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Different Cues of Personality and Health from the Face and Gait of Women

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Abstract: Redundant cues for attractiveness in humans have been identified, but the idea of multiple systems displaying different socially-relevant traits has yet to be extensively examined. We compared the accuracy with which observers could identify socially-relevant information of female targets, both from static images of their faces, and from point-light displays of their gait. Perception of extraversion was at chance. However, agreeableness and sociosexuality were more accurately perceived from the face than gait, while physical health showed the opposite pattern. This double dissociation suggests different information can be carried in different modalities. In addition, partial correlation analyses suggested that even when both modalities allowed accurate trait identification, the information content was different. Our results demonstrate that cues of different socially-relevant traits are communicated more effectively through different modalities, and these modality-specific cues contain distinctive information, supporting a "multiple messages" hypothesis.

Keywords: cues, face, gait, personality, health

Introduction

We provide information about ourselves to the people around us in a variety of ways. From the pitch of our voice to the spring in our step, viewers are able to gain accurate information to predict our future behaviors or improve social interactions from even "thin slices" of behavior (see Ambady and Rosenthal, 1992, for a meta-analysis). Indeed, even the way we structure our own environment provides information about who we are (Gosling, Ko, Mannarelli and Morris, 2002).

How might information from multiple modalities, such as face and gait, be used? In some cases, redundant information may be expressed in multiple modalities in which each cue correlates with the individual's condition, and by combining information, the observer can assemble a better measure of the individual. This might be useful, for example, in noisy environments (Zuk, Ligon and Thornhill, 1992). In contrast, multiple distinctive sources would cue the observer about different properties of the condition of the individual (Møller and Pomiankowski, 1993). For instance, some sources of information may report short-term changes in condition while others may represent a long-term picture. Modeling techniques suggest that the advertisement of multiple qualities through multiple modalities can be evolutionarily stable (Johnstone, 1995). The implications of redundant versus multiple messages are important for human social cognition. In a completely redundant system, observers will get similar information about a target regardless of which sources of information they attend to. However, in a system of multiple modalities and messages, observers will need to flexibly attend to different information sources, based on the social context.

Research investigating how human social information may be conveyed across multiple modalities has tended to support a redundancy account of overall mate value. Much of this work has looked at correlations between attractiveness ratings made from different sources. Thornhill and Grammer (1999) found agreement in judgments of attractiveness of the female face and body, and argued that both traits reflected a single advertisement of genetic quality. The same was also true for males, where the face and body showed agreement for ratings of attractiveness, dominance, and masculinity (Fink, Täschner, Neave, Hugill and Dane, 2010). Similarly, the attractiveness of the female face and voice are positively correlated (Collins and Missing, 2003) and appear to provide overlapping information regarding femininity (Feinberg et al., 2005), which may in turn convey reproductive health and development (see Alonso and Rosenfield, 2002 for a review). Voice attractiveness and body morphology are also related (Hughes, Dispenza, and Gallup, 2004), and both correlate with various measures of sexual behavior. Research has shown that the face, body, and voice are all indicators of overall attractiveness (Saxton, Burriss, Murray, Rowland and Roberts, 2009), and although these measures show some independence, they are correlated (Peters, Rhodes, and Simmons, 2007). Rikowski and Grammer (1999) showed that female facial attractiveness correlated with judged sexiness of body odor, again supporting a redundancy view. In addition to attractiveness, judgments of both the face and voice also predicted self-ratings of power and warmth for both sexes (Berry, 1991), suggesting similar information content for these modalities. Similarly, the face and body may represent redundant cues with regard to strength. Sell and colleagues found that strength judgments of both the face and body correlated with actual measures of strength in women and men (Sell et al., 2009).

It therefore appears there are many different and correlated cues of human

attractiveness. To at least some degree, different forms of attractiveness are therefore redundant cues reflecting an underlying characteristic, most frequently argued to be genetic quality (e.g., Thornhill and Grammer, 1999). This general result is important, as it would not be expected if attractiveness ratings were the result of arbitrary cultural whim. But the existence of redundant cues for genetic quality is in no way incompatible with the possibility of multiple cues for other traits. While a cue to high genetic quality will be universally desirable, there may also exist individual differences in observer preferences (Hönekopp, 2006; Little, Burt and Perrett, 2006), based both on the observer's own best reproductive strategy and the current environment.

