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Facial first impressions are not mandatory: A priming investigation

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ABSTRACT

A common assertion is that, based around prominent character traits, first impressions are spontaneously extracted from faces. Specifically, mere exposure to a person is sufficient to trigger the involuntary extraction of core personality characteristics (e.g., trustworthiness, dominance, competence), an outcome that supports a range of significant judgments (e.g., hiring, investing, electing). But is this in fact the case? Noting ambiguities in the extant literature, here we used a repetition priming procedure to probe the extent to which impressions of dominance are extracted from faces absent the instruction to evaluate the stimuli in this way. Across five experiments in which either the character trait of interest was made increasingly obvious to participants (Expts. 1–3) or attention was explicitly directed toward the faces to generate low-level/high-level judgments (Expts. 4 & 5), no evidence for the spontaneous extraction of first impressions was observed. Instead, priming only emerged when judgments of dominance were an explicit requirement of the task at hand. Thus, at least using a priming methodology, the current findings contest the notion that first impressions are a mandatory product of person perception.

1. Introduction

Will Lucy secure a lucrative promotion, David a position on the town board, and Morgan a lenient custodial sentence? Aside from details pertaining directly to the matters at hand (e.g., relevant experience, local popularity, no prior convictions), a markedly different, and ostensibly irrelevant, source of information has been suggested to drive decision-making in these situations, personality characteristics derived from brief inspection of a person's face (Todorov, 2017; Todorov, Olivola, Dotsch, & Mende-Siedlecki, 2015; Zebrowitz, 2017). Faster than the blink of an eye (Olivola & Todorov, 2010; Willis & Todorov, 2006), face reading is believed to furnish inputs from which a range of noteworthy judgments can be made, including recommendations to hire, elect, and sanction (e.g., Antonakis & Dalgas, 2009; Castelli, Carraro, Ghitti, & Pastore, 2009; Rezlescu, Duchaine, Olivola, & Chater, 2012; Rule & Ambady, 2008; Todorov, Mandisodza, Goren, & Hall, 2005; Wilson & Rule, 2015). While work on this topic has identified core personality characteristics that fuel these impressions, two traits have attracted extensive attention — trustworthiness and dominance — the latter of which comprises the focus of the current investigation (Oosterhof & Todorov, 2008; Sutherland et al., 2013).

In speculating on the origin of face reading, debate has centred on whether this psychological ability is a hardwired feature of person perception (i.e., an innate capacity to detect friend and foe) or an acquired cognitive skill (Cook, Egglestone, & Over, 2022; Over & Cook, 2018; Over, Eggleston, & Cook, 2020; Schaller, 2008; Sutherland & Young, 2022; Zebrowitz, 2004, 2017). Notwithstanding fundamental divergences between these competing theoretical accounts, one shared assumption has garnered near universal agreement. The extraction of primary character traits (e.g., dominance, competence, trustworthiness) from the face is a compulsory (i.e., automatic) facet of person construal (Cook et al., 2022; Sutherland & Young, 2022; Todorov et al., 2015). As Ritchie and colleagues have argued, "…facial first impression formation is mandatory" (Todorov, 2017, p. 3). But is this in fact the case? Is the generation of first impressions an obligatory product of person perception or an outcome that emerges only under certain processing conditions (Blair, 2002; Macrae & Bodenhausen, 2000)? Using a priming methodology, we explored this important theoretical (and practical) question in the current investigation.

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1.1. The automaticity of face reading

As automatic psychological operations vary considerably in their features and triggering conditions (Moors & De Houwer, 2006), careful consideration must be given to the task settings in which first impressions are allegedly spontaneously extracted from faces (Palermo & Rhodes, 2007). A process can be characterized as automatic if it satisfies one or more critical criteria; it is unintentional, capacity free, non-conscious, and (once instigated) unstoppable (Bargh, 1989; Moors & De Houwer, 2006). In this regard, despite the multifaceted nature of the construct, work to date on person perception has focused almost exclusively on the intentionality component of automaticity, with the findings suggesting that mining impressions from faces is an involuntary consequence of social-cognitive functioning (Cook et al., 2022; Sutherland & Young, 2022; Todorov, 2017; Todorov et al., 2015). Absent any explicit intention or instruction to form impressions of others, registration of a face is seemingly sufficient to initiate the spontaneous extraction of core character traits. In other words, first impressions are driven by stimulus-driven automaticity (Bargh, 1989).

