Is Face Recognition Biased by Unintentional Recognition of Distracting Information?

Sapna K. Gupta

School of Psychology

University of Kent

A thesis submitted for the degree of Master of Science by Research in the Faculty of Social Science at the University of Kent, Canterbury

September 2020

Word count: 16944

Student Number: 19909805

Declaration

The research presented in this thesis was conducted at the School of Psychology, University of Kent while the author was a full-time postgraduate student. The author declares that the work presented in this thesis is his/her own and was carried out under the normal terms of supervision by Dr Zara Bergstrom and Dr Markus Bindermann. Where information has been derived from other sources, the author confirms that this has been indicated in the thesis.

Sapna K. Gupta

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Covid-19 Impact Statement

This research thesis was considerably affected by the events relating to the Covid-19 pandemic. The initial plan was to conduct an advanced electroencephalography (EEG) project exploring distractor bias on face recognition and use this time to train extensively in a neurocognitive experimental method. In March 2020, I had designed, piloted, and programmed my EEG experiment and received extensive training in EEG data collection, and was just about to begin EEG data collection when I had to abort the project due to the lockdown. Therefore, I was unable to collect the experimental EEG data, or train in its analysis and reporting to the degree to which I initially planned. Instead, I had to rapidly change plans and convert all my experimental programs for online administration, something which was technically challenging and new for my supervisor and for the technical support team at Kent. Nevertheless, I managed to complete two online behavioural experiments during lockdown, which are written up in this thesis, together with my EEG experiment plans in a “registered report” format. The pandemic unfortunately meant however that I was unable to collect online data from a large enough sample as required for high statistical power, which effected the quality of my results. I was also unable to attend any conferences or present my data both due to the restrictions regarding these events in relating to Covid-19 and having to use my MSc-R funding for participant payments. Lastly, the events certainly took and emotional toll and meant working in an environment that was far from ideal. Therefore, all work completed for this thesis has been conducted to the best standard possible given all of the above.

Sapna K. Gupta

September 2020

Acknowledgements

First, I would like to thank Dr Zara Bergström for being a brilliant supervisor who I genuinely struggle to fault. As well as my second supervisor Dr Markus Bindemann. This project would not have been possible without your support, guidance, and expertise. Secondly, to my friend and collaborator Akul Satish for teaching me all things EEG and spending many hours sifting through lines of code. Likewise, I would also like to thank the University of Kent, School of Psychology technical support team for their unwavering patience and much valued troubleshooting. With special thanks to Frank Gasking for being a literal superhero. I'd also like to thank my fellow MSc-R students Harriet Caesley and Charlotte Wheeler who made life in the office truly entertaining. However, last but not least, and most importantly, I would like to thank my chosen family for their constant support and belief in me through this journey. Particularly, Joseph Slinn, Rhona Lonergan, Kamyla Marques, Jack Hoayun, Vaida Jakubauskaite, Amelia Turrell, Shuchita Gupta, TJ Burt, Arjun Liddar and Isabella Bruno, all of whom I am so grateful to have in my life.

Abstract

Research highlights that we are not as skilful in controlling our memory as we may believe. Instead, our everyday intentional recognition judgments are often biased by what we unintentionally recognise in the same context. So far, it has been demonstrated that the unintentional recognition of image distractors can bias the intentional recognition of word targets, in the form of a familiarity (old/new) congruency bias. This bias reflects improved recognition performance for targets when the distractor/context upon which it is present at test is of the same memory status (also old or new). However, this effect has not yet been explored using face stimuli, despite faces varying in pre-existing familiarity and often being encountered in different familiar or unfamiliar contexts in everyday life. Furthermore, the distractor stimuli used in past literature have often been limited to simple drawings. Past designs have also typically relied on the use of working memory load or divided-attention tasks, or healthy aging to magnify distractibility, which is arguably not ecological valid nor generalisable. Consequently, this research investigated whether distractor-induced congruency biases found for words also apply to faces, using a new database of up-to-date face stimuli and without secondary manipulations of distractibility. I also attempted to replicate these results in an alternative sample and compared effects between target types (words vs faces). Results show novel evidence for the idea that faces are also biased by distracting stimuli in the same manner that has been found in relation to words. In turn, providing evidence for specific cognitive theories (e.g. Perceptual load theory) while questioning others (face processing modularity). Lastly, the study also provides future direction for neurocognitive research to answer questions regarding the underlying mechanisms of distractor bias, based on past research findings of dissociating event-related potentials (ERPs) in relation to unintentional and intentional recognition.

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General Introduction

During day-to-day activities it is often the case that we can recognise what is familiar to us unintentionally, without much conscious effort. Common examples of this include noticing familiar products on a supermarket shelves without actively looking for them, or recognising previously seen road landmarks whilst driving, despite having made no deliberate attempt to do so. From such examples, it becomes apparent that our brains seem capable of recognising items regardless of whether they are the targets of a deliberate extensive search within our long-term memory. It is thought that such unintentional recognition occurs as frequently and if not more so than intentional recognition, (Dalton, 1993; Hayes et al., 2009; Krafka & Penrod, 1985; Mandler, 1980; Schweinberger & Neumann, 2016; Smith & Vela, 1992) which requires conscious effort (e.g. actively searching for a supermarket product or studying a road sign). In turn, it is expected that we must possess the ability to ignore distractions and selectively direct our attention to goal relevant stimuli during such tasks, as the inability to do so would arguably result in information overload or perpetual distractibility and the inability to successfully complete our goals. For example, one would not be able to drive safely if one was constantly distracted by recognition of familiar landmarks.

However, there is a growing body of research which suggests that we are not as great at suppressing what is unintentionally recognised as one may initially believe. In fact, such research proposes that distracting stimuli that are unintentionally recognised can bias intentional recognition judgements for target stimuli, i.e. those stimuli that are subject to an intentional recognition attempt (Anderson et al., 2011; Bergström et al., 2016). Such biases are thought to arise through a misattribution of familiarity. For example, when applied to real-world situations, the familiarity associated with an unintentionally recognised context may be misattributed to a person encountered in that context, biasing us to judge that we recognise that person, even if we do not. Such misattributions could have important real-life consequences. For example, during eye-witness testimony, or during more everyday social or professional interactions. Furthermore, research suggests that this phenomenon is influenced by the level of perceptual processing engaged by stimuli involved (Murphy et al., 2016; Thoma & Lavie, 2013). Therefore, the biasing effect of unintentional recognition may differ depending on the perceptual salience of different stimuli that are being recognised (e.g. words, human faces, animal faces and objects). Consequently, research on unintentional distractor biases also raises questions in relation to the neurocognitive mechanisms surrounding episodic memory. Specifically, via encouraging us to compare and connect our external behaviour relating to the processing of day-to-day varying stimuli, to the internal brain mechanisms which both derive and are influenced by this process. Moreover, it also urges us to evaluate the human ability to selectively attend which we daily take for granted. All of which offers the potential to add to our understanding of both general human cognition, as well as the neuroscience behind cognitive disorders. For example, there are many disorders where processing of varying stimuli, or selectively attending is abnormal, such as in patients with prosopagnosia, agnosia, stroke, neglect, and ADHD. These patients may be particularly susceptible to the type of recognition biases studied here.

However, while there are several such benefits to investigating unintentional recognition biases, this phenomenon is surprisingly under-researched within the literature. Most research on recognition memory seems focused on reducing distractibility within experimental paradigms in the aim of preventing confounds, as opposed to exploring the effect of distraction on recognition judgements. Similarly, there also remains a larger motivation to investigate cognitive processes that specifically improve recognition memory (and the neurocognitive mechanisms which underlie it), as opposed to that which worsens it, or has the ability to bias it in either direction (Hockley, 2008; Murnane et al., 1999). Furthermore, those prior studies which do explore concepts such as selective attention, distractibility, and recognition bias have often used ecologically less valid stimuli, such as simple word recognition tasks. Consequently, there has been little prior focus on how episodic recognition of contextual information can affect intentional recognition judgements for ecologically valid and socially relevant faces, and the neurocognitive mechanisms which might underly these biases. The current project aimed to investigate these neglected issues which are highly relevant to many real-world circumstances.

Clarifying Definitions

Before this thesis begins to review specific literature investigating unintentional recognition biases, it would like to clarify some definitions of key-word relevant to this topic to prevent confusion. This is because this research draws upon theory and research from two separate fields, episodic memory, and face recognition literature within which the definition for the terms "familiarity" often differs (MacKenzie & Donaldson, 2016). In effect, within both episodic memory and face recognition literature, "recognition" is largely regarded as the outcome of cognitive processing, which in other words reflects whether or whether not a stimulus is recognised or not and this phenomenon is thought to be governed by distinct processes.

Within the episodic memory literature, a recognition outcome is thought to be based on either "familiarity", which is described as automatic and rapid, or "recollection", which on the other hand is described as a slower, more deliberate process of recognition (Anderson et al., 2011; Bergström et al., 2016). It is thought that unintentional recognition is likely driven by familiarity due to it automatic nature, and thus the above definition of familiarity has been used in relation to this phenomenon accordingly.

Within the face recognition literature, the basis of a recognition outcome is described by various cognitive models of face perception (e.g. the retrieval-match theory or holistic face processing theory, Bruce & Young, 1986; Johnston & Edmonds, 2009; Russell et al., 2009). Within this literature, the definition of "familiarity" is used to represent the recognition of famous or personally familiar faces, and/or, the recognition of previously familiar faces where extensive learning has been carried out (Johnston & Edmonds, 2009). Hence, all references to familiarity in terms of face recognition within this thesis should be interpreted in this regard.

Unintentional Recognition Bias for Simple Letter and Word Stimuli

Initial research on unintentional recognition biases can be considered to have only scratched the surface of how and to what extent this phenomenon occurs. Primarily, because the stimuli and tasks used in such studies remained very simple, mostly exploring letter on letter biases using variations of The Flanker Task, a selective attention task introduced by Eriksen and Eriksen (1974; see Shaffer & LaBerge, 1979). These tasks generally involve responding to specific letters when they are either flanked (on the left and right) by 'congruent' and 'incongruent' letters. The results of these studies revealed significantly faster choice rection times (CRTs) when flankers were congruent as opposed to incongruent, despite participants attempting to solely focus on the central target (Gaspelin et al., 2014; Ghinescu et al., 2010; McDermott et al., 2007; Meiran & Cohen-Kdoshay, 2012; Sanders & Lamers, 2002; Umebayashi & Okita, 2010). Consequently, such studies provide a strong foundation for research into how unintentional processing of distracting stimuli can bias intentional decision making. However, they do so only in relation to perception and working memory rather than long-term memory, since performance on such tasks is not dependent on prior long-term memory encoding.

It has been less investigated in the literature whether unintentional recognition bias effects occur when stimuli are recognised after a much lengthier periods of delays using long-term memory processing. One of the few early studies to explore the effect of unintentional recognition bias in relation to episodic memory was Ste-Marie and Jacoby (1993), who adapted the Flanker Paradigm to involve the presentation of a long list of words that participants were told to learn for a later test. Later during this test, words were presented flanked above and below by either old words (ones prior encoded and thus familiar) or new words, and participants were asked to judge whether the target words were old or new whilst ignoring the flanking distractor words. Results showed a similar congruency bias effect of flankers on reaction time as that reported by past research. This was so that reaction times (RTs) were significantly faster when both the target word and distractor were of the same memory status (were both old or both new), as opposed to when they were not (one was old and one was new). Notably however, this effect was only significant for participants that were placed in a condition of divided attention, which involved a listening task that was thought to increase participants' distractibility by depleting their limited availability of cognitive control resources (Ste-Marie & Jacoby, 1993). Furthermore, the biasing effect of distractors was subtle in that it was only evident on participants' reaction times (RTs), and not on the accuracy of their actual recognition decisions for targets. Thus, while the study by Ste-Marie & Jacoby (1993) supports the idea that biases caused by unintentional recognition occur when memories are episodic, it implies that such effects may be rather weak across larger periods of delay between encoding and test, when recognition is based on long-term memory rather than perception/working memory. However, it is important to note that findings of biases only on RTs remain consistent with most research utilising the flanker paradigm (Gaspelin et al., 2014; Ghinescu et al., 2010; McDermott et al., 2007; Meiran & Cohen-Kdoshay, 2012; Sanders & Lamers, 2002; Umebayashi & Okita, 2010). In turn, this suggests that other factors than the incorporation of episodic memory were reducing bias effects on recognition accuracy in the above study.