In this work, we examine whether the face and gait are suited for conveying different kinds of information about the individual while still providing an overlapping cue to mate value. Both modalities represent rich sources of information. There is growing evidence demonstrating that even the static presentation of neutral faces provides accurate information about stable and enduring traits, such as personality (Kramer, King and Ward, 2011; Kramer and Ward, 2010, 2011; Little and Perrett, 2007; Penton-Voak, Pound, Little and Perrett, 2006; Shevlin, Walker, Davies, Banyard and Lewis, 2003), sociosexuality (Boothroyd, Cross, Gray, Coombes and Gregson-Curtis, 2011; Boothroyd, Jones, Burt, DeBruine and Perrett, 2008), sexual orientation (Rule, Ambady and Hallett, 2009), propensity for aggression (Carré and McCormick, 2008; Carré, McCormick and Mondloch, 2009), trustworthiness (Stirrat and Perrett, 2010), and health (Kramer and Ward, 2010). Like the static face, the gait is also a rich information source. Research investigating information from gait often uses point-light techniques (Johansson, 1973, 1976) to provide biological motion information while removing cues relating to appearance. These studies have shown that accurate information is perceived relating to actor sex (Kozlowski and Cutting, 1977; Pollick, Kay, Heim and Stringer, 2005; Troje, 2002), identity (Cutting and Kozlowski, 1977), age (Montepare and Zebrowitz-McArthur, 1988), female fertility (Provost, Quinsey and Troje, 2008), vulnerability (Gunns, Johnston and Hudson, 2002), acted emotion (Dittrich, Troscianko, Lea and Morgan, 1996), and mood (Michalak et al., 2009). Although previous research has not investigated the validity of cues of health from gait, it has been previously reported that body symmetry, which may reflect genetic quality (Thornhill and Møller, 1997), is correlated with dancing ability as judged from point-light stimuli (Brown et al., 2005; but see for a re-analysis Trivers, Palestis and Zaatari, 2009). Therefore, while gait and the static face are clearly informative, we are not aware of attempts to directly compare how effectively observers can estimate individuals' traits from these different modalities.

To directly compare cue efficacy from the face and gait, and how accurately individuals' traits are identified by observers, we assessed individuals on four socially-relevant traits that could be measured with well-validated scales: extraversion, agreeableness, sociosexuality, and physical health. Health and sociosexuality were chosen since these traits

have some of the most empirical support for valid cues from the face (e.g., Boothroyd et al., 2008; Kramer and Ward, 2010). Both are important traits when considering mate selection, and indeed may be related (DeBruine, Jones, Crawford, Welling and Little, 2010). Extraversion and agreeableness were selected because previous research has demonstrated links between sociosexuality and both extraversion and agreeableness cross-culturally (Schmitt and Shackelford, 2008).

It is important to understand exactly what we mean by "accurate perceptions" of personality and health. A frequent approach in social cognition is to look at the agreement of observers in rating a social trait. For example, we might find that observers show good agreement in their ratings of extraversion levels in a target group of unfamiliar others. However, if we know something about the actual levels of extraversion for individuals within the target group, we can assess not only whether observers agree on trait levels, but whether observers can accurately estimate these levels. In this study, we compare observer ratings to self-report ratings of individuals in the target group. Self-report measures of personality are readily obtained yet remarkably useful predictors of individual behavior. Self-report measures of Big Five traits show heritability (Bouchard and Loehlin, 2001), internal consistency (Gow, Whiteman, Pattie and Deary, 2005), agreement across measures (Paunonen, 2003), agreement with reports by others (Connolly, Kavanagh and Viswesvaran, 2007), correlations with measures of personality disorders (Reynolds and Clark, 2001; Saulsman and Page, 2004), and validity in predicting complex real-world behaviors and outcomes (Paunonen, 2003; Paunonen and Ashton, 2001; Tett, Jackson and Rothstein, 1991).

Similarly, sociosexuality is also predictive of behavior (Díaz-Loving and Rodríguez, 2008), and shows evidence of being heritable (Bailey, Kirk, Zhu, Dunne and Martin, 2000). Finally, our measure of health has previously shown both reliability and validity (Kontodimopoulos, Pappa, Niakas and Tountas, 2007; Salyers, Bosworth, Swanson, Lamb-Pagone and Osher, 2000). As such, we consider these measures to be a reasonable method of estimating personality and health, against which we are then able to compare unfamiliar observers' judgments.

While there is evidence to suggest that these traits may all be conveyed from the face, they have not yet been explored in gait. A redundancy account would predict that similar information will be available from both the face and gait. In contrast, if the face and gait vary in how effectively they convey different forms of information, we might then see an interaction whereby the two cue modalities allow different relative levels of accuracy, depending on the trait being assessed. However, even if we see similar levels of accuracy in both face and gait, it is still possible that the two modalities may be providing distinctive rather than redundant information. If two information sources are truly redundant, then accuracy from one when controlling for the contribution of the other should be zero. We can therefore use multivariate statistics to directly address the issue of redundancy versus

distinctiveness, and the separate contributions of face and gait to estimates of trait accuracy. In addition, we collected ratings of attractiveness and femininity from both face and gait. This allows us to verify previous findings of correlated cues to universal mate value (e.g., Thornhill and Grammer, 1999), while simultaneously exploring whether different content about personality and health may be cued through the modalities of face and gait.

Materials and Methods

In a two-stage process, we first produced point-light walkers and facial photographs for a number of actors, and then measured the ability of observers to accurately identify a variety of traits from the face and from gait.

Participants
Stimulus generation: Twenty-one Caucasian female Bangor University students (M = 23.19, SD = 4.17) volunteered to take part as sources of cues. Although 9 male students were also used in the stimulus generation and ratings task, we did not include these actors in our design and subsequent analyses due to the small sample size.

Rating task: Fifty-six Bangor University undergraduate students (38 female; age M = 20.71, SD = 3.23) took part in exchange for course credits or money. None of these participants were involved in the stimulus generation.