Theoretically speaking, the unprompted extraction of first impressions is assumed to be grounded in the functional utility of face reading (Fiske, Cuddy, & GLick, 2007; Oosterhof & Todorov, 2008; Sutherland & Young, 2022; Zebrowitz, 2004). In complex stimulus environments in which people have neither the inclination nor capacity to think deeply about others, spontaneously extracting personality characteristics proffers a range of potential benefits. Notably, it streamlines impression-formation, shapes information-processing, and facilitates decision-making (Sutherland & Young, 2022; Todorov et al., 2015). Scrutinized closely, however, this viewpoint sits uncomfortably with the observation that facial first impressions are generally inaccurate. For example, although people may largely agree upon who appears to be trustworthy or dominant (Todorov, Pakrashi, & Oosterhof, 2009; Willis & Todorov, 2006), these judgments are often unrelated to the possession of the personality characteristic in question (Jaeger, Evans, Stel, & Van Beest, 2019; Olivola, Eubanks, & Lovelace, 2014; Oosterhof & Todorov, 2008). By implication, this raises a puzzling conundrum. Why spontaneously extract impressions from faces if this information is an unreliable predictor of behavior?

Additionally, experimental evidence indicating the mandatory nature of face reading is, at best, inconclusive (Brambilla, Biella, & Freeman, 2018; Brambilla, Masi, Mattavelli, & Biella, 2021; Klapper, Dotsch, van Rooij, & Wigboldus, 2016; Santos & Young, 2005; Winston, Strange, O'Doherty, & Dolan, 2002). Three issues merit consideration. First, arguably the most convincing support for the spontaneous extraction of first impressions has been garnered from studies that have utilized artificial stimuli; specifically, computer-generated images (Klapper et al., 2016; Marzi, Righi, Ottonello, Cincotta, & Viggiano, 2014; Swe et al., 2020; Swe et al., 2022). The benefits of such an approach are obvious. With exquisite precision, faces that unambiguously exemplify the character trait under investigation can be presented to participants. In addition, through the creation of stimuli that vary maximally on the characteristic of interest, the effects of other potentially confounding factors (e.g., personal identity, different character traits) can be eliminated. Crucially, however, given this reliance on highly controlled images, it remains to be seen whether comparable effects would emerge if naturalistic faces were used, the stimuli that are encountered outside the laboratory (Sutherland & Young, 2022).

Second, although first impressions are unquestionably extracted from faces rapidly and efficiently (Olivola & Todorov, 2010; Todorov et al., 2009; Willis & Todorov, 2006), stimulus-driven automaticity cannot be concluded from speeded responding in task contexts in which participants have explicitly been instructed to judge targets in terms of specific personality characteristics (Todorov et al., 2015). Moreover, even when target-related impressions have ostensibly been probed implicitly, interpretational ambiguities remain (Ritchie, Palermo, & Rhodes, 2017; Swe et al., 2022; Thierry, Twele, & Mondloch, 2021). For example, with the goal of person recognition, Ritchie et al. (2017) presented participants with multiple images of unfamiliar targets which previously had been rated as either high or low in attractiveness. In the next phase of the study, participants judged additional medium-attractiveness images of the targets. It was assumed that if the extraction of first impressions (of attractiveness) is mandatory, then judgments spontaneously generated during the learning phase would influence responses in the explicit image-rating-task. Importantly, this is exactly what was observed. Herein lies a difficulty, however. Although never instructed to form impressions during the initial phase of the task, the requirement to learn faces for the purpose of subsequent identification would likely have directed attention to differences between the images (i.e., attractive vs. unattractive), thereby making salient the characteristic of interest. A more stringent test of the inevitability of face reading would have entailed passive registration of the stimuli during the initial phase of the task (Quinn & Macrae, 2005).