Literature on the flanker paradigm has highlight several factors which could enhance or reduce biases caused by recognition of distractors. For example, the nature of secondary tasks has been suggested as important (Meiran & Cohen-Kdoshay, 2012), as well as the instructions or strategies provided to participants, since these seem to influence their distractibility (Ghinescu et al., 2010; Tsivilis et al., 2001). However, of these modulating factors, the potentially most influential may be that proposed by perceptual load theory, which suggest that the perceptual characteristics of the target and distractors themselves play a large role in determining the magnitude of a biasing effect (Carmel et al., 2007; Forster & Lavie, 2008; Lavie & Cox, 1997; Thoma & Lavie, 2013; Yi et al., 2004). This line of research highlights that certain stimuli engage more extensive perceptual processing (causing higher “load” on the perceptual system) than others, and such perceptual differences between targets and distractors can modulate the amount of bias that occurs. Specifically, in this research, it has been consistently found that if the target stimuli results in higher perceptual load than the distractor stimuli, bias is less likely to occur (Murphy et al., 2016). Consequently, unintentional recognition of very simple, perceptually sparse stimuli such as letters or short words may not produce very strong distraction-induced biases compared to perceptually richer stimuli, such as scenes, objects or faces. This possibility has been supported by more recent research on unintentional recognition biases, which has found significant biasing effects on both RTs and accuracy of episodic recognition decisions, using more varied, and perceptually richer stimuli (Anderson et al., 2011; Bergström et al., 2016).

Unintentional Recognition Bias for Visually Complex Stimuli

Anderson et al. (2011) demonstrated the unintentional recognition bias effect using an adapted version of the flanker paradigm, in the form of a picture-word “Memory Stroop” task. In this design participants viewed and encoded a range of words and pictures (line-drawings of objects). Episodic recognition of these stimuli was tested in a later phase where previously shown (old) and not shown (new) words were presented upon old or new pictures. Consequently, trials were either congruent (old picture and old word, or new picture and new word) or incongruent (old picture and new word, or new picture and old word). Results showed that participants intentional recognition of the target words was biased by distractor images, so that participants were more likely to respond to target words as old if the distractor was also old, over when it was new. Furthermore, by reversing the roles of target and distractor, the researchers also found that participants were significantly less biased in this manner when the target was a picture, as opposed to a word. Bergström et al. (2016) also replicated these findings in a similar study, showing that unintentional recognition of perceptually rich distractor photographs biased word recognition, but not vice versa (with the addition of ERP recordings, see next section). These prior findings are thus consistent with perceptual load theory, in that words seem more susceptible to bias than images, which may be because words engage lower perceptual load than images, thus allowing images to elicit a distracting effect.

However, it is important to note that Anderson et al. (2011) only found significant bias effects in older adults and younger adults with divided attention, but not in young adults when they were given the opportunity to pay full attention (as found in the previous experiment), whereas Bergström, et al. (2016) only tested younger adults under divided attention conditions. Allen et al. (2019) on the other hand compared young and old adults both with increased cognitive load and found similar degrees of unintentional recognition biases across both age groups. Therefore, while the effects of aging on distractor-induced recognition biases are inconsistent, previous research provides evidence that unintentional distractor recognition can influence intentional recognition accuracy as well as RTs, but primarily under circumstances where participants have reduced availability of cognitive control.

Nevertheless, those reviewed findings do not rule out the possibility that other stimuli with different perceptual and memory characteristics could be susceptible to distraction-induced biases even without cognitive control depletion. For example, a more recent study exploring distractor bias using both image distractors and targets (Doss et al., 2018) found significant effects without the use of a working memory task or cognitive load condition. During the study, participants encoded coloured images of a variety of objects presented superimposed upon visually rich and colourful images of scene contexts (e.g. beach, park). Next, their recognition was tested for the objects, either presented on the same or novel scene image. Results showed participants made more hits and false alarms when the context was previously seen, despite being told to make recognition judgments independent of the scene context. Interestingly, this implies that images high in perceptual load can bias recognition memory for other images that elicit lower perceptual load despite being part of the same general category. Images of objects are more complex in nature and likely slower to process than words (due to the automaticity of reading) but large scene images are likely to be more visually complex and salient than both objects and words. Furthermore, the use of both image distractors and targets arguably brings research on this topic a step closer in terms of ecological validity, since in most real-life situations both target and distractor stimuli are likely to be more perceptually complex than a simple word.

Moreover, another experiment conducted by the same researchers revealed that including similar variations of object images in encoding increased levels of bias (Doss et al., 2018), highlighting that similarities between old and new target images can increase the amount of bias shown. The researchers suggested this effect may be due to recognition decisions between similar old and new images requiring more fine-grained perceptual discrimination. This notion therefore suggests that faces may be a class of stimuli that are particularly influenced by unintentional recognition bias effects in day-to-day life, since all faces are visually similar due to their basic structure. Yet this study, like those reviewed before, did not explore the influence of unintentional distractor bias on face recognition.

Hence, in sum, prior research on unintentional distractor biases in episodic memory that use a variety of different types of stimuli confirms that bias varies depending on perceptual load but also via the influence of additional factors (e.g. strategy, warning, cognitive load, aging and within-category discrimination). Yet it remains unclear as to how or why this occurs. Consequently, these findings have sparked an interest in the neurocognitive mechanisms which may be underlying this effect.

Neurocognitive Mechanisms Underlying Unintentional Recognition Bias

While most research has focused on unintentional recognition effects on behaviour, there are a few studies investigating these issues that have adapted their paradigms for use alongside EEG (Allen et al., 2019; Bergström et al., 2016). These studies use a similar experimental design that was used for prior behavioural research, consisting of the initial encoding of image distractors and target words, followed by an old/new recognition test for these words (and some new/unseen) presented upon the image distractors (and some new/unseen). However, this time alongside behavioural measures, EEG was used to measure recognition-related neural responses generated by both targets and distractors.

The researchers based their investigation on the dual process theory of episodic recognition, which proposes that recognition is supported by two separable processes; familiarity and recollection (Mandler, 1980; Yonelinas & Jacoby, 2012). While familiarity is described as rapid and unintentional, recollection is considered slower and intentional, and ERP distinctions have been found between the two (Rugg et al., 1998; Rugg & Curran, 2007).

Familiarity is associated with a mid-frontal ERP positivity around 300-500 ms post-stimulus onset for old compared to new items (FN400 old/new effect; Curran, 2000; Paller et al., 2007; Rugg et al., 1998), whereas recollection is associated with a greater left parietal ERP positivity between 500-800ms for old compared to new items (the left parietal old/new effect), which can be voluntary controlled (Bergström et al., 2007, 2009a, 2009b; Bergström, Anderson, et al., 2013; Hu et al., 2015; Mecklinger et al., 2009).

It was found that unintentional recognition of distractors was associated with familiarity-related ERP effects as opposed to those associated with recollection, consistent with prior evidence that familiarity is quicker and a more automatic process than recollection (Anderson et al., 2011). Postretrieval monitoring and control processes (Rugg & Wilding, 2000) reflected by ERP slow drifts (Johansson & Mecklinger, 2003) were also engaged, and suggested to index that participants were monitoring and attempting to overcome distracting unintentional recognition. Intentional recognition of target words in contrast elicited parietal old/new ERP effects associated with recollection, consistent with intentional recognition attempts being more likely to result in context retrieval. Results from this research thus provided evidence for a dissociation between the neurocognitive processes engaged by unintentional and intentional recognition.

Furthermore, it was found that ERP effects associated with distractor recognition were only significant when distractors were pictures as opposed to words. This suggests that differences in bias between the two types of distractors (pictures vs words) is related to their likelihood or ability to elicit unintentional recognition. As opposed to the extent to which people engage in post-retrieval processing to discount unintentional memory signals for words vs pictures (Rugg & Wilding, 2000). In other words, familiarity cannot be the only factor driving bias, since if this were the case, we should observe similar effects for both picture and word distractors. Consequently, the researchers, like many others highlight perceptual salience/load as a possible additional key driving factor (Murphy et al., 2016) in that perceptually high load image distractors showed evidence for eliciting unintentional recognition bias when coupled with perceptually low load word targets. However, the reverse pairing did not result in any evidence of recognition of word distractors, possibly due to the perceptual system being fully occupied with processing the image targets. Yet this explanation was post-hoc and indirect, hence, more research is required to understand if and how unintentional recognition biases are dependent on the nature of the stimuli.

Unintentional Distractor Bias on Face Recognition

Another important outstanding issue within the literature is the limited use of facial stimuli in investigating effects of unintentional recognition bias, with little to no research having explored whether similar biases occur during recognition of familiar or unfamiliar individuals. This limitation is particularly surprising since faces may be a particularly common stimuli to be influenced by this phenomenon in day-to-day life. Furthermore, since faces possess pre-existing familiarity, the incorporation of facial stimuli in a “Memory Stroop” paradigm (Anderson et al., 2011) can enable researchers to investigate interactions between different memory types, with familiar face recognition more likely to draw on semantic memory and face-specific perceptual and memory processes, which can be studied in combination with episodic memory for other kinds of stimuli, such as visually rich pictures of scenes.

Consequently, it is of interest to investigate whether unintentional episodic recognition of previously seen contexts would bias face recognition decisions when those decisions are based on pre-experimental familiarity with individuals. This issue is particularly interesting since research on perceptual load theory and face processing already highlights the uniqueness of face recognition both through behavioral and neuroimaging measures

(Kanwisher et al., 1997; Murphy et al., 2016; Renzi, 2000; Thoma & Lavie, 2013; Yeshurun & Marciano, 2013). Cognitive neuroscience research on faces has highlighted specific ERP effects relating to face recognition and has studied how these effects are modulated by context (Bötzel & Grüsser, 1989; Hayes et al., 2009; Herrmann et al., 2002; Linkenkaer-Hansen et al., 1998; Schweinberger & Neumann, 2016; Wiese et al., 2019). For example, researchers have shown pronounced N170 amplitudes only in relation to face stimuli, as well as Late Positive Potentials (LPPs) in relation to congruent emotional (expressions) contexts, and N250 ERPs in relation to familiar face recognition (Kaufmann et al., 2008; Pierce et al., 2011; Schweinberger & Neumann, 2016). In fact some studies go as far to suggest that faces, due to their biological and social significance, may be immune to distractor bias effects (Farah et al., 1998; Lavie et al., 2003). Hence, prior literature that does explore distractor bias effects using faces seems to assign them the role of the distractor, as opposed to the target. Furthermore, due to the application of face recognition and context bias research in relation to eyewitness accuracy, a lot of this research seems more focused or based on unfamiliar as opposed to familiar face recognition (Dalton, 1993; Krafka & Penrod, 1985; Smith & Vela, 1992). In turn, the extent of context effects on ERP and behavioral markers of familiar face recognition remains lesser known.

In contrast with some views, studies do exist where researchers have found distractor bias effects on face recognition by varying the perceptual load of distractors (Jenkins et al., 2005). These studies demonstrate that even face recognition, when met with distractors with greater perceptual loads can be subject to bias. However, most studies investigating distractor bias on face recognition have only used letter sets as distractors varying in terms of perceptual load as opposed to richer stimuli (such as images of scenes), which is arguably ecologically invalid. Furthermore, prior studies have not to my knowledge explored the role of distracting episodic recognition on familiar face recognition. Using more visually complex episodically familiar distractors may elicit stronger biasing effects than prior findings using letter distractors, potentially in the form of similar familiarity congruency biases as observed by recent research with other types of stimuli. This may be particularly likely since research on face recognition suggests that while familiar face recognition is generally more robust than unfamiliar face recognition, this should not be taken as a sign for it itself to be regarded as a largely flawless process (Jenkins et al., 2005; Russell et al., 2009; Young et al., 1985; Young & Burton, 2018). Especially, since there is evidence to suggest that familiar face recognition is an error-prone task susceptible to bias (Mattarozzi et al., 2019). Yet so far, no study has explored this concept in detail.

In fact, several lines of evidence suggest that familiar face recognition is also subject to error and that consequently, familiarity is not the only factor driving face recognition. If knowledge of an individual were the only factor determining successful face recognition, accompanying stimuli would not evoke better results. Research highlights several factors other than familiarity that influence face recognition (Bruce & Young, 1986; Ellis et al., 1979; Lindsay & Wells, 1985; Memon et al., 2011), of which one of the most prominent is context. This is expected as familiar faces are nearly always viewed and learned in association to specific situations, scenarios, and topics (e.g. Tiger Woods/Golf, Daniel Radcliffe/Harry Potter, School-friend - School, Sibling - Home). Consequently, when one attempts to recognise a familiar face, researchers describe the face as becoming a "target" for recognising, whereas the information amongst the periphery it is viewed in, is referred to "context" (Mayes et al., 1992; Schacter et al., 1984). The importance of context for face recognition also can explain why individuals, even with facial information of a known individual, may often face difficulty in recognising them when they are seen out of context (see Memon & Bruce, 1985 for review). This is commonly referred to as the "butcher-on-the-bus" phenomenon, originally described by Mandler, (1980), who failed to recognise the identity of his butcher upon seeing him on a bus (despite experiencing a vague sense of familiarity). However, it is important to note that in most cases familiar faces are successfully recognized independent of context. Consequently, it is likely that there are additional variables at play when context effects occur, of which, two likely contenders are the familiarity of the individual and the amount of perceptual load the context requires to be processed (Neumann et al., 2011; Thoma & Lavie, 2013).