Design
The experiment was defined by three factors describing the observers and stimuli: Observer Sex (male or female) x Trait (extraversion, agreeableness, sociosexuality, physical health) x Modality (face or gait). Observer Sex varied between participants, while all other factors varied within participants. The dependent measure was the accuracy of observers' perceptions. For a given trait and modality, the accuracy for each observer was calculated by correlating their ratings with the actors' self-ratings. This measure reflects our question: can individual observers scale their estimates of a trait in a way that accurately covaries with actual trait levels (i.e., actor self-report)?

Stimuli
Thirty actors participated in a motion capture session in which they were required to wear only a t-shirt and shorts. The t-shirt was tucked in, and the legs of the shorts were taped to avoid loose material when necessary. Various anatomical measurements were collected, along with weight and height, as required by the motion capture software. Thirty-five retro-reflective markers were then placed on the skin and clothing, and comprised a full-body

marker set. The lower body was modeled based on the Helen Hayes marker set (Kadaba, Ramakrishnan and Wooten, 1990), highlighting aspects of the pelvis, thighs, knees, lower legs, ankles, and feet, while the upper body was modeled as the thorax, upper and lower arms, hands, and head using the Plug In Gait model (Vicon Motion Systems). This model is well-documented and has been used previously (Gutierrez and Saraste, 2002). We recorded approximately five walking trials for each actor using a 12-camera motion capture system (Vicon, Oxford Metrics). Participants were asked to walk back and forth across a 4m-long motion capture field at their own pace.

For each actor, we studied each trial working backwards from the last, until one was found that included a full gait cycle where all marker locations were available for every frame. For most actors, two consecutive gait cycles were available and so were used to produce the point-light walkers. Full gait cycles were required in order that the resulting video stimuli could be played continuously on a loop with minimal jolt between loops.

We used custom MATLAB software to produce the point-light videos, with walking viewed front-on, and actors were represented by 14 landmarks. Eleven of these were actual markers: the clavicle, shoulders, elbows, knees, ankles, and two at the front of the pelvis. The other three were virtual: the midpoint of the head, and the midpoint of the wrists.

In addition, digital photographs of each actor's face were taken prior to filming. Photos were constrained to reflect neutral expression, direct gaze, consistent posture, lighting, and distance to the camera. Participants were asked to remove any glasses, jewelry, or make-up and to tie their hair back. These photographs were then cropped around the head and neck so that shoulders and any visible clothing were removed.

In order to confirm that these photographs were non-expressive, six new participants (3 female) rated every photograph (including the male images) for how emotional it was, on a scale from -5 (highly negative), through 0 (neutral), to 5 (highly positive). Photographs were presented individually on a computer screen in a random order for each observer. Analysis of these ratings for the female photographs found high inter-observer agreement, with a Cronbach's α of .84. The mean rating for each photograph was calculated, and these values (M = 0.18, SD = 1.64) did not differ from a perceived neutrality score of zero, t(20) = 0.70, p = .49, d = .15.

Further, we looked for any value in the facial expressions within our photo stimuli. Although perceptions of the emotional content of the faces did not, on average, differ from neutrality, there was still some small variation in the average ratings around zero. As such, it may be the case that observers are influenced by their perceptions of emotional content when rating the faces even though the average face was perceived to be neutral. We therefore correlated the average emotion rating for each actor's face with their self-report scores on extraversion, agreeableness, sociosexuality, and physical health (see below). No relationships were found (all p > .12), suggesting that actors' personalities and health were not

significantly related to the emotional content of their photographs.

Actors also completed the Big Five Personality Inventory (BFI; John and Srivastava, 1999), the Kinsey Scale of Sexual Orientation (Kinsey, Pomeroy and Martin, 1948), the Short-Form 12-Item Health Survey (SF-12; Ware, Kosinski and Keller, 1996), the revised Sociosexual Orientation Inventory (SOI-R; Penke and Asendorpf, 2008), the Interpersonal Jealousy Scale (IJS; Mathes and Severa, 1981), and two hypothetical situations relating to the Ultimatum and Dictator games. Thus for each actor, we had a profile of behavioral traits, facial appearance, and gait information.

Female actors also completed information regarding their method of contraception, length of menstrual cycle, and number of days since last period. Ten of the women were using some form of birth control that would affect their hormone levels. Although previous research has shown that the attractiveness of both face (Roberts et al., 2004) and gait (Provost et al., 2008) is affected by menstrual cycle phase, we were unable to investigate this further due to the small sample size.

Procedure

Point-light walker videos and face photos were presented in separate blocks, with the order of blocks counterbalanced across observers. A Latin square design was used to create four stimulus orders for each block. Participant numbers within each set were balanced as much as possible.

For each trial, observers were shown a point-light walker video or face photograph on an individual computer screen using Microsoft PowerPoint software. Stimuli were presented one at a time, and observers made their judgments in a booklet while advancing through the stimuli at their own pace. The point-light walkers played on a continuous loop onscreen, and the faces remained onscreen, until observers decided to move to the next stimulus by pressing a key. All trait ratings were made for each stimulus before observers advanced to the next one. Four ratings booklets were used, each containing the traits to be rated in a different order. The type of booklet completed was approximately counterbalanced across observers for the first 36 participants. A further 20 participants were run using one of the initial four booklets.