Finally, for one reason or another, electrophysiological and neuroimaging investigations also furnish only suggestive evidence for the involuntary extraction of first impressions (Marzi et al., 2014; Swe et al., 2020; Swe et al., 2022; Winston et al., 2002). A basic difficulty with several of these studies is how to interpret differences in neural responsivity to faces absent concomitant trial-by-trial person-related judgments (Swe et al., 2020; Swe et al., 2022). Using an oddball paradigm, for example, Swe et al. (2022) reported an electrophysiological marker of facial trustworthiness that was independent of the prevailing task requirements. Specifically, paralleling explicit judgments of facial trustworthiness, neural discrimination (i.e., trustworthy vs. untrustworthy) was also observed when participants reported the size of the images (i.e., large vs. small). In other words, at the level of the neural response, changes in facial trust were detected implicitly. In this task setting, however, it is possible that oddball responses captured contextually induced sensitivity to perceptual differences between the stimuli (i.e., feature differentiation) rather than the generation of personality judgments. That is, the observed neural response may be necessary but not sufficient for the extraction of first impressions (Liu, Harris, & Kanwisher, 2002; Mouchetant-Rostaing & Giard, 2003; VanRullen & Thorpe, 2001).

Acknowledging these limitations/ambiguities in the existing literature, here we used naturalistic faces in combination with a repetition priming procedure to explore the extent to which first impressions are spontaneously extracted during person perception. Elsewhere, this approach has been employed successfully to inform understanding of a closely related social-cognitive topic, the automaticity (or otherwise) of stereotype activation (Bargh, 1989; Blair, 2002; Kidder, White, Hinojos, Sandoval, & Crites Jr., 2018; Macrae & Bodenhausen, 2000).

1.2. Priming first impressions

With an established track record in person perception and face processing research, repetition priming tasks are well positioned to explore the automaticity of face reading (Bruce, Carson, Burton, & Kelly, 1998; Ellis, Flude, Young, & Burton, 1996; Goshen-Gottstein & Ganel, 2000; Hay, 1999; Lewis & Ellis, 1999; Quinn & Macrae, 2005). Operationally, repetition priming charts the effects of prior exposure to a stimulus (e.g., face) on subsequent processing of that same item (Bruce & Valentine, 1985; Bruce & Young, 1998). For example, in a typical experiment, participants initially judge a series of faces along a particular dimension (e.g., familiarity). Then, in a subsequent test phase, they perform the judgment task once again on both the previously presented stimuli, together with a collection of new (familiar & unfamiliar) faces. In research of this kind, responses are typically speeded to repeated compared to new faces, the so-called repetition priming effect.

Underpinning repetition priming are stimulus-response (S-R) bindings formed during the initial appraisal of an item (Henson, Eckstein, Waszak, Frings, & Horner, 2014; Hommel, 2007). If these bindings are retrieved when the stimulus is encountered on a subsequent occasion, a judgment can be furnished rapidly without the necessity of reengaging the component processes that were originally required to generate a response. Crucially, effects of this kind reflect the operation of an automatic process (Logan, 1990). As participants are never asked to recall the stimuli from the initial phase of the experiment, speeded responding to repeated (vs. new) faces implies that the earlier stimulus representation (including associated responses) was reactivated during the second round of the task. In this way, repetition priming is informative in the current context as priming effects can be used to index both the instructed and, theoretically important, involuntary extraction of first impressions from faces.

If, as has repeatedly been suggested, first impressions are an obligatory stimulus-driven product of person perception (Cook et al., 2022; Sutherland & Young, 2022; Todorov et al., 2015), then a particular pattern of effects would be expected to emerge in a repetition priming task. First, when required to report whether faces display a specified personality characteristic, participants should respond more rapidly to items that have been judged previously on the basis of this trait compared to new faces (Bruce & Young, 1998). Second, this repetition priming effect should be independent of the processing operation that was initially undertaken on the stimuli. That is, whether participants actively judged the faces in terms of the characteristic of interest, evaluated the faces along some other dimension, or simply passively registered the presentation of the faces, repetition priming should emerge (i.e., response savings to repeated vs. new faces). If observed, such a finding would corroborate the contention that mere exposure to a face is sufficient to trigger the mandatory extraction of first impressions (Cook et al., 2022; Sutherland & Young, 2022; Todorov et al., 2015). Alternatively, if the generation of first impressions necessitates the explicit evaluation of faces in terms of the trait characteristic of interest, then repetition priming should only emerge under these conditions.