Yet, while there is a multitude of research exploring effects elicited by context on face recognition, this body of research remains primarily focused on context effects via reinstatement of original encoding contexts, which specifically lead to improvements in memory (Dalton, 1993; Krafka & Penrod, 1985; Memon & Bruce, 1985; Smith & Vela, 1992; Vakil et al., 2007). Furthermore, the type of context used in these studies usually consists of pre-existing semantic linkages between face and context (e.g. names or occupations; Chua et al., 2007; Dennis et al., 2008; Tsukiura & Cabeza, 2008; Yovel & Paller, 2004). On the other hand, little to no research has explored the unintentional distracting influence of episodically induced scene familiarity on familiar and unfamiliar face recognition, as it would most commonly occur in day-to-day instances. In turn, rendering this a unique and interesting research question for the current research. If this bias was found to occur in the same manner as found in relation to words, this could mean word and face recognition are more similar than often assumed.

Consequently, this study explores unintentional recognition bias through two experiments. The first of which investigates whether the unintentional recognition of a variety of distracting rich scene images (episodically induced as either old or new) can bias the recognition of pre-existingly familiar and unfamiliar face targets. While the second of which explores whether the results found in the first are replicable in an alternative sample. Alongside this, the second experiment also investigates whether the same scene image targets are capable of unintentionally biasing the recognition of episodically induced old and new word targets, as previously demonstrated by past literature. Lastly, the study also provides an unsubmitted registered report, which outlines how the above unintentional recognition bias effects could also be explored neurocognitively using EEG, to provide even further insight into its mechanisms.

Experiment 1

The first experiment in this thesis investigated the effects of unintentional episodic recognition of distractors on familiar face recognition, by creating an adapted version of the "Memory Stroop" experimental paradigm used in past research (Bergström et al., 2016; Allen, 2019; Anderson et al., 2011). In this adapted version, target stimuli consisted of colour images of famous and non-famous faces, while visually rich images of scene contexts were used as distractors. Half of these scene images were first incidentally encoded, which was followed by a face recognition test where famous and non-famous faces were superimposed on old and new scenes, and participants were asked to judge whether they recognised faces while ignoring the scenes. Importantly, none of the face images presented to the participants were presented to them prior to this test. Consequently, in this experiment and all others outlined within this thesis, face recognition was reflective of identity recognition judgements, whereby participants answered whether they recognised the person depicted in the image as opposed to the stimulus. The study aimed to test whether unintentional recognition of these distracting scene images would bias individual's intentional recognition of these likely to be known or unknown faces. If face processing is completely modular and encapsulated and therefore unaffected by the presence of other non-face objects (Kanwisher, 2000; Kanwisher et al., 1997; Nachson, 1995; Spunt & Adolphs, 2017), then episodic scene memory would not be expected to influence face recognition. However, if previous perceptual load theory findings are correct, then face recognition may be subject to biases if the distracting scenes are sufficiently salient and perceptually rich (Carmel et al., 2007; Forster & Lavie, 2008;

Gaspelin et al., 2014; Lavie & Cox, 1997; Thoma & Lavie, 2013; Yi et al., 2004). If so, then higher accuracy and faster reaction times should be found when the distractor and target memory status is congruent (i.e. both familiar or both unfamiliar), as opposed to incongruent (i.e. one item familiar and the other unfamiliar), which could indicate that the memory processes engaged during familiar face recognition and episodic memory for scenes is more similar than one might expect based on modular theories of face processing (Fodor, 1983; Kanwisher, 2000; Kanwisher et al., 1997; Nachson, 1995; Spunt & Adolphs, 2017).

Method

Participants

Seventy participants (54 females, 16 males) with a mean age of 20 (18-25) were included. They were recruited either in return for credits through a research participation scheme in the School of Psychology, University of Kent, or via online social media. A further five participants were excluded due to an excessive number of missed responses, extreme RTs, or not meeting inclusion criteria. Participants were not excluded for low accuracy due to the possibility that unintentional recognition bias may be dependent on varying levels of accuracy. That is, participants may in fact be more biased by distractor recognition when their subjective recognition of the targets is less confident (e.g., because of weaker memory), Hence it was considered counterproductive to include only participants who had very high performance. Consequently, these participants were not removed to prevent biased results. All included participants had normal or corrected-to-normal vision and were long-term residents of the UK (10 + years) to ensure they would be able to recognise a sufficient number of famous faces. We aimed for a sample size of at least 66 but ideally above 84, since 84 participants were required to have 0.8 power to detect an effect size of Cohen's $d = 0.31$ with a two-tailed test at alpha $p = 0.05$, whereas a sample size of 66 would achieve the same power with a one-tailed test given the same alpha level and effect size. The effect size used for power calculations was estimated based on the average biasing effect of image distractors on word recognition in relevant past research (Allen et al., 2019; Bergström et al., 2016). The study acknowledges that the use of these effect sizes might not seem appropriate due to the use of face targets in this experiment as opposed to word targets used in previous research. However, since it was not possible to find a similar-enough research design which used face stimuli in relation to unintentional recognition bias within past literature, it seemed most appropriate to conduct calculations using the most relevant research available. Furthermore, it is important to note the effect sizes used were that observed from labs studies. Therefore, it is expected that effects observed through online research will be weaker due to noisier measurement. The study had ethical approval from the University of Kent School of Psychology Ethics committee.

Materials

Colour photographs of faces (260 in total, 130 familiar, 130 unfamiliar) were collated from online search engines, with some "familiar" faces drawn from on a list of face photographs that received high familiarity ratings in a prior study (Bergström, Henson, et al., 2013). This list was supplemented with face photographs of other individuals who were thought to be famous in Britain in 2019. Unfamiliar face photographs were also retrieved from online search engines, but these were of individuals from contexts likely to be unfamiliar to long term British residents (e.g. famous people in other European countries who are unlikely to be known by British residents). Photographs of famous and non-famous faces were selected in this manner to ensure that both image characteristics (e.g. camera angle, resolution) and the type of people and their setting (gender, age, attractiveness, facial expression, etc.) were similar across both categories, in order to ensure the face recognition task could only be solved by processing the faces for identity information, instead of relying on superficial image characteristics.

Lastly, subjective recognition of all the faces was also piloted prior to the main experiment (with a different sample (N = 9) to that used in the main study), in order to determine baseline accuracy levels, detect possible item floor/ceiling effects and to remove any stimuli that did not elicit recognition responses in line with the required manipulation. Pilot results showed that stimuli in the famous condition were recognised as familiar on average 85% of the time, with 1050ms mean RTs, compared to the non-famous condition which were only recognised as familiar 7% of the time (with 1170ms mean RTs). Piloting thus confirmed that the face stimuli used in this study were reflective of the familiarity condition in which they were placed, and that familiarity was effectively manipulated.

Colour photographs of a variety of scenes (260 in total) that varied in terms of affect, colour and semantic content were compiled from open-source image websites (unsplash.com, pexels.com, pixabay.com). None of these images contained visible faces, but some images did contain people that were either in the distance, blurry or obscured. Furthermore, a scene pilot recognition test (N = 7) was carried out to ensure that participants were able to sufficiently encode and later recognise the scenes. In this pilot, participants conducted the same scene encoding task that would be used in the main experiment (see next section for details), but this was followed by an old/new recognition test for scenes where participants had to discriminate between previously shown ("old") and not previously shown ("new") scene images. Participants showed a mean accuracy of 90.8% on this task, confirming that the encoding task was sufficient to establish highly accurate recognition memory for the scenes (which was important to verify, since the main experimental task does not involve a direct test of distractor recognition). Scenes eliciting floor and ceiling accuracy (accuracy for images varied from 42.9 to 100%) were removed from the stimuli list prior to the conduction of the main experiment.

All the images were edited (using GIMP photo editing software) to be uniform in size (200 x 200 pixels for faces, 900 x 500 for distractor scenes) and resolution (72 x 72). Both scenes and faces were shown in colour. A simple black border was added to face images to ensure separation from the scene images upon which they would be superimposed in the recognition test. All testing was carried out using experiment programming software PsychoPy2 (for lab pilots) and PsychoPy3 (for online data collection via Pavlovia).

Design

The experimental design largely resembled that of Anderson et al. (2011) and Bergström et al. (2016) in the form of a "Memory Stroop" paradigm, which originates from the classic colour-word Stroop task (Stroop, 1935) The Memory Stroop paradigm entails asking participants to recognise target stimuli while simultaneously ignoring an additional distractor stimulus (e.g. word vs image). However, while the Memory Stroop studies conducted so far involved presenting words and images as targets and distractors (or vice versa), the study in question adapted the paradigm further by replacing words with face images. Furthermore, prior Memory Stroop studies involved a study phase involving learning half of both the target and distractor stimuli (words and images) so that both could be divided in terms of "old and newness" (studied/old, not studied/new) during a subsequent recognition test. In contrast, the current study only included an encoding task for half of the distractor scene images, whereas the face images were instead grouped into "familiar" vs. unfamiliar" conditions based on the likelihood that participants would have pre-experimental familiarity with the person in the images. Therefore, as mentioned previously intentional recognition decisions made by participants reflected face "identification", rather than image recognition. Thus, the experiment used a 2 x 2 within-subjects design whereby the first independent variable was target face familiarity (Familiar/Unfamiliar). The second IV was distractor memory status ("old/newness" of context/scene image). The dependent variables were face recognition accuracy (proportion of hits for familiar faces and correct rejections for unfamiliar faces) and RTs. Note however that while we refer to old/new recognition judgments to faces as indicative of accuracy to facilitate comparison with previous research using the Memory Stroop paradigm, those judgments cannot be considered objective measures of accuracy since these were scored on the *assumption* that familiar faces were known to the participants and unfamiliar faces were unknown to the participants. While piloting indicated that this assumption would likely be true on average, it is unlikely that it applied to all individual participants and stimuli.

Procedure

All participants completed the experiment online. Consent was recorded through Qualtrics which then randomly assigned participants to one of four versions of the experimental program that counterbalanced stimuli assignment to conditions and ensured all stimuli were used across participants. The experimental programs were counterbalanced according to sets of face stimuli, specifically so that all stimuli within the face database constructed for this study were used in the study across the programs to ensure variety. The database consisted of twice the number of face stimuli than what was required for the study and so two versions of the experiment were created so that all the stimuli could be used. Furthermore, two extra programs were created to counterbalance the programs according to scene memory status. This was to ensure that all scene stimuli were granted the opportunity to act both as old/familiar distractors in addition to new/familiar ones across the programs. This was implemented to prevent any individual differences that could have been present if only one specific set of scenes were assigned to each of these roles. Detailed task instructions were provided through the experimental program, including practice tasks and reminders to ensure optimal understanding. Optional breaks were provided approximately every five minutes.

The experiment consisted of two tasks, the first of which was the scene encoding phase. This involved the presentation of 64 scene images, shows individually in a random order for 4000ms and preceded by a 1000ms fixation cross. Participants were asked to imagine themselves in the scene and then give a “yes/no” response as to whether they found each scene to be pleasant by pressing the ‘S’ (Yes) and ‘K’ (No) keys on the keyboard. This judgement task was used to ensure deep processing and sufficient encoding of the scenes. Participants were not told that their memory would later be tested, thus encoding was incidental (in contrast to prior Memory Stroop studies that used intentional encoding instructions, e.g. Bergström et al., 2016).

Next, participants completed the recognition test. This involved the randomised presentation of 128 target faces superimposed upon scene images that were either previously shown (old) or not previously shown (new) within the study phase (64 of each). Consequently, recognition trials were made up of four possible combinations of images: Old Scene Familiar Face, Old Scene Unfamiliar Face, New Scene Familiar Face, and New Scene Unfamiliar Face (32 trials in each condition). Stimuli were presented at the center of the screen for 3000ms, preceded by a 1000ms fixation cross. During this test phase, participants were asked if they recognised the person in the image as familiar and used the same keyboard keys ‘S’ and ‘K’ to give “yes” or “no” responses, respectively. They were told that the scene image in the background was irrelevant to the task and that they should try to ignore the scene, and only base their responses on whether they recognised the face or not.

Results

Hits and correct rejection rates and recognition judgement RTs for the four conditions in the test phase were analysed to ensure direct comparisons with past research (Anderson et al., 2011; Bergström et al., 2016; Ste-Marie & Jacoby, 1993). Descriptive summary statistics for accuracy and RTs are presented in Table 1, and individual participant data are shown in Figure 1.

Table 1. Mean proportion accurate responses and RTs for target face recognition decisions in Experiment 1, depending on face familiarity and scene memory status.

	Mean Accuracy (SD)		Mean Reaction Time (SD)	
	Familiar Face	Unfamiliar Face	Familiar Face	Unfamiliar Face
Old Scene	.81 (.16)	.93 (.09)	1019 (187)	1093 (217)
New Scene	.79 (.18)	.94 (.07)	1036 (202)	1091 (216)

Note. RTs are shown in ms.