Stimuli were rated on four traits (extraversion, agreeableness, sociosexuality, physical health) that represented the main interest of the current work, along with two others (attractiveness, gender) that are most frequently investigated in the literature. Agreeableness, extraversion, attractiveness, sociosexuality, and physical health were rated on a Likert scale from 1 (low) to 6 (high). A low sociosexuality rating indicated restricted sociosexuality, for example, not open to short-term relationships. Stimuli were also rated for gender (1=masculine, 6=feminine). An even-numbered scale was used to force non-neutral judgments. Printed definitions of all the traits were provided with the ratings booklets (see

Appendix 1). Observers were instructed not to rate a particular face if it was familiar to them (faces recognized M = 0.50, SD = 1.01).

Results

For each modality, we found high inter-observer agreement for all six ratings that were made (Cronbach's α ranged from .83 to .96). The only possible exception was agreeableness from gait (.54). This lack of consensus suggests that accuracy is likely unattainable for this specific judgment.

We first examined the correlation of trait ratings between modalities. In line with previous research (e.g., Saxton, Caryl and Roberts, 2006), we correlated attractiveness ratings of the faces and walkers for female actors for each observer. After applying Fisher's r-to-z transformation (which corrects the skew in the distribution of r), we found that these correlations were significantly above zero (mean z = .07; t(55) = 2.30, p = .025, d = .31), suggesting that observers found people with attractive faces to also have attractive gaits, even when face and gait were presented separately. This was also true for ratings of gender (mean z = .11; t(54) = 2.90, p = .005, d = .39), so that women judged to have feminine-looking faces were also judged to have feminine-looking gaits. Given the strong relationship between gender and attractiveness in previous research (e.g., face - Law Smith et al., 2006; gait – Johnson and Tassinary, 2007), we carried out similar analyses investigating the correlations of these two judgments for individual observers within each modality. We found that female faces perceived as more attractive were judged to be more feminine (mean z = .67; t(54) = 12.84, p < .0001, d = 1.73), and that this was also true for gait (mean z = .39; t(55) = 9.07, p < .0001, d = 1.21). These results show an overlap, at least for women, of gender and attractiveness. That ratings agreed across modalities for each judgment demonstrated that, as expected, body motion alone, independent of surface or contour information, is part of a constellation of redundant, correlated cues to attractiveness and femininity. This confirms and extends previous work demonstrating that correlated cues for attractiveness include the face, body shape (Thornhill and Grammer, 1999), odor (Rikowski and Grammer, 1999), and voice (Saxton et al., 2009).

Analyses were also conducted for the other four traits in order to investigate the agreement of ratings for the face and gait. These analyses found that ratings of extraversion (mean z = .09; t(55) = 3.52, p = .0009, d = .47) and physical health (mean z = .09; t(55) = 2.66, p = .010, d = .36), were significantly correlated across modalities. Therefore, people with faces that look extraverted or healthy tend to have gaits that also give this impression. Agreement across modalities for sociosexuality and agreeableness were not significant (all p > .31).

These simple correlations indicate areas of observer agreement and disagreement in the

perception of social traits. However, for the personality traits and health, we are not so much interested in observer agreement, but mainly in whether trait perceptions accurately reflect actor self-reports for those traits. In particular, our main goal was to compare the accuracy of trait perceptions from the two different modalities. Actor scores on extraversion and agreeableness were taken from the actors' Big Five answers, sociosexuality from the SOI-R, and physical health from the physical component summary (PCS) of the SF-12. For each observer, we produced a measure of accuracy by correlating their ratings with actor scores for each combination of trait and modality. That is, for each observer we calculated eight correlations, with four based on the face and four based on body motion. These eight correlations were each transformed using Fisher's r-to-z method. Accuracy was calculated for each of the eight conditions as the average of transformed correlations for all observers. By using this method of averaging individual observers' correlations (accuracies), rather than averaging ratings for all participants and then performing correlations with self-report measures, we take into account inter-observer differences in perception accuracy (Monin and Oppenheimer, 2005). Further, this dependent measure best addresses our question of whether individual observers can scale their estimates of a trait in line with actual variation. If the stimulus carries no information about a trait, then the correlation of perceptions and actor self-ratings would be zero. However, if the average correlation across observers was greater than zero, this would demonstrate both that the stimulus carried information, and that the observers accurately judged this information.

Using the above correlations, we conducted a 2 (Observer Sex: male or female) x 4 (Trait: extraversion, agreeableness, sociosexuality, physical health) x 2 (Modality: face or gait) ANOVA. The analysis revealed a main effect of Trait ($F(3, 159) = 9.69$, $p < .001$, $\eta_p^2 = 0.155$), which showed, unsurprisingly, that accuracy varied with the trait that was rated. The key result was the significant Trait x Modality interaction ($F(3, 159) = 5.42$, $p = .001$, $\eta_p^2 = 0.093$, see Figure 1), which showed that accuracy in ratings was affected by the stimulus modality. Further analyses compared faces and walkers for each trait, and showed higher accuracy with faces for agreeableness ($t(55) = 2.23$, $p = .030$, $d = .30$) and sociosexuality ($t(54) = 3.00$, $p = .004$, $d = .41$). In contrast, physical health showed higher accuracy with walkers ($t(55) = 2.07$, $p = .043$, $d = .28$). Extraversion accuracy showed no significant difference between modalities ($p = .608$). There was no main effect of Observer Sex ($F(1, 53) = 0.30$, $p = .59$, $\eta_p^2 = 0.006$) and no other significant effects or interactions (all $p > .13$).

