – Yellow Ghost	North Europe	South East Asia	0.695**	0.292	0.018
		East Asia	1.002**	0.390	0.011
	South East Asia	East Asia	0.307	0.406	0.451
7 – Red Turquoise	North Europe	South East Asia	-0.507	0.274	0.065
		East Asia	-1.167***	0.366	0.002
	South East Asia	East Asia	-0.660	0.381	0.084
9 – Blue Diamond	North Europe	South East Asia	1.731***	0.407	< 0.001
		East Asia	-0.276	0.544	0.613
	South East Asia	East Asia	-2.006***	0.566	< 0.001

*Significance levels are indicated as * for p < 0.10, for ** for p < 0.05 and *** for p < 0.01.*

Appendix L15 Parameter estimates for significant models between groups based on shape

Image	Source	B-Effect	Std. Err.	*t*	*p*	Partial η^2
2 – Yellow Ghost	Intercept	6.877***	0.190	36.111	< 0.001	0.782
	South East Asia	-0.695**	0.292	-2.379	0.018	0.015
	East Asia	-1.002**	0.390	-2.569	0.011	0.018
	North Europe	0				
7 – Red Turquoise	Intercept	4.637***	0.179	25.949	< 0.001	0.649
	East Asia	1.167***	0.366	3.187	0.002	0.027
	South East Asia	0.507	0.274	1.849	0.065	0.009
	North Europe	0				
9 – Blue Diamond	Intercept	4.386***	0.309	14.193	< 0.001	0.356
	North Europe	1.731***	0.407	4.249	< 0.001	0.047
	East Asia	2.006***	0.566	3.543	< 0.001	0.033
	South East Asia	0				

*Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

Appendix L16 Kruskal-Wallis test statistics of images based on UN sub-region and shape

Image	*d. f.*	X^2	*p*
1 – Wild Blue	2	19.889***	< 0.001
3 - Golden	2	10.548***	0.005
5 – Pigeon Blood	2	0.061	0.970

*Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

Appendix L17 Mann-Whitney U post-hoc test between groups based on shape

Image	Sub-Region (I)	Sub-Region (J)	Mann-Whitney U	*Z*	*p*
1 – Wild Blue	North Europe	South East Asia	8453.500***	-4.313	< 0.001
		East Asia	4473.000	-1.222	0.222
	South East Asia	East Asia	2845.500**	-2.513	0.012
3 – Golden	North Europe	South East Asia	10961.000	-1.095	0.274
		East Asia	3812.000***	-2.718	0.007
	South East Asia	East Asia	2656.500***	-3.066	0.002

*Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

Appendix L18 Spearman's rank correlation coefficients of associations between and within groups

Association		***N***	r_s	***p***
Between groups	c_NEurope * c_SEAsia	10	0.903***	< 0.001
	c_NEurope * c_EAsia	10	0.578	0.080
	c_SEAsia * c_EAsia	10	0.669**	0.035
	p_NEurope * p_SEAsia	10	0.964***	< 0.001
	p_NEurope * p_EAsia	10	0.697**	0.025
	p_SEAsia * p_EAsia	10	0.745**	0.013
	s_NEurope * s_SEAsia	10	0.842***	0.002
	s_NEurope * s_EAsia	10	0.867***	0.001
	s_SEAsia * s_EAsia	10	0.721**	0.019
Within groups	c_NEurope * p_NEurope	10	0.600	0.067
	c_NEurope * s_NEurope	10	0.733**	0.016
	p_NEurope * s_NEurope	10	0.770***	0.009
	c_SEAsia * p_SEAsia	10	0.733**	0.016
	c_SEAsia * s_SEAsia	10	0.964***	< 0.001
	p_SEAsia * s_SEAsia	10	0.709**	0.022
	c_EAsia * p_EAsia	10	0.571	0.084
	c_EAsia * s_EAsia	10	0.675**	0.032
	p_EAsia * s_EAsia	10	0.891***	0.001

*Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

Appendix M Results for CS analyses on survey language

Appendix M1 One-way ANOVA between groups based on colour

Image	Source	*d. f.*	*SS*	*MS*	*F*	*P*	Partial η^2
2 – Yellow Ghost	Survey Language	1	41.254	41.254	5.108**	0.024	0.012
	Residual	428	3456.644	8.076			
	Corrected Total	429	3497.898				
3 – Golden	Survey Language	1	0.879	0.879	0.124	0.725	< 0.001
	Residual	428	3030.898	7.082			
	Corrected Total	429	3031.777				
4 – Heckel	Survey Language	1	0.448	0.448	0.076	0.783	< 0.001
	Residual	428	2525.527	5.901			
	Corrected Total	429	2525.974				
8 – Blue Snakeskin	Survey Language	1	0.004	0.067	0.011	0.915	< 0.001
	Residual	428	2858.144	5.961			
	Corrected Total	429	2551.212				
10 – Super Marlboro Red	Survey Language	1	2.526	2.526	0.320	0.572	0.001
	Residual	428	3382.044	7.902			
	Corrected Total	429	3384.570				

*Significance levels are indicated as * for p < 0.10, for ** for p < 0.05 and *** for p < 0.01.*

Appendix M2 Parameter estimates for significant models between groups, based on colour

Image	Source	B-Effect	Std. Err.	*t*	*p*	Partial η^2
2 – Yellow Ghost	Intercept	5.167***	0.519	9.958	< 0.001	0.188
	English	1.216**	0.538	2.260	0.024	0.012
	Chinese	0				

*Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

Appendix M3 Kruskal-Wallis test statistics of images based on colour

Image	*d. f.*	X^2	*p*
1 – Wild Blue	1	0.025	0.875
5 – Pigeon Blood	1	0.050	0.822
6 – Red Spotted Green	1	0.673	0.412
7 – Red Turquoise	1	0.063	0.803
9 – Blue Diamond	1	0.021	0.884

*Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

Appendix M4 One-way ANOVA between groups based on pattern

Image	Source	*d. f.*	*SS*	*MS*	*F*	*p*	Partial η^2
1 – Wild Blue	Survey Language	1	1.487	1.487	0.221	0.638	0.001
	Residual	428	2873.864	6.715			
	Corrected Total	429	2875.351				
2 – Yellow Ghost	Survey Language	1	20.720	20.720	3.117	0.078	0.007
	Residual	428	2845.057	6.647			
	Corrected Total	429	2865.777				

Image	Source	*d. f.*	*SS*	*MS*	*F*	*p*	Partial η^2
3 – Golden	Survey Language	1	5.991	5.991	1.106	0.294	0.003
	Residual	428	2319.007	5.418			
	Corrected Total	429	2324.998				
4 – Heckel	Survey Language	1	0.472	0.472	0.092	0.762	< 0.001
	Residual	428	2197.240	5.134			
	Corrected Total	429	2197.712				
5 – Pigeon Blood	Survey Language	1	0.067	0.067	0.010	0.921	< 0.001
	Residual	428	2913.144	6.806			
	Corrected Total	429	2913.212				
6 – Red Spotted Green	Survey Language	1	3.820	3.820	0.952	0.330	0.002
	Residual	428	1716.740	4.011			
	Corrected Total	429	1720.560				
7 – Red Turquoise	Survey Language	1	12.126	12.126	2.081	0.150	0.005
	Residual	428	2493.644	5.826			
	Corrected Total	429	2505.770				
8 – Blue Snakeskin	Survey Language	1	4.691	4.691	0.868	0.352	0.002
	Residual	428	2312.660	5.403			
	Corrected Total	429	2317.351				
9 – Blue Diamond	Survey Language	1	1.947	1.947	0.269	0.604	0.001
	Residual	428	3092.864	7.224			
	Corrected Total	429	3094.812	7.226			
10 – Super Marlboro Red	Survey Language	1	0.028	0.028	0.005	0.944	< 0.001
	Residual	428	2406.077	5.622			
	Corrected Total	429	2406.105				

*Significance levels are indicated as * for p < 0.10, for ** for p < 0.05 and *** for p < 0.01.*