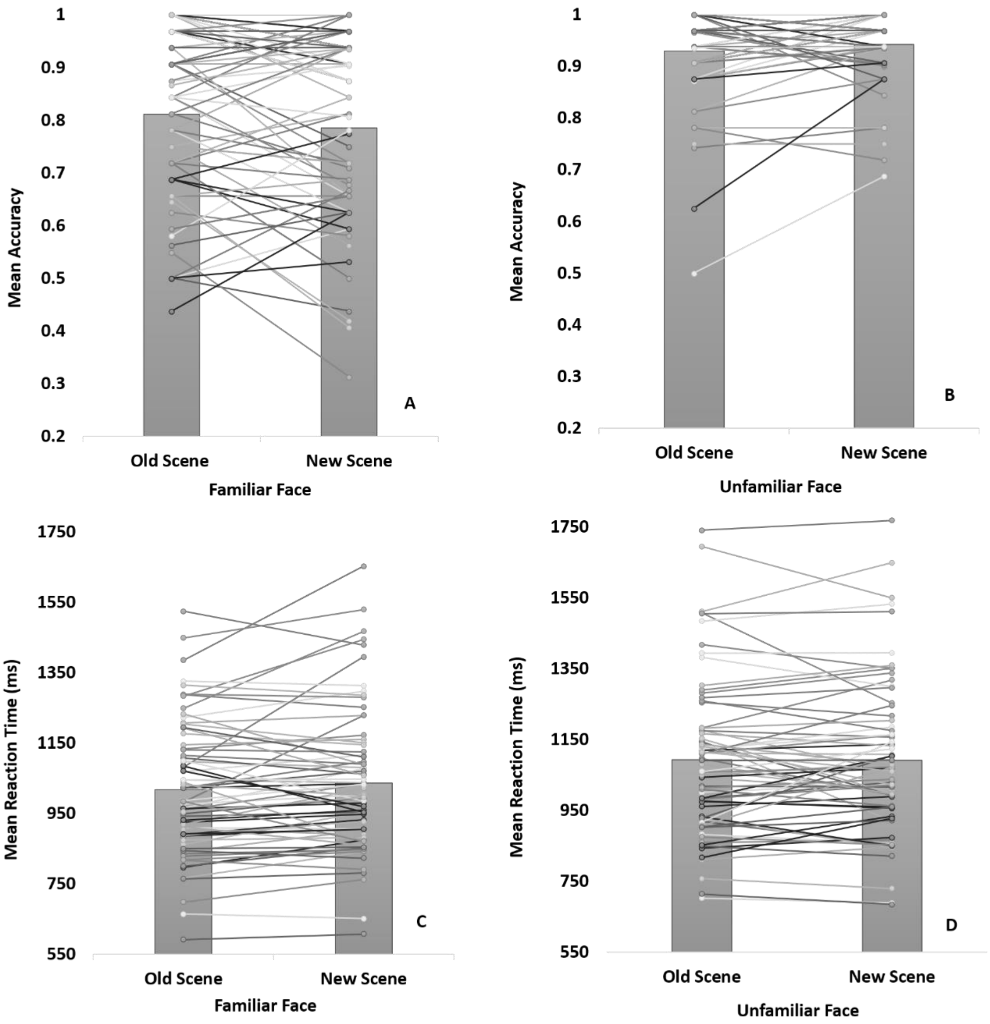

Figure 1. Proportion accurate face recognition responses and associated mean reaction times (in ms) shown for each individual participant across conditions in Experiment 1, together with the group mean for each condition. Dots show individual participant scores, with lines connecting scores from the same individual. Bars show the mean score across participants within each condition. **A**, Proportion accurate responses for familiar face targets when paired with old vs new distractor scenes. **B,** Proportion accurate responses for unfamiliar face targets when paired with old vs new distractor scenes. **C**, Mean RTs for familiar face targets when paired with old vs new distractor scenes. **D,** Mean RTs for unfamiliar face targets when paired with old vs new distractor scenes.

A 2 (familiar/unfamiliar face) x 2 (old/new scene) repeated measures ANOVA on the accuracy data revealed a significant main effect for target memory status ($F(1, 69) = 47.53$, $p < .001$, $\eta p^2 = .41$), whereby accuracy was significantly higher for trials with unfamiliar faces ($M = .94$, $SEM = .02$) as opposed to familiar faces ($M = .80$, $SEM = .02$). In other words, participants were better at correctly rejecting unfamiliar individuals as opposed to recognising (assumed) familiar ones. However, there was no significant main effect of distractor memory status ($F(1, 69) = .64$, $p = .426$, $\eta p^2 = .01$). Moreover, the interaction between distractor status and target status was significant ($F(1, 69) = 6.94$, $p = .010$, $\eta p^2 = .09$). Paired *t*-tests revealed that participants were more likely to report recognising familiar faces when the corresponding distracting scene image was old as opposed to new ($t(69) = 1.93$, $p = .058$ two tailed, $p =.029$ one-tailed, $d = 0.16$). Similarly, participants were more likely to report not recognising unfamiliar faces when the distractor was new as opposed to old ($t(69) = -1.83$ $p = .071$ two-tailed, $p = .035$ one-tailed, $d = 0.16$). Although these differences were only strictly significant with one-tailed tests, it is justified to interpret them as tentatively supportive of the directional prediction that unintentional recognition of distractors will bias face recognition judgements in a *congruent* way (i.e. higher accuracy when target and distractor have the same memory status (either familiar/old or unfamiliar/new), as found in previous research (Anderson, et al., 2011; Bergström, et al. 2016; Allen, et al., 2020). However, it should be noted that the effect sizes for these bias effects were smaller than in prior research with word targets (Cohen's $d = 0.16$ here, in comparison to an average Cohen's $d = 0.31$ in the most relevant previous research by Allen et al., 2020; Bergstrom et al., 2016).

For reaction times, the 2 (familiar/unfamiliar face) x 2 (old/new scene) repeated measures ANOVA revealed only a significant main effect for target memory status ($F(1, 69) = 15.48$, $p <.001$, $\eta p^2 = .18$). RTs were significantly faster when the face target depicted a familiar (*M* = 1027, *SEM* = 23) as opposed to unfamiliar individual (*M* = 1092, *SEM* = 25). No significant main effect was found for distractor memory status, ($F(1, 69) = 1.31$, $p = .257$, $\eta p^2 = .02$), nor was there a significant interaction between distractor memory status and target memory status, ($F(1, 69) = 1.72$ $p = .194$, $\eta p^2 = .02$)[1]. Similarly, there was also no significant difference found between the RTs for unfamiliar faces when the corresponding distracting scene image was new as opposed to when it was old ($t(69) = .17$, $p = .865$ two-tailed, $p = .432$ one-tailed, $d = 0.01$). However, reaction times to familiar faces were slightly faster when the corresponding distracting scene image was old as opposed to new ($t(69) = -1.73$, $p = .087$ two-tailed, $p = .044$ one-tailed, $d = 0.09$).

In sum, the key results revealed a significant target/distractor congruency effect on face recognition accuracy, whereby participants were more likely to report recognising faces as familiar if they were superimposed on previously shown scenes as opposed to novel scenes, as predicted on the basis of previous Memory Stroop research. For RTs, there was a weaker tendency towards a congruency effect only for familiar faces, with faster responses to familiar faces when the scene was old than new but no RT difference for unfamiliar faces depending on scene memory status. However, this latter pattern was not predicted and was only significant with a one-tailed test, so should be interpreted with caution.

1 Note that t-tests were conducted here and for other comparisons despite an insignificant interaction effect, in order for the results to be comparable with previous research, which has sometimes shown significant biases only for old or new target stimuli (e.g. Anderson et al., 2011). In those cases, the interaction was not significant but the pairwise differences between distractor types were still analysed and significantly different within one type of target only. In order to compare our results to that prior work, pairwise t-tests were included despite significant interaction effects throughout the experiments in this thesis to maintain consistency.

Experiment 1 Discussion

In Experiment 1 I investigated the effects of unintentional episodic recognition of distractors on familiar face recognition. The study aimed to test whether the unintentional recognition of distracting scene images would bias individual's intentional recognition of likely to be known or unknown faces. It was theorised that if face processing is wholly modular and encapsulated as literature makes it out to be (Kanwisher, 2000; Kanwisher et al., 1997; Nachson, 1995; Spunt & Adolphs, 2017), it will be unaffected by the presence of other non-face objects and thus will remain uninfluenced by episodic scene memory. However, in line with perceptual load theory, it was also theorised that face recognition may be subject to biases if the distracting scenes are sufficiently salient and perceptually rich (Carmel et al., 2007; Forster & Lavie, 2008; Gaspelin et al., 2014; Lavie & Cox, 1997; Thoma & Lavie, 2013; Yi et al., 2004).

The results of this experiment revealed, be it weak, significant results in support of a target/distractor congruency effect on face recognition accuracy. As well as an additional tendency towards a congruency effect on RTs for familiar faces. Therefore, this suggests that face identity recognition judgements are biased by unintentional recognition of distracting scene information, despite participants trying to ignore the scenes and only base their recognition judgement on the face images. Which in turn implies that face recognition may not be as modular as prior research initially outlines, and that perceptual load theory may be a more accurate descriptor for the underlying mechanisms for distractor bias. Specifically because perceptual load theory provides an alternative, arguably more tangible explanation for what seems a more subtle and fluctuating extent of difference between the way varying stimuli experience unintentional recognition biases (e.g., faces vs word). This is because perceptual load theory acknowledges that the extent of bias that manifests is likely influenced by the combining characteristics of the distractor and target involved at any one specific time. A factor which hardly ever remains consistent across research designs and possible could be a reason behind the inconsistency of the results. Furthermore, arguably it is very difficult to relate behavioural results to domain-specificity, especially without robust, consistent results or neurocognitive backing, which this experiment cannot provide stand-alone. While researchers generally acknowledge that perceptual processing of faces is domain-specific (Kanwisher, 2000; Kanwisher et al., 1997), it remains less certain that they would also claim specificity for recognition memory. In turn, more research is required to provide clearer insight into the unintentional recognition bias effects and the implications which follow them.

However, notably the findings are similar to results from the most relevant previous research, which found that while word recognition accuracy showed a congruency pattern, reaction times did not (e.g. Allen et al., 2020; Bergström et al., 2016). The current research therefore can be considered as an extension on previous findings that episodic word recognition can be biased by unintentional recognition of images, by showing similar biasing effects using more ecologically valid and qualitatively different stimuli – images of faces superimposed on scenes. Furthermore, while the study acknowledges the possible limitation of comparing effects using words versus faces targets due to research supporting the possibility that they are processed differently (Farah, 1991; Farah et al., 1995, 1998), it is important to acknowledge that there are studies which suggest that face and word recognition are more similar in nature than expected. For example, through their possible shared used of bottom-up processing and semantic memory (Burton et al., 2016; Martelli et al., 2005). Further, any potential differences in cognitive processes between faces and words recoded by such a comparison can arguably also be considered of interest. Since such findings might imply a varying of susceptibility to distractor-induced recognition biases across target types, Yet, regardless of this, the effects of distractors on face recognition were weaker/less reliable than previous word recognition results, as the effect sizes were smaller and paired comparisons were only significant with one-tailed tests, despite using a larger sample size than in previous research (70 in the current study vs. 24 participants in Bergström, et al., 2016). Hence, although the current findings can be tentatively interpreted as evidence that face recognition judgements are biased by unintentional distractor recognition, Experiment 1 did use a smaller sample than ideal, and was also conducted online as a result of Covid-19, which may have resulted in inadequate statistical power and noisier measurements. Consequently, a second experiment was conducted with an alternative sample of participants to test if the results of Experiment 1 would replicate, as well as test for possible differences in bias depending on the target stimuli type. This was conducted by included both words and faces within the experimental design.

Experiment 2

In Experiment 2, I investigated the effects of unintentional recognition of distracting scenes on both face identity recognition and episodic word recognition. Here, participants were recruited through a commercial online pool of paid volunteers (Prolific), and were randomly assigned either to an identical face recognition task as in Experiment 1, or an episodic word recognition task similar to that used in the most relevant prior Memory Stroop research (Bergstrom, et al., 2016; Allen et al., 2020). The purpose of this design was twofold; firstly, to determine whether the results of Experiment 1 could be replicated in alternative sample, and secondly to assess whether words were subject to different distractor-induced recognition biases than faces when exposed in relation to the same distracting stimuli. That is, previous research (as reviewed in the introduction) has consistently found such biases for word stimuli, and it was therefore of interest to assess whether intentional recognition judgements for words may be subject to larger biases than intentional recognition judgements for faces, as would be predicted by perceptual load theory (Carmel et al., 2007; Forster & Lavie, 2008; Lavie & Cox, 1997; Thoma & Lavie, 2013; Yi et al., 2004). Comparing bias effects in Experiment 1 with that found by past research alone however would be problematic because of differences in task design and procedure, differences in the distracting stimuli, and sample differences, etc. Consequently, Experiment 2 directly compared biases for faces and word stimuli using the same distractors and within the same participants, to allow for a better comparison of effects between target types.