To explore these competing possibilities, across five experiments, a standard repetition priming procedure was adopted in which the nature of participants' initial processing experience was varied (Quinn & Macrae, 2005). Specifically, in the first phase of the task, whereas one group of participants judged whether faces were high or low in dominance (i.e., active-processing operation; Expts. 1–5), another group reported either when each stimulus appeared on the screen (i.e., passive-processing operation; Expts. 1–3) or whether the faces had long/short hair or were high/low in intelligence (i.e., shallow and deep face-related processing operations, respectively; Expts. 4 & 5). In the next phase of the task, all participants judged whether faces (i.e., those seen previously and new faces) were high/low in dominance. Of theoretical interest was whether the extraction of first impressions would emerge regardless of the processing context in which the faces were initially encountered.

2. Experiment 1

2.1. Method

2.1.1. Participants and design

One hundred and twenty participants (71 females, 48 males, 1 other; $M_{age} = 24.42$, $SD = 3.05$), with normal or corrected-to-normal visual acuity took part in the experiment. Four participants (2 females, 2 males) failed attention checks, thus were excluded from the analysis. The experiment was conducted online using Prolific Academic (www.prolific.co), with each participant receiving compensation at the rate of £8.00 (~$10) per hour. Informed consent was obtained from participants prior to the commencement of the experiment and the protocol was reviewed and approved by the Ethics Committee at the School of Psychology, University of Aberdeen. The experiment had a 2 (Initial Processing: active or passive) X 2 (Faces: repeated or new) mixed design with repeated measures on the second factor. To detect either a significant main effect of Faces or an Initial Processing X Faces interaction, a sample of fifty-eight participants per between-participants condition afforded approximately 90% power for a medium effect size (i.e., $d = 0.50$; PANGEA, v 0.0.2). This calculation was adopted for all five experiments.

2.1.2. Stimulus materials and procedure

The experiment was conducted online using Inquisit Web. On accessing the experiment via a web link, participants were randomly assigned to either the active or passive-processing condition. Whereas participants in active-processing condition were instructed to categorize, as quickly and accurately as possible, faces as either high or low in dominance using two buttons on the keyboard (i.e., M & N), those in the passive-processing condition were told simply to press the space bar each time a face appeared on the screen. During this phase of the experiment, 40 male faces (20 high dominance & 20 low dominance) were presented (see Fig. 1). In the test phase that followed, all participants were required to judge 80 male faces as high or low in dominance. These stimuli comprised the 40 faces seen previously, together with 40 (20 high dominance & 20 low dominance) new faces. As the sex of a face impacts ratings of dominance, only male faces were used (Sutherland, Young, Mootz, & Oldmeadow, 2015).

On each trial, a fixation cross appeared for 500 ms, followed by a face for an additional 1000 ms. If participants failed to report the dominance level (i.e., high or low) of the face within 1750 ms, the next trial commenced. The intertrial interval was 1000 ms. A total of 80 male faces depicting young Caucasian adults, aged 20–30 years, were selected from the Chicago Face Database (Ma, Correll, & Wittenbrink, 2015). The stimuli were 140 × 176 pixels in size, grayscale, and matched for luminance and contrast. Based on the ratings in the database, 40 faces were high and 40 were low in dominance (respective *M*s: 3.55 vs. 2.34, $t(78) = 14.14$, $p < .001$). The order of presentation of the items was randomized, and the response key mappings and the status of the faces (i.e., repeated or new) were counterbalanced across participants. On

Fig. 1. Examples of high (left) and low (right) dominance faces.

completion of the task, participants were thanked for their assistance and the purpose of the experiment was explained.