Figure 1. Mean correlation of observers for health and personality traits after applying the Fisher transformation. Chance performance level is zero. Error bars indicate 95% confidence interval and can be used to compare conditions to baseline (i.e., error bars overlapping the zero line are not significantly different from chance; * indicates significant difference at an uncorrected alpha level of .05; ** at .01).
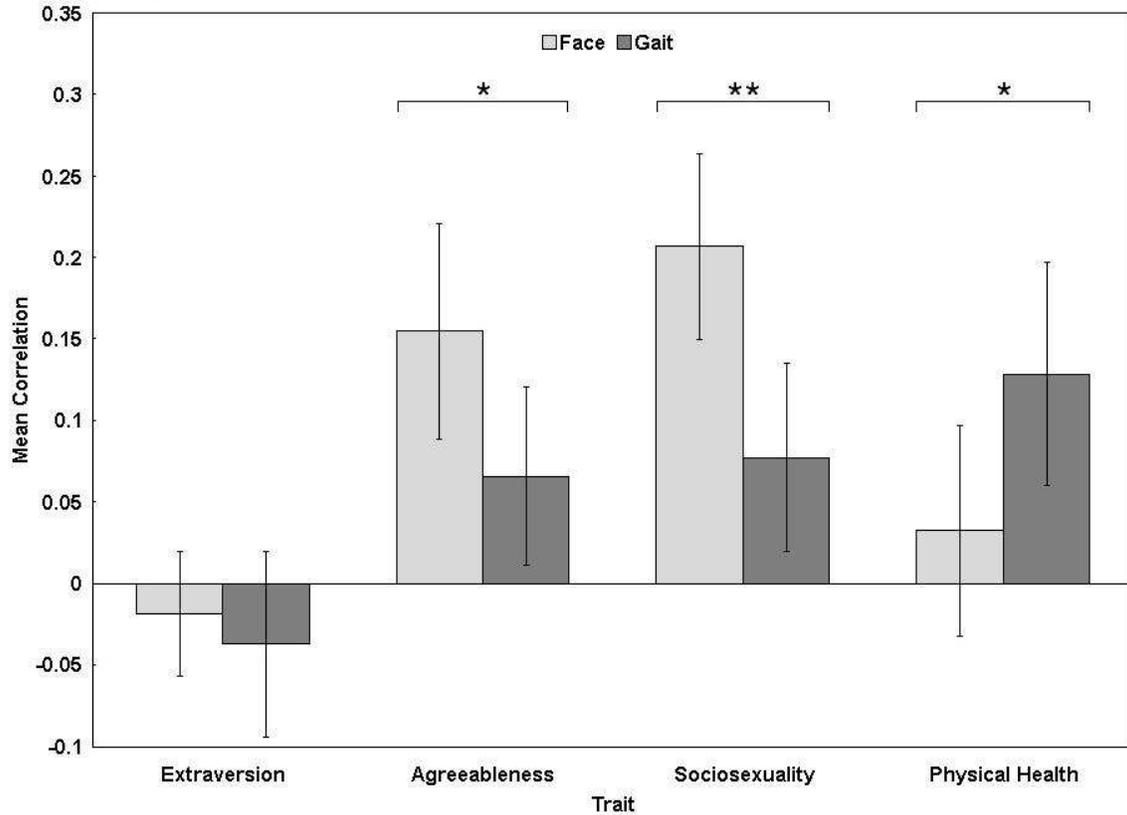

Figure 1 also compares the individual accuracy correlations described above with chance at an uncorrected alpha value of .05. Chance was defined as a mean individual accuracy of zero, which indicates no relationship between observer ratings and individuals' traits (e.g., Back et al., 2010). If observers accurately perceive information about the actors, correlations between their ratings and the actors' self-ratings would tend to be positive rather than show no relationship (zero correlation). As such, observer correlations would significantly differ from zero (chance performance or no relationship). Significance was assessed using a one-sample t test. Not all the effects shown were large enough to survive correction for multiple comparisons. Using Bonferroni correction, accuracy was above chance with faces for agreeableness (t(55) = 4.68, p = .00002, d = .63) and sociosexuality

(t(55) = 7.31, p < .00001, d = .98), and with walkers for physical health (t(55) = 3.76, p = .0004, d = .50; uncorrected p-values). Further information regarding the distributions of these accuracies can be found in Appendix 2. The accuracies found here were comparable with previous research investigating personality information in the face (Penton-Voak et al., 2006). Regardless of the effects of correction, our results demonstrate a double dissociation, such that agreeableness and sociosexuality were more accurately identified from the face, but physical health was more accurately identified from the gait.