The first question was addressed by comparing accuracy and reaction time data from participants assigned to the face recognition task in Experiment 2 to data collected in Experiment 1. It was expected that results should replicate. However, it was also considered that there may be differences in the results due to individual differences between the sample (primarily University of Kent Psychology students in Experiment 1, vs. more varied participant characteristics in the commercial volunteer database). Consequently, this experiment also tested for possible differences in congruency bias between the samples. Secondly, the study aimed to investigate the possible effect of face vs. word target type by comparing accuracy and reaction time data for participants from the commercial volunteer pool that were assigned to the word vs. face version of the task (data from Experiment 1 was not included). Based on the results from Experiment 1, it was expected that both groups would show similar results in the form of a congruency bias caused by unintentional scene recognition, regardless of whether the targets were faces or words. However, since faces are considered to be less prone to bias than other stimuli within the literature, specifically in relation to their preserved encoding under conditions of high perceptual load (Kanwisher et al., 1997; Lavie et al., 2003; Murphy et al., 2016; Neumann et al., 2011; Thoma & Lavie, 2013; Yeshurun & Marciano, 2013), it was expected that episodic word recognition may be more biased than face recognition.

Method

Participants

One hundred participants were recruited through Prolific (www.prolific.co) in return for payments of £2.50 each, and were randomly assigned to either the word recognition experiment (*N* = 53; 33 female, 20 male, mean age 21) or the face recognition experiment (*N* = 46; 33 female 13 males, mean age 21). One additional participant was excluded due to an excessive number of missed responses. Likewise, and for the same reason as in Experiment 1, no participants were excluded for low accuracy. Consequently, the overall sample consisted of 99 participants (66 females, 33 male) with a mean age of 21 (18-25). This sample size was determined by a combination of budget and time constraints, and provided between .66 (with *N* = 46) and .72 (with *N* = 53) power to detect an effect size of Cohen's *d* = 0.31 with a one-tailed test (based on the average biasing effect of image distractors on word recognition in relevant past research; Allen et al., 2019; Bergström et al., 2016). As in Experiment 1, participants were aged between 18-25, right-handed, had normal or corrected-to-normal vision and had lived in the UK for over ten years. Further, since this experiment included word stimuli, all participants were also required to be native English speakers. The study received ethical approval from the University of Kent School of Psychology Ethics committee.

Materials

The face and scene stimuli remained identical to those used in Experiment 1, with the addition of 256 words procured from a past study (Bergström et al., 2016). Words consisted of a maximum of eight letters and varied in terms of emotional valence ratings from 3.75 to 7.58 on a 9-point scale (thus indicating that the words were relatively emotionally neutral). Words were selected from both the ANEW and GAPED databases (Bradley & Lang, 2007; Dan-Glauser & Scherer, 2011).

Design and Procedure

Participants were randomly assigned to one of eight experimental versions using the survey flow feature on Qualtrics, four of which consisted of the different versions of face recognition tasks used in Experiment 1, created through counterbalancing the same factors as mentioned in Experiment 1 (stimuli set, role assigned to scene stimuli). The other four versions were identical in terms of the scene stimuli, scene encoding task, recognition test etc., but had been altered so that all face stimuli were replaced with words (Bergström et al., 2016). These four versions were also created through counterbalancing the same factors as described in relation to Experiment 1. To induce different levels of recognition of the words, familiarity was episodically induced as part of an additional encoding block. This took place prior to the encoding of scenes, as in Bergström et al. (2016). All words were presented individually for 4000ms after a 1000ms fixation cross. Participants were asked to think about the meaning of the words to ensure deep encoding and were then asked to respond to the question "Do you find this word pleasant?" with a "yes" or "no" answer using the 'S' and 'K' keys on the keyboard respectively. Other than this, the rest of the experimental procedure for these programmes remained identical to that of Experiment 1. As in the face recognition task, four versions of the program were created to counterbalance stimuli assignment to conditions across participants.

Results

Hit and correct rejection rates from the test phase and RTs for each condition were analysed to ensure direct comparisons with Experiment 1 and past research (Anderson et al., 2011; Bergström et al., 2016; Ste-Marie & Jacoby, 1993).

Experiment 2 Face Recognition Results

The first analysis investigated whether the congruency bias effect that was found for face recognition judgements in Experiment 1 would replicate in a new sample of participants. Descriptive summary statistics for accuracy and RTs on the face recognition task are presented in Table 2, and individual participant data are shown in Figure 2.

Table 2. Mean proportion accurate responses and reaction times for target face recognition decisions in Experiment 2, depending on face familiarity and scene memory status.

	Mean Accuracy (SD)		Mean Reaction Time (SD)	
	Familiar Face	Unfamiliar Face	Familiar Face	Unfamiliar Face
Old Scene	.78(.20)	.94(.08)	1032 (190)	1074 (191)
New Scene	.77(.20)	.94(.08)	1050 (182)	1061 (208)

Note. RTs are shown in ms.

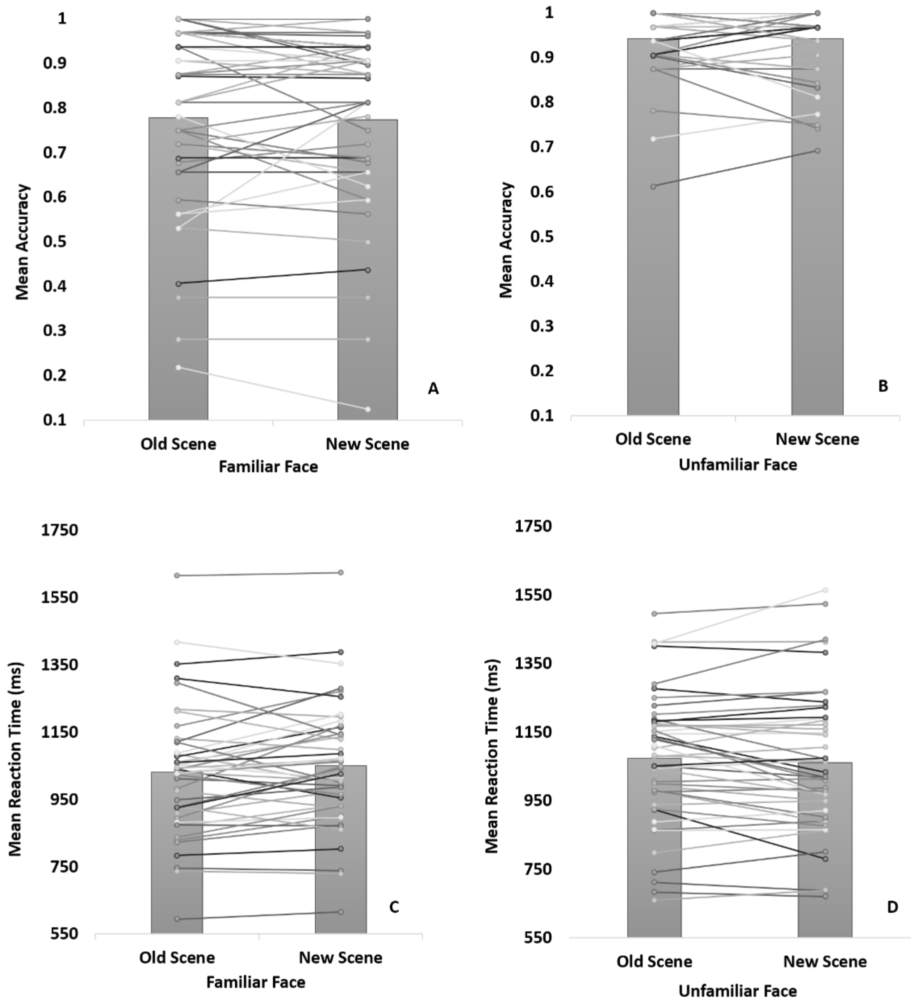

Figure 2. Proportion accurate face recognition responses and associated reaction times shown for each individual participant across conditions in Experiment 2, together with the mean for each condition. Dots show individual participant scores, with lines connecting scores from the same individual. Bars show the mean score across participants within each condition. **A**, Proportion accurate responses for familiar face targets when paired with old vs new distractor scenes. **B,** Proportion accurate responses for unfamiliar face targets when paired with old vs new distractor scenes. **C**, Mean RTs for familiar face targets when paired with old vs new distractor scenes. **D,** Mean RTs for unfamiliar face targets when paired with old vs new distractor scenes.

A 2 (familiar/unfamiliar face) x 2 (old/new scene) repeated measures ANOVA on the accuracy data revealed a significant effect of target memory status, ($F(1, 45) = 26.66$, $p < .001$, $\eta p^2 = .37$) whereby accuracy was significantly higher for trials with unfamiliar faces (*M* = .94, *SEM* = .01) as opposed to familiar faces (*M* = .78, *SEM* = .03). Thus, like in Experiment 1, participants were better at correctly rejecting unfamiliar individuals as opposed recognising familiar ones. No significant main effect was found in relation to distractor memory status ($F(1, 45) = 0.15$, $p = .699$, $\eta p^2 < .01$). Furthermore, unlike in Experiment 1, the interaction between distractor status and target status was found to be not significant, ($F(1, 45) = 0.13$, $p = .716$, $\eta p^2 < .01$). Paired *t*-tests also revealed no significant difference in recognition accuracy for familiar faces when the corresponding distracting scene image was old as opposed to new ($t(45) = 0.44$, $p = .662$ two-tailed, $p = .331$ one-tailed, $d = 0.03$). Likewise, there was also no significant difference in accuracy for unfamiliar faces depending on whether the distractor was old or new ($t(45) = 0.02$ $p = .984$ two-tailed, $p = .492$, $d < 0.01$). Thus, the finding in Experiment 1 that face recognition judgement accuracy was biased by distractor recognition failed to replicate in Experiment 2.

Concerning reaction times, unlike in Experiment 1, a 2 (familiar/unfamiliar face) x 2 (old/new scene) repeated measures ANOVA revealed no significant main effect for distractor memory status, ($F(1, 45) = 0.20$, $p = .660$, $\eta p^2 < .01$), nor target memory status ($F(1, 45) = 2.31$, $p = .136$, $\eta p^2 = .05$), and no significant interaction between distractor memory status and target memory status, ($F(1, 45) = 2.96$ $p = .092$, $\eta p^2 = .06$). As in Experiment 1, there was also no significant difference between the RTs for unfamiliar faces when the corresponding distracting scene image was new as opposed to when it was old ($t(45) = 1.21$, $p = .232$ two-tailed, $p = .116$ one-tailed, $d = 0.06$). However, like in Experiment 1, there was a tendency whereby reaction times to familiar faces were slightly faster when the corresponding distracting scene image was old as opposed to new ($t(45) = -1.53$, $p = .134$ two-tailed, *p*

= .067 one-tailed, $d = 0.10$) although this difference was not significant even with a one-tailed test.

Consequently, since the second experiment involving face targets did not reveal any significant congruency bias, a further analysis was conducted to test for significant differences in performance across Experiments 1 and 2, which may have been caused by the difference in samples.

Experiment 1 vs. 2 Face Recognition Comparison

The face and word recognition samples were analysed in separate analysis first, prior to being analysed as one large sample. This was done to test the reliability of the effects by conducting two independent analyses. As well as to observe any difference caused by individual differences between samples. However, since this was not the case, the samples were later combined and potential differences across experiments were then assessed by investigating the interaction between experiment and the other factors. A 2 (Experiment 1/2) x 2 (familiar/unfamiliar face) x 2 (old/new scene) mixed ANOVA was conducted on the accuracy data to directly compare the Experiment 1 sample with those assigned to the face condition in Experiment 2. This analysis revealed no significant three-way interaction between distractor memory status, target memory status and group, $F(1, 114) = 2.52$, $p = .115$, $\eta p^2 = .02$. However, the two-way interaction effect between target and distractor memory status, was found to be significant (but “diluted” because of the strong face recognition congruency effect in Experiment 1 and the absent face recognition congruency effect in Experiment 2), $F(1, 114) = 4.23$, $p = .042$, $\eta p^2 = .04$. There were no significant two-way interactions between distractor status and group ($F(1, 114) = 0.10$, $p = .748$, $\eta p^2 < .01$) nor target status and group ($F(1, 114) = 0.69$, $p = .408$, $\eta p^2 = .01$). Regarding main effects, a significant effect was only found in relation to target status, $F(1, 114) = 71.80$, $p < .001$, ηp^2

= .39. This was so that accuracy was greater for new targets (M = .94 SEM = 0.1) as opposed to old (M = .79, SEM = .02). There was no significant main effect in relation to distractor status, $F(1, 114) = 0.64$, $p = .425$, $\eta p^2 = .01$ or group, $F(1, 114) = .19$, $p = .664$, $\eta p^2 < .01$). Thus, although the pattern of results were different when face recognition accuracy was analysed separately for Experiment 1 and 2, there were no significant experiment differences in accuracy when these experiments were compared directly.