2.2. Results and discussion

Responses faster than 200 ms and slower than 1100 ms were excluded from the analysis, eliminating approximately 8% of the overall number of trials. A 2 (Initial Processing: active or passive) X 2 (Faces: repeated or new) mixed model analysis of variance (ANOVA) was conducted on participants' mean response times. The analysis yielded only a significant Initial Processing X Faces interaction, $F(1, 114) = 8.68$, $p = .004$, $\eta_p^2 = 0.071$ (see Fig. 2). Follow-up *t*-tests (one-tailed) indicated that, in the active-processing condition, responses were faster to repeated compared to new faces, $t(57) = 3.60$, $p < .001$, $d = 0.47$, $BF_{+0} = 79$. In contrast, no such repetition priming effect was observed in the passive-processing condition, $t(57) = -0.74$, $p = .768$, $BF_{0+} = 11$.

The current findings failed to furnish evidence for the automaticity of face reading (Cook et al., 2022; Sutherland & Young, 2022; Todorov et al., 2015). Only when participants were instructed to categorize faces according to dominance during the initial phase of the experiment did a repetition priming effect emerge (Quinn & Macrae, 2005). Indeed, in the passive-processing condition, strong evidence for the null hypothesis was observed. Thus, mere exposure to a face did not trigger the spontaneous extraction of impressions of dominance. One possibility however is that, during passive processing, repetition priming failed to emerge because participants did not attend to the faces (but see Bruce et al., 1998). Accordingly, to address this possibility, we conducted a follow-up on-line investigation in which an additional 60 participants (46 females, 14 males; $M_{age} = 23.78$, $SD = 2.80$, 4 female participants were excluded due to failed attention checks) completed the initial phase of Experiment 1 (i.e., trait judgment vs. passive viewing), followed by a surprise recognition task in which they had to report whether each of the 80 faces was old (i.e., seen before) or new (i.e., previously unseen). Importantly, recognition accuracy (i.e., hits – false alarms) did not differ as a function of initial processing ($t(54) = 1.70$, $p = .095$), indicating that attention to the stimuli was equivalent in the active and passive conditions (see also Quinn & Macrae, 2005).

A second possibility is that, although participants in the passive-processing condition attended to the faces (as evidenced by their ability to recognize the stimuli), they were focused on characteristics other than dominance. This, however, is unlikely as care was taken to minimize stimulus differences that would drive other categorizations (e.g., sex, age). Additionally, even if participants in the passive-processing condition spontaneously extracted other person-related information from the stimuli, there is ample evidence to indicate that repetition priming generalizes across different judgment tasks (Burton, Kelly, & Bruce, 1998; Ellis, Young, & Flude, 1990; Horner & Henson, 2009; Tobin & Race, 2017). Thus, all things considered, the results of Experiment 1 failed to support the viewpoint that first impressions are spontaneously extracted from faces (Cook et al., 2022; Sutherland & Young, 2022; Todorov et al., 2015). Acknowledging the theoretical significance of these findings, the motivation for our second experiment was straightforward — to explore the replicability of the observed pattern of effects. As such, in a modified priming context in which trait-related differences in the to-be-viewed faces were made salient to participants in the passive-processing condition (i.e., participants were informed the faces differed in dominance), we re-examined this matter.

3. Experiment 2

3.1. Method

3.1.1. Participants and design

One hundred and twenty participants (77 females, 43 males, $M_{age} = 24.43$, $SD = 2.80$), with normal or corrected-to-normal visual acuity took part in the experiment. Three participants (2 females, 1 male) failed attention checks, thus were excluded from the analysis. The experiment was conducted online using Prolific Academic (www.prolific.co), with each participant receiving compensation at the rate of £8.00 (~$10) per hour. Informed consent was obtained from participants prior to the commencement of the experiment and the protocol was reviewed and approved by the Ethics Committee at the School of Psychology, University of Aberdeen. The experiment had a 2 (Initial Processing: active or passive) X 2 (Faces: repeated or new) mixed design with repeated measures on the second factor.