The double dissociation above indicates that face and gait can contribute distinctive but valid information about social traits. However, we can also look in more detail at the issue of redundant and distinctive sources. We considered the possible distinctive nature of the information provided by each modality by assessing whether ratings of the face and gait contributed separately to trait accuracy. For example, although we know that the face provides more information than gait with regard to agreeableness (see Figure 1), this does not tell us whether information in the gait is distinctive or redundant with the information in the face. We conducted partial correlation analyses for the three traits which showed significant differences across modalities. To illustrate, ratings of agreeableness from the face were correlated with actor self-reports for each observer while controlling for their ratings of agreeableness from the gait. These partial correlations were then transformed and compared with chance performance as before. Our results showed that accuracy from the face remained significant after controlling for gait ratings for both agreeableness (mean z = .16; t(55) = 4.52, p = .00003, d = .60) and sociosexuality (mean z =.20; t(55) = 7.07, p < .00001, d = .95). In addition, physical health accuracy from the gait remained significant after controlling for face ratings (mean z = .11; t(55) = 3.20, p = .0023, d = .43). Further, accuracy from the gait remained significant after controlling for face ratings for both agreeableness (mean z = .07; t(55) = 2.60, p = .012, d = .35) and sociosexuality (mean z =.06; t(54) = 2.05, p = .045, d = .28). However, as above, neither of these survived correction for multiple comparisons. These results support a "distinctiveness" account for these traits, whereby the information from the two modalities is distinctive rather than simply differing in magnitude.

Given that each observer provided ratings for multiple actors, we might also address the question of redundant vs. distinctive cues using hierarchical linear modeling, which takes into account the nesting of ratings within observers (e.g., Sell et al., 2009). For each trait, one model was used to estimate the average accuracy of individual observers, and allowed direct comparison of face and gait information. Specifically, the outcome variable was the actor scores, and the level 1 predictors were the ratings of both face and gait. The level 2 units were the identities of the 56 observers, and there were no level 2 predictors. As such, the relationship of interest lay only at level 1, and the presence of units at level 2 was merely to statistically control for the non-independence of ratings derived from the same observer. Prior to being entered into the models, all variables were z-scored (ratings of faces and

ratings of gait were standardized within observer). This means that the models' gamma coefficients (γ) are equivalent to standardized βs in multiple regressions (and that the first level intercepts are zero for all analyses).

For each trait, we assessed how well face and gait ratings predicted actor scores in a single model (using HLM 7 software), allowing us to determine the information in each modality controlling for the other. The results of these models are summarized in Table 1.

Table 1. Summary of hierarchical linear modeling results for each trait model.

Trait	Modality	Regression coefficient γ (p)
Extraversion	Face	-0.002 (.939)
	Gait	-0.03 (.317)
Agreeableness	Face	0.10 (<.001)
	Gait	0.04 (.201)
Sociosexuality	Face	0.18 (<.001)
	Gait	0.09 (.002)
Physical health	Face	-0.03 (.244)
	Gait	0.23 (<.001)

These results mirror those of our partial correlation analyses above, with the same pattern of significance regarding accuracy, as well as offering further support that face and gait can provide distinctive rather than purely redundant information with regard to agreeableness, sociosexuality, and health.

Are some people generally better at reading cues than others over multiple modalities? If there were individual differences between observers, such that some were better at reading cues independent of modality, we would find a correlation between face and gait accuracy. For each trait, we correlated observers' accuracies for face and gait. However, we found no relationship between accuracy across modalities for any of the traits (all p > .69). Apparently, those who were successful in perceiving cues from the face were not necessarily better at

perceiving information in the gait and vice versa. This suggests that observers may have used different strategies to accurately identify traits from the face and from gait.

Discussion

Previous work has shown that both gait and static neutral faces, when presented individually, provide accurate information about various traits. By directly comparing the accuracy of perceptions by using traits that can be objectively measured, we have been able to investigate for the first time how efficiently the face and the gait convey different forms of socially-relevant information. Agreeableness and sociosexuality were more accurately perceived from the face than gait, while physical health showed the opposite pattern. Finally, perception of extraversion was at chance levels in both cases. Cues of different socially-relevant traits were therefore conveyed more effectively through different modalities. Interestingly, these results contrast with our findings regarding perceptions of attractiveness and femininity, which confirm previous studies indicating strong agreement across cues to overall quality (e.g. Thornhill and Grammer, 1999).

We also demonstrated distinctive sources by considering the accuracy of perceptions from one modality while controlling for those produced by the other modality. For example, the information about agreeableness contained in the face was not explained by the perceptions of agreeableness from the gait. Different information content in the face and gait is also consistent with what seemed to be the different abilities of observers to utilize face and gait information, as the accuracy of observers in one modality did not predict their accuracy in the other. Information from the face and from gait can therefore be distinctive.

The contrast between our findings on mate value (attractiveness and femininity), and more specific social traits makes sense: honest cues to overall mate value must be correlated by the single, underlying mate value of the actor. However, specific cues to statistically independent (or loosely coupled) traits, such as personality factors, can be signaled more or less effectively in different modalities.

Of course, it is important to bear in mind that our results apply to cues from females but may not generalize to a male population or to older adults. Previous work has found sex differences in cues signaled by the face (Little and Perrett, 2007; Penton-Voak et al., 2006) and this may also be the case for gait. Further investigation is needed in order to explore these issues.