Concerning reaction times, a mixed 2 x 2 x 2 ANOVA of the same design as used for accuracy also revealed no significant three-way interaction between distractor status, target status and group, $F(1, 114) = 0.21$, $p = .648$, $\eta p^2 < .01$. However, in contrast to the previous within-experiment analyses, the two-way interaction effect between target and distractor status was found to be significant when collapsed across both experiments, $F(1, 114) = 4.58$, $p = .035$, $\eta p^2 = .04$. Follow up paired t-tests in relation to this interaction revealed that participants were faster at recognising familiar faces when the corresponding distracting scene image was old as opposed to new ($t(115) = -2.31$, $p = .022$ two-tailed, $p = .011$ one-tailed, $d = 0.10$). However, there was no significant difference in reaction time for unfamiliar faces depending on whether the distractor was old or new ($t(115) = 0.80$ $p = .424$ two-tailed, $p = .212$ one-tailed, $d = 0.03$). No significant two-way interaction effects were found between distractor and group, $F(1, 114) = 0.25$, $p = .616$, $\eta p^2 < .01$, nor target and group, $F(1, 114) = 2.46$, $p = .120$, $\eta p^2 = .02$. As for main effects, similar to the accuracy data, a significant effect was only found in relation to target status, $F(1, 114) = 13.61$, $p < .001$, $\eta p^2 = .11$. This was so that reaction times were significantly faster for old targets (M = 1034, SEM = 18) as opposed to new targets (M = 1080, SEM = 20). There was no significant main effect in relation to distractor status, $F(1, 114) = 1.16$, $p = .285$, $\eta p^2 = .01$, nor group, $F(1, 114) = 0.02$, $p = .876$, $\eta p^2 < .01$. Thus, like the accuracy data, the RTs associated with face recognition judgements did not differ strongly depending on sample.

Experiment 2 Word Recognition Results

Next, I investigated whether word recognition in Experiment 2 was biased by unintentional recognition of scenes, as had been found in previous research. Since the biasing effects of scene recognition on face recognition were not very strong and replicable, this analysis investigated whether stronger bias effects might be observed on word recognition judgements, since previous research found that words were more susceptible to distraction-induced biases from images than vice versa (Anderson et al., 2011; Bergström et al., 2016). Accuracy[2] and reaction time data for those assigned to the word version were analysed in the same manner as were the other within group analyses (See Table 3, Figure 3 for descriptive statistics).

Table 3. Mean proportion accurate responses and reaction times for target word recognition decisions in Experiment 2, depending on word and scene memory status.

	Mean Accuracy (SD)		Mean Reaction Time (SD)	
	Old Word	New Word	Old Word	New Word
Old Scene	.81(.18)	.83 (.15)	1218 (219)	1277 (213)
New Scene	.81 (.19)	.85 (.14)	1226 (223)	1255 (195)

Note. RTs are shown in ms.

[2] Note that while recognition rates might seem quite high for words that have only been seen once, deep encoding tasks typically result in high recognition performance and accuracy on this task in line with that of past relevant research (Anderson et al., 2011; Bergström et al., 2016; Ste-Marie & Jacoby, 1993).

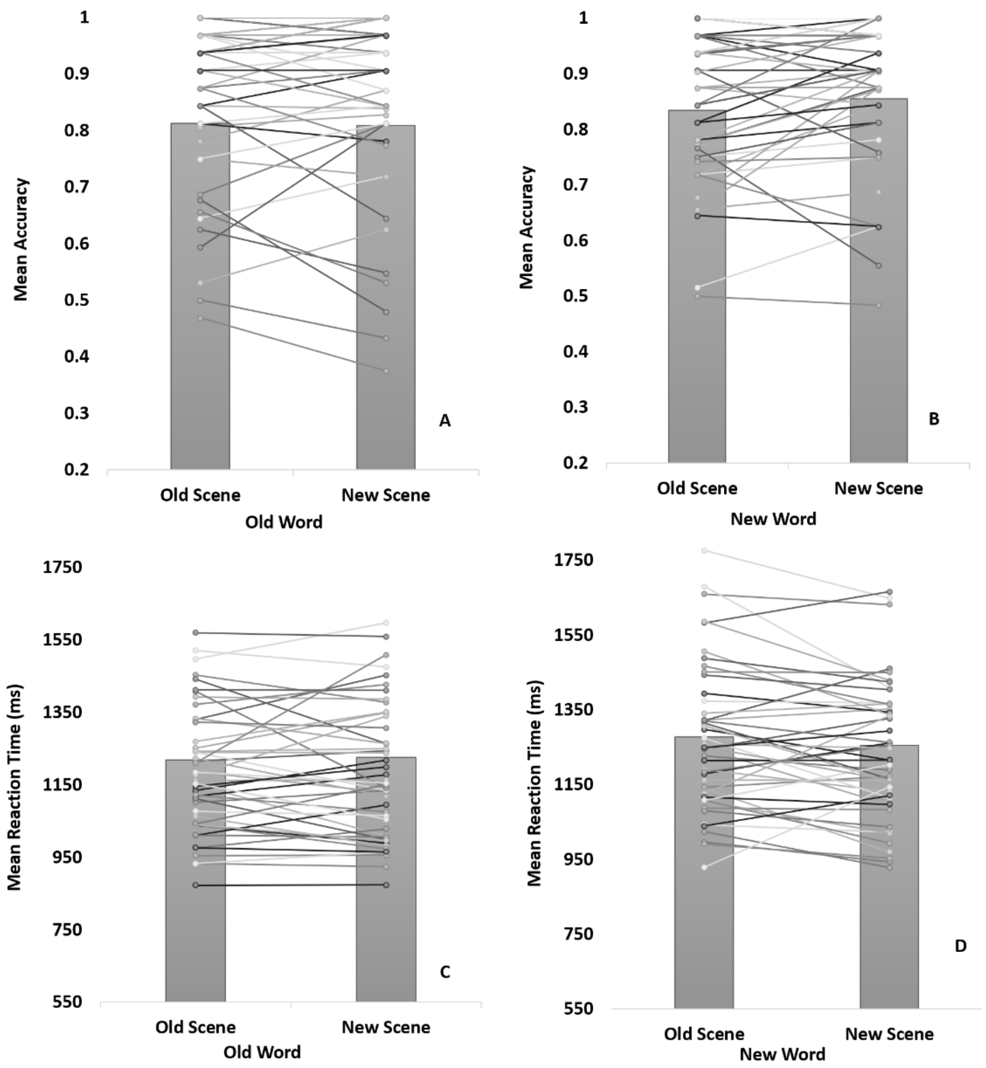

Figure 3. Proportion accurate word recognition responses and associated reaction times shown for each individual participant across conditions in Experiment 2, together with the mean for each condition. Dots show individual participant scores, with lines connecting scores from the same individual. Bars show the mean score across participants within each condition. **A**, Proportion accurate responses for old word targets when paired with old vs new distractor scenes. **B,** Proportion accurate responses for new word targets when paired with old vs new distractor scenes. **C**, Mean RTs for old word targets when paired with old vs new distractor scenes. **D,** Mean RTs for new word targets when paired with old vs new distractor scenes.

A 2 (old/new word target) x 2 (old/new scene distractor) repeated measures ANOVA on the accuracy data revealed no significant effect of distractor memory status ($F(1, 52) = 1.09$, $p = .302$., $\eta p^2 = .02$), or target memory status ($F(1, 52) = 1.35$, $p = .250$, $\eta p^2 = .03$). Further, the interaction between distractor status and target status was not significant, ($F(1, 52) = 2.36$, $p = .130$, $\eta p^2 = .04$). Paired *t*-tests also revealed no significant difference between participants' accuracy at recognising old words when the corresponding distracting scene image was old as opposed to new ($t(52) = 0.34$, $p = .737$ two-tailed, $p = .369$ one-tailed, $d = 0.02$). However, participants ability to correctly reject new words was higher when the distractor scene was new than old ($t(52) = -1.73$, $p = .089$ two-tailed, $p = .045$ one-tailed, $d = 0.14$). Thus, for the word recognition task, there was a tendency towards a congruency effect for new words only.

Concerning reaction times, the 2 x 2 ANOVA (of same design as for accuracy) revealed a significant main effect of target memory status ($F(1, 52) = 5.72$, $p = .020$, $\eta p^2 = .10$), whereby reaction times were significantly faster for old words ($M = 1222$, $SEM = 29$) as opposed to new words ($M = 1266$, $SEM = 27$). No significant main effect for distractor memory status, ($F(1, 52) = 0.47$, $p = .498$, $\eta p^2 = .01$, and no interaction between distractor memory status and target memory status was found, ($F(1, 52) = 2.56$ $p = .115$, $\eta p^2 = .05$). Furthermore, paired *t*-tests revealed no significant difference between reaction times in relation to old words when the corresponding distracting scene image was old as opposed to new ($t(52) = -0.49$, $p = .623$ two-tailed, $p = .31$ one-tailed, $d = 0.03$). However, in line with the accuracy analysis, there was a non-significant tendency for faster RTs to new words when the corresponding distracting scene image was also new as opposed to when it was old ($t(52) = 1.52$, $p = .136$ two-tailed, $p = .07$ one-tailed, $d = 0.11$).

Thus, the word recognition experiment revealed only very weak tendencies towards biasing effects of unintentional scene recognition on intentional word recognition judgements, and only for new words with no effect at all for old words. This pattern contrasts with several previous studies that have found such biases for word recognition (Allen et al., 2019; Anderson et al., 2011; Bergström et al., 2016), although it should be noted that there were several important design differences between the current study and those prior studies (see Discussion section for details).

Experiment 2 Face vs Word Recognition Comparison

A 2 (group: face task/word task) x 2 (target memory status: old (familiar)/ new (unfamiliar)) x 2 (distractor memory status: old/new scene) mixed ANOVA was conducted on the accuracy data of participants assigned to the face vs. word recognition conditions in Experiment 2. This was conducted to investigate directly whether there were significant differences in distractor bias effects on words versus face targets, which would predict a significant three-way interaction between the factors (i.e. a larger distractor x target congruency effect for words than faces). However, there was no significant three-way interaction between distractor memory status, target memory status and group, ($F(1, 97) = 0.81$, $p = .372$, $\eta p^2 = .01$). However, a significant effect was found for the two-way interaction effect between target memory status and group, ($F(1, 97) = 9.51$, $p = .003$, $\eta p^2 = .09$). This interaction was driven by the stronger effect of target familiarity on accuracy for faces versus words since the face recognition group were more “accurate” for unfamiliar faces than familiar faces, whereas there was no significant difference in recognition accuracy between old and new words in the word recognition test (see previous sections). No other two-way interaction effects were significant, including that between target and distractor memory status, ($F(1, 97) = 1.89$, $p = .172$, $\eta p^2 = .02$) and distractor memory status and group, ($F(1, 97) = 1.06$, $p = .306$, ηp^2

= .01). Concerning main effects, only that in relation to target memory status was found to be significant, $F(1, 97) = 21.52$, $p < .001$, $\eta p^2 = .18$. This was so that accuracy was overall significantly higher for new targets ($M = .89$, $SEM = .01$) as opposed to old targets ($M = .79$, $SEM = .02$). The main effects of distractor memory status, $F(1, 97) = 0.29$, $p = .595$, $\eta p^2 < .01$ and group, $F(1, 97) = 1.90$, $p = .172$, $\eta p^2 = .02$ were found to be non-significant.

Another 2 x 2 x 2 ANOVA of the same design conducted on reaction time data revealed no significant three-way interaction between distractor memory status, target memory status and group, $F(1, 97) < 0.01$, $p = .972$, $\eta p^2 < .01$. However, a significant two-way interaction effect was revealed between target and distractor memory status, $F(1, 97) = 5.42$, $p = .022$ $\eta p^2 = .05$. Follow up paired *t*-tests in relation to this interaction revealed no significant difference in recognition reaction time for old targets when the corresponding distracting scene image was old as opposed to new ($t(98) = -1.30$, $p = .197$ two-tailed, $p = .099$ one-tailed, $d = 0.10$). However, it was found that participants were faster at recognising new targets when the corresponding distracting scene image was also new as opposed to old ($t(115) = 1.929$, $p = .057$ two-tailed, $p = .029$ one-tailed, $d = 0.08$). Although, this difference was only strictly significant with a one-tailed test, it is tentatively supportive of my directional prediction that unintentional recognition of distractors will bias target recognition judgements in a *congruent* way (i.e. higher accuracy and faster RTs when target and distractor have the same memory status (either familiar/old or unfamiliar/new), as found in previous research (Anderson, et al., 2011; Bergström, et al. 2016; Allen, et al., 2020). No significant two-way interaction effects were found between distractor memory status and group, $F(1, 97) = .61$, $p = .436$, $\eta p^2 = .01$, nor target memory status and group, $F(1, 97) = .50$, $p = .486$, $\eta p^2 = .01$.