Appendix M5 One-way ANOVA between groups based on shape

Image	Source	*d. f.*	*SS*	*MS*	*F*	*p*	Partial η^2
1 – Wild Blue	Survey Language	1	1.641	1.641	0.255	0.614	0.001
	Residual	428	2753.978	6.435			
	Corrected Total	429	2755.619				
2 – Yellow Ghost	Survey Language	1	2.798	2.798	0.410	0.523	0.001
	Residual	428	2923.967	6.832			
	Corrected Total	429	2926.765				
3 – Golden	Survey Language	1	39.574	39.574	5.194**	0.023	0.012
	Residual	428	3261.144	7.619			
	Corrected Total	429	3300.719				
4 – Heckel	Survey Language	1	0.454	0.454	0.066	0.798	< 0.001
	Residual	428	2962.498	6.922			
	Corrected Total	429	2962.951				
5 – Pigeon Blood	Survey Language	1	0.171	0.171	0.027	0.869	< 0.001
	Residual	428	2699.457	6.307			
	Corrected Total	429	2699.628				

Image	Source	*d. f.*	*SS*	*MS*	*F*	*p*	Partial η^2
6 – Red Spotted Green	Survey Language	1	5.140	5.140	0.810	0.369	0.002
	Residual	428	2717.104	6.348			
	Corrected Total	429	2722.244				
7 – Red Turquoise	Survey Language	1	34.798	34.798	6.015**	0.015	0.014
	Residual	428	2475.967	5.785			
	Corrected Total	429	2510.765				
8 – Blue Snakeskin	Survey Language	1	0.179	0.179	0.036	0.849	< 0.001
	Residual	428	2117.440	4.947			
	Corrected Total	429	2117.619				
10 – Super Marlboro Red	Survey Language	1	7.282	7.282	0.557	0.456	0.003
	Residual	428	5594.764	13.072			
	Corrected Total	429	5602.047				

*Significance levels are indicated as * for p < 0.10, for ** for p < 0.05 and *** for p < 0.01.*

Appendix M6 Parameter estimates for significant models between groups, based on shape

Image	Source	B-Effect	Std. Err.	*t*	*p*	Partial η^2
3 – Golden	Intercept	4.267***	0.504	8.466	< 0.001	0.143
	English	1.191**	0.523	2.279	0.023	0.012
	Chinese	0				
7 – Red Turquoise	Intercept	5.967***	0.439	13.588	< 0.001	0.301
	English	-1.117**	0.455	-2.453	0.015	0.014
	Chinese	0				

*Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

Appendix M7 Kruskal-Wallis test statistics of images based on shape

Image	*d. f.*	X^2	*p*
9 – Blue Diamond	1	0.575	0.448

*Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

Appendix M8 Spearman's rank correlation coefficients of associations between and within groups

Association		*N*	r_s	*p*
Between groups	c_English * c_Chinese	10	0.915***	< 0.001
	p_English * p_Chinese	10	0.863***	0.001
	s_English * s_Chinese	10	0.894***	< 0.001
Within groups	c_English * p_English	10	0.697**	0.025
	c_English * s_English	10	0.806***	0.005
	p_English * s_English	10	0.794***	0.006
	c_Chinese * p_Chinese	10	0.705**	0.023
	c_Chinese * s_Chinese	10	0.766***	0.010
	p_Chinese * s_Chinese	10	0.756**	0.011

*Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

Appendix N Results for CS analyses on survey completeness

Appendix N1 One-way ANOVA between groups based on colour

Image	Source	*d. f.*	*SS*	*MS*	*F*	*p*	Partial η^2
1 – Wild Blue	Survey Completeness	1	49.946	49.946	7.235***	0.007	0.017
	Residual	428	2954.801	6.904			
	Corrected Total	429	3004.747				
2 – Yellow Ghost	Survey Completeness	1	0.849	0.849	0.104	0.747	< 0.001
	Residual	428	3497.048	8.171			
	Corrected Total	429	3497.898				
3 – Golden	Survey Completeness	1	12.042	12.042	1.707	0.192	0.004
	Residual	428	3019.735	7.055			
	Corrected Total	429	3031.777				
4 – Heckel	Survey Completeness	1	1.303	1.303	0.221	0.639	0.001
	Residual	428	2524.671	5.899			
	Corrected Total	429	2525.974				
5 – Pigeon Blood	Survey Completeness	1	16.304	16.304	2.465	0.117	0.006
	Residual	428	2831.315	6.615			
	Corrected Total	429	2847.619				
8 – Blue Snakeskin	Survey Completeness	1	31.193	31.183	4.720**	0.030	0.011
	Residual	428	2827.759	6.607			
	Corrected Total	429	2858.942				
9 – Blue Diamond	Survey Completeness	1	0.275	0.275	0.034	0.854	< 0.001
	Residual	428	3469.411	8.106			
	Corrected Total	429	3469.686				
10 – Super Marlboro Red	Survey Completeness	1	3.441	3.441	0.436	0.510	0.001
	Residual	428	3381.129	7.900			
	Corrected Total	429	3384.570				

*Significance levels are indicated as * for p < 0.10, for ** for p < 0.05 and *** for p < 0.01.*

Appendix N2 Parameter estimates for significant models between groups, based on colour

Image	Source	B-Effect	Std. Err.	*t*	*p*	Partial η^2
1 – Wild Blue	Intercept	7.104***	0.155	45.962	< 0.001	0.832
	CS Only	0.726***	0.270	2.690	0.007	0.017
	CE + CS	0				
8 – Blue Snakeskin	Intercept	4.176***	0.151	27.622	< 0.001	0.641
	CS Only	-0.574**	0.264	-2.172	0.030	0.011
	CE + CS	0				

*Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

Appendix N3 Kruskal-Wallis test statistics of images based on colour

Image	*d. f.*	X^2	*p*
6 – Red Spotted Green	1	0.407	0.524
7 – Red Turquoise	1	1.683	0.195

*Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

Appendix N4 One-way ANOVA between groups based on pattern

Image	Source	*d. f.*	*SS*	*MS*	*F*	*p*	Partial η^2
2 – Yellow Ghost	Survey Completeness	1	7.569	7.569	1.133	0.288	0.003
	Residual	428	2858.208	6.678			
	Corrected Total	429	2865.777				
3 – Golden	Survey Completeness	1	0.371	0.371	0.068	0.794	< 0.001
	Residual	428	2324.627	5.431			
	Corrected Total	429	2324.998				
5 – Pigeon Blood	Survey Completeness	1	46.314	46.314	6.914***	0.009	0.016
	Residual	428	2866.898	6.698			
	Corrected Total	429	2913.212				
6 – Red Spotted Green	Survey Completeness	1	0.542	0.542	0.135	0.714	< 0.001
	Residual	428	1720.018	4.019			
	Corrected Total	429	1720.560				
8 – Blue Snakeskin	Survey Completeness	1	10.754	10.754	1.995	0.159	0.005
	Residual	428	2306.597	5.389			
	Corrected Total	429	2317.351				
9 – Blue Diamond	Survey Completeness	1	26.012	26.012	3.628	0.057	0.008
	Residual	428	3068.800	7.170			
	Corrected Total	429	3094.812				

*Significance levels are indicated as * for p < 0.10, for ** for p < 0.05 and *** for p < 0.01.*

Appendix N5 Parameter estimates for significant models between groups, based on pattern

Image	Source	B-Effect	Std. Err.	*t*	*p*	Partial η^2
5 – Pigeon Blood	Intercept	4.408***	0.152	28.956	< 0.001	0.662
	CS Only	-0.699***	0.266	-2.629	0.009	0.016
	CE + CS	0				

*Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

Appendix N6 Kruskal-Wallis test statistics of images based on pattern

Image	*d. f.*	X^2	*p*
1 – Wild Blue	1	2.173	0.140
4 – Heckel	1	4.322**	0.038
7 – Red Turquoise	1	0.081	0.776
10 – Super Marlboro Red	1	2.080	0.149

*Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

Appendix N7 One-way ANOVA between groups based on shape

Image	Source	*d. f.*	*SS*	*MS*	*F*	*p*	Partial η^2
1 – Wild Blue	Survey Completeness	1	6.865	6.865	1.069	0.302	0.002
	Residual	428	2748.753	6.422			
	Corrected Total	429	2755.619				
2 – Yellow Ghost	Survey Completeness	1	48.458	48.458	7.206***	0.008	0.017
	Residual	428	2878.307	6.725			
	Corrected Total	429	2926.765				

Image	Source	*d. f.*	*SS*	*MS*	*F*	*p*	Partial η^2
3 – Golden	Survey Completeness	1	0.082	0.082	0.011	0.918	< 0.001
	Residual	428	3300.636	7.712			
	Corrected Total	429	3300.719				
4 – Heckel	Survey Completeness	1	31.601	31.601	4.614**	0.032	0.011
	Residual	428	2931.351	6.849			
	Corrected Total	429	2962.951				
5 – Pigeon Blood	Survey Completeness	1	62.037	62.037	10.067***	0.002	0.023
	Residual	428	2637.591	2637.59			
	Corrected Total	429	2699.628				
6 – Red Spotted Green	Survey Completeness	1	41.497	41.497	6.625**	0.010	0.015
	Residual	428	2680.747	6.263			
	Corrected Total	429	2722.244				
7 – Red Turquoise	Survey Completeness	1	1.090	1.090	0.186	0.667	< 0.001
	Residual	428	2509.675	5.864			
	Corrected Total	429	2510.765				
8 – Blue Snakeskin	Survey Completeness	1	1.121	1.121	0.227	0.634	0.001
	Residual	428	2116.498	4.945			
	Corrected Total	429	2117.619				
10 – Super Marlboro Red	Survey Completeness	1	23.165	23.165	4.107**	0.043	0.010
	Residual	428	2414.139	5.641			
	Corrected Total	429	2437.305				

*Significance levels are indicated as * for p < 0.10, for ** for p < 0.05 and *** for p < 0.01.*

Appendix N8 Parameter estimates for significant models between groups, based on shape

Image	Source	B-Effect	Std. Err.	*t*	*p*	Partial η^2
2 – Yellow Ghost	Intercept	6.093***	0.153	39.945	< 0.001	0.788
	CS Only	0.715***	0.266	2.684	0.008	0.017
	CE + CS	0				
4 – Heckel	Intercept	7.308***	0.154	47.472	< 0.001	0.840
	CS Only	-0.577**	0.269	-2.148	0.032	0.011
	CE + CS	0				
5 – Pigeon Blood	Intercept	5.405***	0.146	37.013	< 0.001	0.762
	CS Only	-0.809***	0.255	-3.173	0.002	0.023
	CE + CS	0				
6 – Red Spotted Green	Intercept	4.484***	0.147	30.461	< 0.001	0.684
	CS Only	-0.662**	0.257	-2.574	0.010	0.015
	CE + CS	0				
10 – Super Marlboro Red	Intercept	6.775***	0.140	48.496	< 0.001	0.846
	CS Only	0.494**	0.244	2.027	0.043	0.010
	CE + CS	0				

*Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

Appendix N9 Kruskal-Wallis test statistics of images based on survey completeness and shape

Image	***d. f.***	X^2	***p***
9 – Blue Diamond	1	1.290	0.256

*Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*

Appendix N10 Spearman's rank correlation coefficients of associations between and within groups

	Association	***N***	r_s	***p***
Between groups	c_CS * c_CE+CS	10	0.964***	< 0.001
	p_CS * p_CE+CS	10	0.863***	0.001
	s_CS * s_CE+CS	10	0.927***	< 0.001
Within groups	c_CS * p_CS	10	0.638**	0.047
	c_CS * s_CS	10	0.758**	0.011
	p_CS * s_CS	10	0.924***	< 0.001
	c_CE+CS * p_CE+CS	10	0.733**	0.016
	c_CE+CS * s_CE+CS	10	0.794***	0.006
	p_CE+CS * s_CE+CS	10	0.867***	0.001

*Significance levels are indicated as ** for p < 0.05 and *** for p < 0.01.*