3.1.2. Stimulus materials and procedure

The study closely followed Experiment 1, but with a procedural modification. On this occasion, in the passive-processing condition, participants were informed at the start of the experiment they would be presented with faces that were high or low in dominance. In other words, prior to viewing the stimuli, the trait characteristic of interest was made salient. In all other respects, the procedure was identical to Experiment 1.

3.2. Results and discussion

Responses faster than 200 ms and slower than 1100 ms were excluded from the analysis, eliminating approximately 8% of the overall number of trials. A 2 (Initial Processing: active or passive) X 2 (Faces:

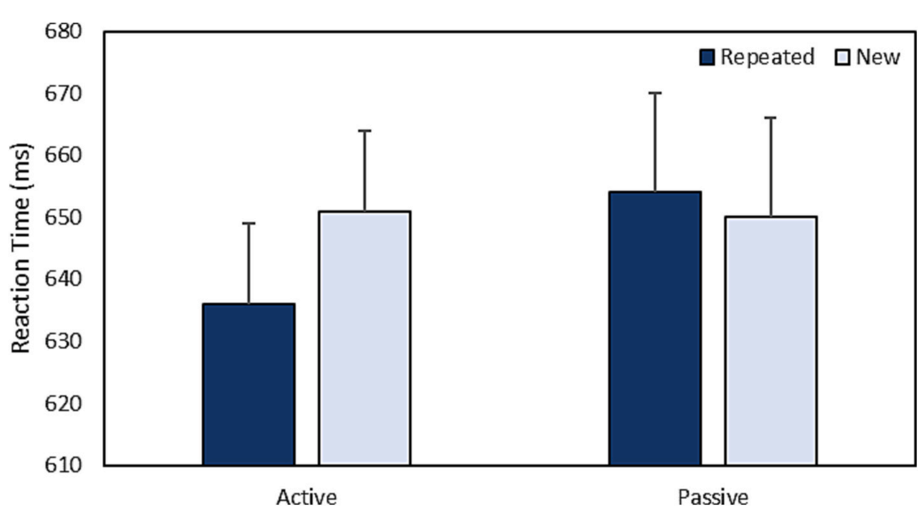

Fig. 2. Mean reaction time (ms) as a function of Initial Processing and Faces. Error bars represent +1 SEM (Expt. 1).

repeated or new) mixed model ANOVA was conducted on participants' mean response times. The analysis yielded a main effect of Faces, $F(1, 115) = 4.37$, $p = .039$, $\eta_p^2 = 0.037$, and a significant Initial Processing X Faces interaction, $F(1, 115) = 10.86$, $p = .001$, $\eta_p^2 = 0.086$ (see Fig. 3). Follow-up *t*-tests (one-tailed) indicated that, in the active-processing condition, responses were faster to repeated compared to new faces, $t(56) = 3.83$, $p < .001$, $d = 0.51$, $BF_{+0} = 149$. In contrast, no such repetition priming effect was observed in the passive-processing condition, $t(59) = -0.85$, $p = .800$, $BF_{0+} = 12$.

Directly replicating Experiment 1, the current findings failed to furnish evidence for the spontaneous extraction of first impressions from faces (Cook et al., 2022; Sutherland & Young, 2022; Todorov et al., 2015). Only when participants were initially told to categorize faces according to dominance did a repetition priming effect emerge. Indeed, as in Experiment 1, strong evidence for the null hypothesis was observed in the passive-processing (i.e., mere exposure) condition. To further probe the replicability of these findings, in our next experiment we re-explored the automaticity of face reading in a modified priming task context in which trait-related differences in the stimuli were made even more obvious to participants in the passive-processing condition.

4. Experiment 3

4.1. Method

4.1.1. Participants and design

One hundred and twenty participants (74 females, 46 males, $M_{age} = 24.20$, $SD = 2.70$), with normal or corrected-to-normal visual acuity took part in the experiment. Three participants (3 females) failed attention checks, thus were excluded from the analysis. The experiment was conducted online using Prolific Academic (www.prolific.co), with each participant receiving compensation at the rate of £8.00 (~$10) per hour. Informed consent was obtained from participants prior to the commencement of the experiment and the protocol was reviewed and approved by the Ethics Committee at the School of Psychology, University of Aberdeen. The experiment had a 2 (Initial Processing: active or passive) X 2 (Faces: repeated or new) mixed design with repeated measures on the second factor.