Concerning main effects, significant effects were found in relation to target status, ($F(1, 97) = 7.60$, $p = .007$, $\eta p^2 = .07$) and group ($F(1, 97) = 25.07$, $p < .001$, $\eta p^2 = .21$).

Concerning target memory status, this was so that reaction times were significantly faster when the target was old (*M* = 1132, *SEM* = 20) as opposed to new (*M* = 1167, *SEM* = 20). Concerning group, reaction times were faster for those assigned to the Experiment 2 face condition (*M* = 1054, *SEM* =28), as opposed to the word condition (*M* = 1244, *SEM* = 26). The main effect of distractor memory status was found to be non-significant, $F(1, 97) = 0.12$, $p = .727$, $\eta p^2 < .01$.

Thus, in summary, the direct comparison of word vs. face recognition tasks did not show any evidence that unintentional recognition of scenes had a more biasing effect on intentional recognition judgements to words than faces. Instead, the analysis revealed that the face recognition task was associated with faster reaction times than the word recognition task, and a larger difference in “accuracy” between familiar and unfamiliar faces than the difference between recognition accuracy for old vs. new words (which was not significant). There was however a congruency effect for RTs when collapsed across both word and face versions of the task, caused by participants tendency to react faster to unfamiliar/new targets, when corresponding distractors were also new rather than old. The same effect was not present for familiar/old targets.

Experiment 2 Discussion

In Experiment 2, I investigated the effects of unintentional recognition of distracting scenes on both face identity recognition and episodic word recognition. Firstly, to determine whether the results of Experiment 1 could be replicated in alternative sample and secondly to investigate the possible effect of target type (faces vs words).

Regarding the first aim, results revealed that Experiment 2 did not replicate the findings of Experiment 1, since the only significant effect found reflected that of a tendency for participants to be faster at reacting to congruent as opposed to incongruent trials when the targets were familiar faces, which was also found in Experiment 1. No other significant congruency bias effects were found, either in relation to accuracy or reaction time for Experiment 2. However, while this lack of significant results might initially lead us to theorise that the significant congruency bias effect recorded during Experiment 1 was a false positive result, it is possible that the results of Experiment 2 were not strong enough to negate Experiment 1 findings. Specifically, the three-way interaction effect (congruency effect by group) was found to be non-significant, suggesting that the results in Experiment 2 were not meaningfully different from Experiment 1. However, it is important to note that a non-significant result cannot be interpreted as evidence for "no difference", and so these results are rendered inconclusive and further research would be required to draw any specific conclusions.

Furthermore, generally the *p*-values for both experiments were also similar, implying other factors are likely responsible. For example, there is a strong possibility that the small sample used in Experiment 2 led to inadequate statistical power to detect an effect. In addition, the online administration of both experiments likely led to increased noise within the data compared to prior Memory Stroop studies that were conducted in a lab setting (Allen et al., 2019; Bergström et al., 2016), particularly since instructions could not be provided as efficiently as what would be possible in person. Thus, both experiments were likely underpowered to some degree, which can cause inconsistent results. Consequently, this reaffirms that it would be of value to re-run the study in future within a lab setting using a larger sample to draw firmer conclusions.

Concerning the second aim, no strong differences in congruency effect was found between the Experiment 2 participants that were assigned to the word condition as opposed to the face condition. There was also no significant congruency bias for recognition accuracy within only the word task either, other than a tendency for participants to be better at correctly rejecting new words for congruent as opposed to incongruent trials. Therefore, the study revealed that word and face recognition may be similarly susceptible to biases caused by unintentional distractor recognition, contrasting with my prediction that words would be more susceptible than faces. However, further research would be required to understand whether there are similarities or differences in distractor bias in relation to each target type as the non-significant results of this experiment cannot be used to draw firm conclusions. Furthermore, since the word experiment within this research was conducted with several design differences to that used in past research (Allen et al., 2019; Anderson et al., 2011; Bergström et al., 2016), these may also be responsible for differences with prior research findings (see next section). As well as the fact that participants assigned to the word group had to do more tasks (i.e., to learn the words in a study phase) than those assigned to the face condition. Therefore, it might be of use to repeat this experiment in the future using only unfamiliar faces, half of which are assigned to be learned to develop familiarity as it was done in this experiment, in relation to the word stimuli. Such a design would enable a test of potential stimuli differences between faces and words while keeping the task demands constant.

General Discussion

In two experiments, this research aimed to investigate whether the bias caused by unintentional distractor recognition observed by past literature in relation to word recognition, also occurs for face recognition. I also tested whether the biasing effects found were replicable, and whether the magnitude of the biasing effect differed when targets were faces as opposed to words. This research question was motivated by the literature suggesting that faces are less likely to be prone to bias than other stimuli due to their specialised processing in the brain, specifically in relation to their preserved encoding under conditions of high perceptual load (Kanwisher et al., 1997; Lavie et al., 2003; Murphy et al., 2016; Neumann et al., 2011; Thoma & Lavie, 2013; Yeshurun & Marciano, 2013).

Overall, the results suggested that face recognition accuracy can be biased by unintentional scene recognition, since Experiment 1 showed a similar congruency pattern found by past research on episodic word recognition (Allen et al., 2019; Anderson et al., 2011; Bergström et al., 2016). Experiment 1 also showed faster reaction times for congruent trials involving familiar faces, so that familiar faces were more quickly recognised when on top of an episodically familiar scene than unfamiliar scene. While this effect of reaction times was not explicitly predicted due to mixed results within past research (Allen et al., 2019; Anderson et al., 2011; Bergström et al., 2016; Ste-Marie & Jacoby, 1993), it likely occurred due to response conflict occurring when two stimuli elicit conflicting response tendencies, and a lack of conflict when the stimuli were of the same memory status (both old or both new).

However, while these effects were present, they were weak and only significant through the use of one-tailed significance tests, and therefore cannot be regarded as robust. Especially, since the results of Experiment 1 did not replicate in Experiment 2, and that all effects were diluted when collapsed across the two experimental samples. Consequently, while the strong amount of literature supporting the directional hypothesis of this study allows us to tentatively interpret these results as evidence of distractor bias in relation to face recognition accuracy, this finding remains inconclusive, requiring more research to establish its replicability. The limitation with small sample sizes would have been countered with use of a larger sample size, but this was not possible due to Covid-19. The small samples were specifically due to a combination of the closure of the university's Research Participant Scheme during Experiment 1, and a lack of funding to procure more paid participants via Prolific Academic combined with a lack of time to complete testing due to having to replace my original plans with online experiments, which caused delays. Additionally, it is important to note that face familiarity was established using likely-to-be-known famous individuals, and while pilot testing was conducted to ensure this manipulation was effective in general, there is a chance that levels of familiarity with each identity varied within the sample and likely affected the results to some degree. Consequently, it would be of benefit to provide more rigorous and individualised stimuli checks in future similar face recognition research and make sure face databases are up to date when conducting future research.

This study did find interesting results in relation to the lack of a difference in bias by unintentional recognition when targets are words in comparison to faces. However, it is important to note that the pattern of results exhibited by participants assigned to the word task was less prominent than what has been reported by past research (Allen et al., 2019; Anderson et al., 2011; Bergström et al., 2016) with weaker bias effects all-round. Yet, as mentioned in earlier discussion, it is possible that this was due to some important design differences between this study and those conducted previously. Firstly, the distractors used in this study were very different in nature, larger, richer, coloured and depicting scene contexts as opposed to line drawings of objects (as used in Anderson et al., 2011) or potentially emotive scenes actions or events (IAPS pictures, as used in Allen et al., 2020; Bergström et al., 2016). Thus, it is likely that the scene stimuli in the current study exhibited their own unique magnitude of distractibility. Secondly, this study did not include any working memory task to increase participants distractibility. Therefore, it is possible that participants in this study were not distracted enough in order to be strongly significantly biased by unintentional recognition, as has been show by some past research (Anderson et al., 2011), where bias was often only present under conditions of divided-attention or healthy ageing. However, more research on the role of working memory and attention in distractor bias by unintentional recognition would be required to confirm this point.

At present, data from an unpublished PhD thesis (Ates, 2018) has demonstrated mixed evidence for the effect of working memory load on distractor-induced recognition bias in the Memory Stroop task. While some experiments showed that bias disappears with low working memory load, one study found that bias was the same regardless of working memory load, and most importantly the latter study had the most similar design to the present research and other closely related studies (Allen et al., 2019; Bergström et al., 2016). This pattern of results was interpreted as being due to the use of highly salient distractor stimuli (IAPS pictures) in the experiment where biases were found despite low working memory load, as opposed to the experiments where load effects were found that used less salient line drawings as distractors. Based on this unpublished work, it was decided to not use working memory load tasks in the current study (since my experiments also used salient distractors). Removing the working memory load task also had the added benefits of producing a more ecologically valid and generalisable paradigm, that would be easier for participants to complete without extensive training (which is particularly difficult to implement with online testing). As a result, however, it could be the case that the distractor stimuli used in the present study were simply less distracting overall because of the lack of a secondary working memory/divided attention task, yet this explanation lacks direct evidence and so remains inconclusive.

However, EEG data from the unpublished PhD thesis (Ates, 2018) provides some relevant information to this issue. When varying working memory load, the researcher sometimes found a significant dissociation in ERPs in relation to the distractor-induced recognition bias. These results therefore inspire a method by which to measure the processing of distractor stimuli in future studies, which could help resolve some of this study's inconclusive results. For example, an ERP study could be run using the same stimuli and design as in the current experiments to determine whether the distractors used in this study were sufficiently encoded and led to unintentional recognition for either target types. This could help answer the question of whether the lack of bias recorded by this study was determined by participants effectively ignoring the scene image during early processing, or instead because they were able to prevent errors in late stage post-retrieval evaluation (See Experiment 3 for a planned design for this research, with more details) (Halamish et al., 2012; Morcom, 2016). After those basic questions have been answered, the manipulation working memory load and additional factors such as individual differences in face and word recognition ability could also be explored.

In conclusion, this study provides novel but tentative evidence for the idea that the recognition of face targets can be biased by unintentionally recognised distractors in a manner similar to that which has been established in relation to word stimuli. However, it is important to note that face targets have not been explored within the distractor bias literature in this specific manner before and thus additional research on this topic is crucial for clarifying and building on these initial results. Furthermore, these initial experiments provide ample direction/suggestions for future research via questioning the modularity of face processing, providing evidence for perceptual load theory, and providing designs for future research investigating the neurocognitive mechanisms underlying distractor effects on face recognition. As well as implications for theory and everyday life, since if future research were to confirm that incidentally encoded scenes bias familiar recognition, this finding would subsequently influence the face recognition literature. Alongside, providing insight and commentary on a range of real-life scenarios involving face recognition (e.g., eye-witness testimony, post-traumatic stress disorder).

In effect, evidence for biased familiar face recognition via unintentionally encoded scenes could provide evidence for context playing a potentially larger, more covert role and episodic role in face recognition than one might initially expect. Especially, as most literature on face recognition and bias generally seems to feature unfamiliar faces as opposed to familiar and seems to mainly focuses on sematic linkages as opposed to previously encoded or familiar contexts (Krafka & Penrod, 1985; Memon & Bruce, 1985; Vakil et al., 2007; Young & Burton, 2018). Furthermore, any similarities and or differences in the unintentional bias effect found by future research in relation to different stimuli types (words vs faces) could arguably refine what momentarily remains a nuanced mechanism. Furthermore, as for implications in relation to eyewitness testimony and PTSD, evidence of unintentional bias effects on face recognition could aid with the developing of better interviewing and interpretation practices of eyewitness accounts and experiences. Specifically, by allowing interviewers to acknowledge the role that context might be playing on their eye-witnesses' reports and decisions and by providing insight into the role of context-dependent triggers in relation to trauma-linked flashbacks. However, it is important to acknowledge, a substantial amount of further researcher would be required before these connections could be critically drawn.

Experiment 3 (Registered Report Format)

Past research on distractor bias has highlighted distinct differences in ERPs in relation to unintentional recognition of distracting stimuli versus the intentional recognition of target stimuli, suggesting that multiple neurocognitive processes contribute to the biasing effects of familiar distractors on target recognition judgements (Allen et al., 2019; Bergström et al., 2016). However, as established in the literature review, these processes have not been explored in relation to face recognition. The results from prior experiments within this research found significant distractor bias effects during face recognition, building on past literature. However, these results were weak and inconsistent across varying samples, rendering the findings inconclusive. By drawing on cognitive neuroscience research (Allen et al., 2019; Bergström et al., 2016) using similar designs, I have highlighted a manner by which to provide further insight into the underlying mechanisms that give rise to distractor biases, which could answer questions raised by the previous experiments in this study.