To our knowledge, these results demonstrate for the first time that physical health information is reliably revealed in human gait. The SF-12 measure we used to assess health is probably best described as a measure of health in daily living. For example, questions include whether health problems interfere with social life, and whether the person suffers from persistent pain. Multiple traits from body motion are associated with health (such as

movement amplitude and balance; Voermans, Snijders, Schoon and Bloem, 2007) and so gait may provide a similar source of information. Indeed, extracting health information from gait may utilize information that has already been shown to produce accurate age perception (Montepare and Zebrowitz-McArthur, 1988). We hypothesize that these considerations may explain the greater accuracy in estimating health from the gait as opposed to the static face.

Our results with faces are largely consistent with previous findings, although the literature itself does not yet give an entirely clear picture. We found accurate identification of agreeableness but not extraversion from the individual faces we used. In previous studies, extraversion, agreeableness, and physical health have been readily identified in composite faces (Kramer and Ward, 2010; Little and Perrett, 2007; Penton-Voak et al., 2006), but results have been more mixed with individual faces, where the ratio of signal to noise may be smaller. Agreeableness from individual faces has been found before with men's faces, but was not significant with women's faces (Penton-Voak et al., 2006). For extraversion, some studies have allowed actors to pose naturally and with uncontrolled facial expressions, and found accuracy in perceiving extraversion from individual faces (e.g., Borkenau, Brecke, Möttig and Paelecke, 2009). Using controlled poses, Penton-Voak et al. (2006) found accurate identification of extraversion, although Shevlin et al. (2003) did not. And while cues from the face of physical health are readily identified from composite images (Kramer and Ward, 2010), they are weaker with individual faces (Rhodes, Chan, Zebrowitz and Simmons, 2003). In addition, reports of accurate health cues do not often control for facial expressions (Kalick, Zebrowitz, Langlois and Johnson, 1998; Rhodes et al., 2003). We also replicated previous research showing that sociosexuality information is present in individual faces (Boothroyd et al., 2008). The bases for some of these discrepancies are currently unclear, but a number of other points are. First, there is information in the non-expressive individual face for many of these traits. Second, the difference between composites and individual photos must be considered. In many cases, the relevant cue appears to be enhanced by the averaging involved in creating composite images, not washed away. At least some of the information seems due to consistent variation rather than the degree of random variation. For example, differences between groups in the level of fluctuating asymmetries (such as reported for health – Rhodes et al., 2001; and extraversion - Pound, Penton-Voak and Brown, 2007) would be greatly reduced or eliminated in composites reflecting the group averages. But third, and most important for the current study, a trait that is for whatever reason weakly conveyed in the individual face is not necessarily weakly conveyed in the individual walk, and vice versa.

Our results are also consistent with previous studies in the magnitude of effects. The magnitude of our correlations are similar to those from comparable research investigating accuracy of personality information from the face (e.g., Penton-Voak et al., 2006). We would expect fairly low accuracies given the multiple sources of noise that blur the relationship

between an actor's personality and an observer's perception of that personality from the neutral face or gait. To name a few of these sources: the relationship between the actor's personality and their self-report, the actor's personality and their face/gait, and the perception of those cues by the observer. Furthermore, our stimuli are, by design, remarkably impoverished. However, our results demonstrate that even the static, non-expressive, neutral face and the "pure" motion from gait provide useful social cues, and can convey distinctive information.

In the current work, we compared observers' perceptions to actors' self-report measures in order to determine how accurately information can be observed by strangers. However, other recent research has shown that informants (well-acquainted others) represent a useful source of information regarding actors, showing both high consensus with each other and high agreement with self-reports (Vazire, 2006). Therefore, further research might investigate whether accuracy in perceiving cues is affected by the source of the information considered as a measure of true personality.

Our results also further develop the set of correlated traits conveying attractiveness and femininity, to include the pure motion cue from gait, excluding surface and contour information present in studies using video clips (e.g., Saxton et al., 2009). The range of correlated features, from gait, to the face, to odor, and so on, argue strongly for an underlying biological basis to attractiveness judgments, likely reflecting a biologically significant factor, such as genetic quality (Thornhill and Grammer, 1999). While these modalities may be redundant with respect to cues from attractiveness, our findings emphasize that different cue modalities may also be suited for conveying qualitatively different information, i.e., the "multiple message" hypothesis of Møller and Pomiankowski (1993).

Throughout this research, we have shown that the face and gait are sources of socially-relevant information that others may use to guide their behavior. As such, these can be termed "cues" (Hasson, 1994). However, if a cue has evolved because of its effect on others then it is a special type of cue, sometimes termed a "signal" (Maynard Smith and Harper, 2003). Clearly, it is difficult to be completely certain why a specific cue has evolved. Further, signals may often evolve from cues that have been the focus of selection (Johnson, 2010), and subsequently, may be at any point on the theoretical pathway from cue to signal (Wyatt, 2010). For example, a receiver may have successfully evolved a response to a cue, and in turn, the sender may be in the process of evolving to take advantage of this response. Here, we would like to suggest that cues to personality and health present in the face and gait may reasonably be hypothesized to be signals.