Specifically, in relation to the distractibility of the scene images, ERPs can be used to investigate whether participants engage in early or late-stage control over unintentional recognition. ERPs can also be used to explore whether participants show the same distinct dissociations in ERPs in relation to unintentional vs. intentional episodic recognition as seen within the prior literature (Bergström et al., 2016) or whether different ERP effects are observed during face recognition, as would be expected based on the literature on face-specific ERP correlates (Bötzel & Grüsser, 1989; Hayes et al., 2009; Herrmann et al., 2002; Linkenkaer-Hansen et al., 1998; Schweinberger & Neumann, 2016; Wiese et al., 2019). Consequently, this experiment proposes a design to explore these hypotheses (see Predicted Results for predictions) in the format of a registered report which has not been submitted but may be in future.

Method

Participants

Sixty-six participants will be recruited either in return for credits through a research participation scheme in the School of Psychology, University of Kent, via online social media, or through adverts places around the University of Kent campus. This sample size will provide 0.8 power to detect an effect size of Cohen's $d = 0.31$ (based on the average bias effect size in relevant prior literature, Bergstrom et al., 2016; Allen, et al., 2020) with a one-tailed paired *t*-test. While it may seem unjustifiable to use effect sizes from word studies for power calculations since effects for faces observed in Experiments 1 and 2 were substantially smaller, it is important to note I predict less noisy measurements and hence stronger effects in a lab study than an online one. Consequently, the biasing effect of distractor recognition on faces is expected to be more similar to prior lab studies that have used word targets. Participants will be aged between 18-25, should have normal or corrected-to-normal vision, must exhibit no history of neurological disorder or current use of psychoactive medications, are to be right-handed and must have lived in the UK for over ten years. The study has received ethical approval from the University of Kent School of Psychology Ethics committee.

Materials

All stimuli will remain identical to that used for Experiment 1. Programming for this experiment has already been completed with PsychoPy2.

Design and Procedure

The experimental design and procedure will be highly similar to Experiment 1, with slight adjustments for the incorporation of EEG and running the tasks face-to-face instead of online.

As a brief recap, participants will first rate a series of individually presented scene images for pleasantness. Subsequently, they will complete a face recognition test where photographs of faces (depicting familiar and unfamiliar individuals) will be presented superimposed on top of scene images. These scene images will have either been previously shown in the scene rating task or will be completely new. Consequently, there will be four experimental conditions for the recognition test: Familiar Face Old Scene; Familiar Face New Scene; Unfamiliar Face Old Scene and Unfamiliar Face New Scene. This recognition test therefore incorporates the same 2 x 2 within-subjects design with the same independent variables as in Experiment 1: target memory status (familiar vs. unfamiliar faces) and distractor memory status ("old/newness" of scene image). In addition to measuring the same behavioural dependent variables (face recognition accuracy and reaction times) as in Experiment 1, we will also measure ERP markers of recognition processes (see EEG analysis plan section).

Most importantly, the EEG experiment will include twice the number of stimuli both in the encoding and test phases to ensure that each experimental condition in the recognition test has a sufficient number of trials for reliable ERP measurements (specifically, 64 trials in each). Hence, the encoding phase will now include 128 scene images split across two blocks with a break in between (64 images per block), while the test phase will now include 256 images of scene/face combinations also presented in two blocks with a break in between. Although using twice the number of stimuli could result in a worsening of memory of scenes, pilot studies confirmed that the memory for scenes was still sufficiently high despite the larger number of stimuli. Scene images that are shown in the first block of the encoding phase will be shown as "old" distractors in the first block of the recognition test, while scene images that are shown in the second block of the encoding phase will be shown as "old" distractors in the second block of the recognition test. This design will therefore ensure consistent time delay between encoding and test for distractors, as well as providing participants with breaks to prevent fatigue. Note that although past studies have often divided stimuli into smaller study-test cycles (Allen et al., 2019; Bergström et al., 2016) to ensure adequate recognition performance when using large numbers of stimuli. However, we have decided to use one study and test phase to enable the incidental encoding of distractors, without participants knowing that they would later need to ignore those distractors in the recognition test. This design thus circumvents the concerns in previous studies that participants may attempt to prevent encoding of distractors since they are task-irrelevant, which could reduce recognition bias.

Apart from these design changes, all other characteristics of both encoding and test phases will remain the same in as in Experiment 1, including instructions, trial timings, response keys, etc. Scene stimuli assignment to old/new conditions and face and scene stimuli assignment to block 1 vs. 2 will be counterbalanced across participants.

To further understand how unintentional recognition of distractors influences face recognition, we will also add a more comprehensive test of person recognition after the “Memory Stroop” phase. This person recognition test will measure which of the individuals in face photographs are known to individual participants, to assess whether biasing effects of distractors occur both for known and unknown individuals. The test will therefore ask participants to name and/or provide semantic information about the person in each face photograph that they recognise (following previous protocols in similar research, e.g. Bergström et al., 2013).

EEG Recording and Pre-Processing

Participants’ electrical brain activity during the Memory Stroop recognition test will be recorded with a QuickAmp (Brain Products GmbH) from 30 scalp EEG electrodes placed in an extended 10-20 system using an Easy-Cap. EOG will also be recorded from bipolar electrodes placed around the left eye (VEOG) and the left and right outer canthi (HEOG). The EEG will be recorded at 500 Hz with a 0.05-70 Hz bandwidth using an average reference. EEG pre-processing and analysis will be conducted in EEGLAB (Delorme & Makeig, 2004), following Bergström et al. (2016). The EEG will be re-referenced to average of the mastoids and divided into -1000 to 3000ms epochs time-locked to the onset of the face-scene image pair presentations, and baseline corrected using the -200 to 0ms pre-stimulus period. Next, epochs will be concatenated and submitted to extended infomax Independent Component Analysis using runica from the EEGLAB toolbox, with default extended-mode training parameters (Delorme & Makeig, 2004). Independent components reflecting eye movements and additional sources of noise will be detected by visual inspection of component scalp topographies, time courses and activation spectra, and subsequently will be removed from the data. The corrected data will then be digitally lowpass filtered at 30Hz and any trials still containing visible artefacts post-filtering will be discarded. Similarly, so will trials where the participants have failed to respond within the timeframe required. Lastly, ERPs will be formed for each of the four possible combinations of distractor and target memory status: Familiar Face Old Scene; Familiar Face New Scene; Unfamiliar Face Old Scene, and Unfamiliar Face New Scene. Based on typical trial rejection rates with this EEG pre-processing pipeline, I estimate that I should be able to retain at least 50 epochs per ERP condition.

EEG Statistical Analysis Plan

Modulations of predicted episodic recognition-related ERP effects will be first tested through targeted statistical analysis of the ERP mean amplitudes from two-time windows and electrode sites where the FN400 and left parietal old/new effects are typically maximal; 300-500ms at the mid-frontal site (Fz) and 500-800ms at the left parietal site P3 (see Rugg &

Curran, 2007 for a review). Targeted analysis will not include late ERP slow drifts that past research has highlighted as an index of retrieval monitoring processes, because such slow drifts have been found to vary in terms of timing and scalp distributions across different studies. Consequently, it is not possible to make clear predictions about their exact timing and spatial locations.

Recognition of pre-experimentally familiar faces may involve other ERP effects than episodic recognition, since these two types of recognition may involve partially different neurocognitive processes. ERPs associated with face perception and recognition is typically measured across the posterior parietal-occipital scalp in the first few 100ms after a face is presented. ERP mean amplitudes will therefore also be analysed for the P7 and P8 electrodes between 200-400ms, after first re-referencing the data to an average reference (in line with e.g. Wiese, et al., 2019). This analysis will be conducted since past research has highlighted this time window and electrode sites as showing ERP effects specific to face processing (Eimer, 2011; Hayes et al., 2009; Herrmann et al., 2002; Linkenkaer-Hansen et al., 1998; Schweinberger & Neumann, 2016; Wiese et al., 2019), most relevantly, the N250 components that is thought to be reflective of facial familiarity (Collins et al., 2018; Tanaka et al., 2006).

Since analysing ERP data from a limited number of electrode sites and time points can often lead to the overlooking of effects occurring at alternative scalp locations and time pints-head analysis, it is recommended to also carry out whole-head analysis. Consequently, alongside targeted analysis, I will also conduct data-driven analyses where all scalp electrodes will be included, and multiple comparisons will be controlled for using nonparametric cluster-based permutation tests using the Fieldtrip toolbox (Oostenveld et al., 2010) in MATLAB. More specifically, this will involve first performing *t*-tests at every ERP data sample to estimate any significant differences (uncorrected α = .05) between conditions/groups. Any significant samples that are next to each other in time and space (spanning across a minimum of two electrodes) will be grouped into clusters and their *t*-values will be added together to form one cluster-level *t*-value. The false positive rate for the full spatiotemporal data matrix will be controlled by testing the cluster-level *t*-values against a null distribution of cluster-level t-statistics created by 5000 random permutations, where ERP data will be randomly assigned to conditions for all participants and clusters shall be recalculated for each sample. *P*-values will be calculated as the proportion of the randomisation null distribution surpassing the observed maximum cluster-level test statistic (i.e. the Monte-Carlo *p*-value). This analysis will allow us to identify significant clusters extending over time and electrodes to estimate both the timing and spatial distribution of effects. In particular, it will allow us to investigate ERP effects related to recognition of face targets and scene distractors that fall outside the specific time windows and locations used for the targeted analysis.

Expected Results

Behavioural

Behavioural results are expected to support the findings of Experiment 1 and past research on unintentional distractor recognition biasing intentional target recognition (Allen et al., 2019; Anderson et al., 2011; Bergström et al., 2016). Higher accuracy and faster reaction times are expected for congruent as opposed to incongruent trials, specifically when the face target is familiar. Since no significant bias effect was found in relation to the recognition of new faces in Experiment 1, it is expected this will also be true of this dataset.

Targeted ERP analysis: N250, FN400 & Left Parietal Old/New Effects

In line with past research it is expected that due to their familiarity, both familiar target faces and old distractor scene images will generate significantly more positive FN400 amplitudes in comparison to unfamiliar target faces and new distractor scene images respectively (Bergström et al., 2016; Curran, 2000; Curran & Cleary, 2003; Curran & Hancock, 2007) . That is, I predict there will be main effects of face and scene recognition on the FN400 effect, as found in prior Memory Stroop research with words and images. In relation to the left parietal effect, it is expected that there will be increased parietal positivity for intentional recognition of familiar in comparison to unfamiliar faces (MacKenzie et al., 2018), while scene images will elicit increased negative amplitudes for old in comparison to new distractors, as found in Bergström et al. (2016). This prediction therefore would lead to a statistical interaction whereby a positive old-new difference for intentional recognition of faces would be reversed for unintentional recognition of scenes. Consequently, it is expected that results from this research will provide further evidence for the dissociable neurocognitive nature of unintentional and intentional recognition. Since distractors, which are presumably processed unintentionally are expected to exhibit a different neural effect associated with recognition (parietal negativity), in comparison to intentionally processed targets (parietal positivity).

However, since this study used face stimuli as targets as opposed to words, the neurocognitive mechanisms observed in this experiment may not be similar to ERP effects in prior Memory Stroop research. For example, familiar face recognition may result in more negative N250 components when compared to unfamiliar faces, in line with prior studies (Farah et al., 1998; Kaufmann et al., 2008; Lavie et al., 2003; Pierce et al., 2011). It will also be of interest to investigate whether these ERP effects associated with face familiarity are modulated by distractor old/new memory status, which would suggest that face processing and episodic memory brain systems are interacting during early stages of recognition. That is, if the difference between familiar and unfamiliar faces in the N250 time-window is modulated by scene old/new status that would indicate that early face familiarity processes are "gated" by the context of those faces.

Early Stage/Late-Stage Distractor Processing

In line with past research, it is possible that depending on the distractibility of the scene images used in this study and the perceptual load of face recognition (i.e., the amount of cognitive load that is associated with the perception of the stimuli and/or the attention it draws), participants will engage in either early pre-retrieval control or later post-retrieval control to counteract distractor recognition effects on behaviour. If participants can engage early pre-retrieval control), this suggests that previously shown scenes will fail to elicit recognition-related activity (specifically FN400 effects), as found in Bergström et al. (2016) when words were used as distractors during image recognition. Alternatively, if participants are primarily engaging in post-retrieval control, then old scenes would be expected to still elicit FN400 effects (due to still being recognised), but participants may show large later ERP negativities that have been linked with post-retrieval monitoring and response conflict resolution (Bergström et al., 2016). Such late ERP effects are broadly distributed and sustained and should be revealed through the exploratory whole-scalp analysis. Thus, this ERP analysis can answer the question from my behavioural experiments regarding whether the perceptual load of faces prevented unintentional recognition of distracting information, or whether distractors are still recognised, but they just fail to influence behaviour.

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