We do not think it is possible at this point to be certain that gait and the static face have evolved for their signal value, but in our view, there is a good case to be made. Our argument takes several parts. First, on the "receiver end", it is clear that the neural response to face and gait is well adapted. Both face and gait are rich information sources, and it is perhaps not

surprising then that the human brain has specialized systems for processing the bodies, motion, and faces of other humans. The distinctive processing of these brain areas and their contributions to social cognition represent a highly active topic in social neuroscience. The extrastriate body area responds particularly well to representations of the human body, as well as to biological motion stimuli (Downing, Jiang, Shuman and Kanwisher, 2001). Regions which respond particularly well to properties of human faces include the so-called "core" face processing system of fusiform gyrus, inferior occipital gyrus, and superior temporal sulcus (Haxby, Hoffman and Gobbini, 2000).

Second, on the "sender end", by comparing humans with the other apes, it seems clear that both the human gait and face have been under intense selection pressures. The evolution of human bipedalism has fundamentally changed gait compared to other apes. Similarly, the human skull demonstrates many highly distinctive characteristics, some of which are related to bipedalism (e.g., the position of the foramen magnum), some of which are related to our relatively large brains (e.g., the increased size of the cranium), and changes in diet (e.g., structure of the jaw), and other changes with less obvious benefits (e.g., the apparent neoteny of human adult faces as compared with chimpanzee or other infant apes). All of these characteristics are integrated with, influence, and are influenced by, the structure of the human face (Lieberman, 2011). At the very least, it seems reasonable to conclude that information still present in the human face and gait has been maintained despite the evidently strong selective pressures affecting the evolution of these traits.

Third, it is plausible that the human gait and face have been subject to sexual selection pressure (e.g., Puts, Jones and DeBruine, 2012; Weston, Friday and Liò, 2007). Both gait (e.g., Provost et al., 2008) and static, neutral faces (e.g., Willis and Todorov, 2006) are readily judged as attractive or unattractive. The attractiveness of the static face in particular has been well investigated, and many qualities, such as height of the eyeline and fullness of the lips in women, demonstrate universal appeal (e.g., Johnston and Franklin, 1993). If feelings of attraction reflect evolved preferences for mate choice (as is frequently argued, e.g., Buss, 1989), and given that gait and face evoke such feelings of attraction, then it follows that displays of gait and face could evolve subject to intersexual competition and sexual selection pressure. They would then be similar to other sexually selected signals evolving within a context of mate choice and overlapping, but non-identical, genetic interests.

Although none of these considerations are decisive, we believe that collectively they suggest it is at least plausible that human gait and face have evolved under multiple pressures, including (given evidence on human attractiveness ratings) a social display function. Whether any socially-relevant information is present despite or because of this evolution, we cannot be sure. But at the very least, information about socially-relevant traits has been maintained in the face and gait. In fact, there is good reason to believe that at least

some socially-relevant information from the static face is shared with other apes, as recent research has demonstrated that humans can accurately identify dominance and other personality traits from the static chimpanzee face (Kramer et al., 2011; Kramer and Ward, in press).

To conclude, we show that the face and gait contain distinctive information with regard to personality and health when presented individually. Other personality and social traits may show similar or varied patterns, and it would be interesting to compare these with the accuracy of judgments made from the body, voice, odor and other systems available to us. It is important to realize that in everyday life, we are rarely limited to one form of information, and we are able to accumulate a range of information about an individual by combining these multiple messages (Freeman and Ambady, 2011). As such, real-world judgments are likely informed by numerous cues that are present in the dynamic social environment. Different nonverbal modalities can simultaneously convey different yet accurate messages to nearby observers, frequently without conscious control or awareness by either party. Our results suggest that observers will benefit by attending to a variety of cue modalities, based on the goals of their interaction, the social context, and the nature of information that these different modalities can convey.

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Appendix 1. Definition of terms provided for the stimuli ratings task

Agreeableness
How sympathetic, kind, affectionate, trusting, good-natured is this person?
Sociosexuality
How open to short-term relationships, one-night stands and the idea of sex without love is this person?
Gender
How masculine or feminine is this person?
Physical Health
What is this person's level of physical health? (Feels healthy, can climb stairs, free from pain, work not limited by health problems)
Attractiveness
How attractive is this person to others?
Extraversion
How extraverted is this person? (Talkative, energetic, social, assertive)

Appendix 2. Accuracies, calculated by correlating each observer's perceptions with actors' self-reports, for each trait and modality. Chance performance is represented by a mean correlation, after applying the Fisher transformation, of zero.

Trait	Modality	Median	Mean	Standard Error	95% confidence interval	
					Upper bound	Lower Bound
Extraversion	Face	-0.03	-0.02	0.02	-0.06	0.02
	Gait	-0.06	-0.04	0.03	-0.09	0.02
Agreeableness	Face	0.11	0.15	0.03	0.09	0.22
	Gait	0.07	0.07	0.03	0.01	0.12
Sociosexuality	Face	0.22	0.21	0.03	0.15	0.26
	Gait	0.08	0.08	0.03	0.02	0.14
Physical health	Face	0.00	0.03	0.03	-0.03	0.10
	Gait	0.10	0.13	0.03	0.06	0.20