4.1.2. Stimulus materials and procedure

The study closely followed Experiment 2, but with an additional modification. On this occasion, during both the active- and passive-processing conditions, participants were presented with trait-related labels (i.e., high dominance and low dominance) on the left and right side of the screen during both phases of the task. These corresponded with the meaning of the response keys for participants in the active-processing condition during both phases of the task, and participants in the passive-processing cognition during the test phase. Thus, participants in the passive-processing condition were aware that faces high and low in dominance would be presented, with the provision of trait-related labels serving as a reminder. In all other respects, the procedure was identical to Experiment 2.

4.2. Results and discussion

Responses faster than 200 ms and slower than 1100 ms were excluded from the analysis, eliminating approximately 6% of the overall number of trials. A 2 (Initial Processing: active or passive) X 2 (Faces: repeated or new) mixed model ANOVA was conducted on participants' mean response times. The analysis yielded only a significant Initial Processing X Faces interaction, $F(1, 115) = 4.20$, $p = .043$, $\eta_p^2 = 0.035$ (see Fig. 4). Follow-up *t*-tests (one-tailed) indicated that, in the active-processing condition, responses were faster to repeated compared to new faces, $t(57) = 3.00$, $p = .002$, $d = 0.39$, $BF_{+0} = 16$. In contrast, no such repetition priming effect was observed in the passive-processing condition, $t(58) = -0.36$, $p = .639$, $BF_{0+} = 9$.

Importantly, despite making the personality characteristic of interest extremely obvious to participants in the passive-processing condition through the presentation of trait-related labels during the initial phase of the task, the results of Experiment 3 directly replicated the effects observed previously. Only when participants were instructed to categorize faces according to dominance did repetition priming emerge (i.e., active-processing condition). Furthermore, corroborating Experiments 1 and 2, moderate evidence for the null hypothesis was observed in the passive-processing (i.e., mere exposure) condition. Once again, these findings failed to support the viewpoint that first impressions of dominance are extracted from faces in an involuntary manner (Cook et al., 2022; Sutherland & Young, 2022; Todorov et al., 2015).

5. Additional analyses

Given that each of the reported experiments adopted the same design and methodology, a combined 2 (Initial Processing: active or passive) X 2 (Faces: repeated or new) mixed model ANOVA was conducted on participants' mean response times across the three experiments. The analysis yielded a main effect of Faces, $F(1, 348) = 9.89$, $p = .002$, $\eta_p^2 = 0.028$, and a significant Initial Processing X Faces interaction, $F(1, 348) = 23.36$, $p < .001$, $\eta_p^2 = 0.063$ (see Fig. 5). Follow-up *t*-tests (one-tailed) indicated that, in the active-processing condition, responses were faster to repeated compared to new faces, $t(172) = 6.06$, $p < .001$, $d = 0.46$, $BF_{+0} > 1000$. No such repetition priming effect was observed in the passive-processing condition, $t(176) = -1.13$, $p = .130$, $BF_{0+} = 24$. Thus, across Experiments 1–3, compelling evidence for the extraction of first impressions (i.e., repetition priming) was observed in the active-processing condition, but strong evidence for the null hypothesis under conditions of passive processing. This pattern of effects is inconsistent with the contention that face reading is a mandatory facet of person perception (Todorov et al., 2015).

The repetition priming effect that was observed in the active-processing condition raises an interesting issue. Was priming restricted to judgments that were identical across both phases of the task (i.e., high-dominance/high-dominance or low-dominance/low-dominance) or did it extend to different judgments (i.e., high-dominance/low-dominance or low-dominance/high-dominance)? To explore this matter, a single factor (Judgment: repeated-same or repeated-different or new) repeated measures ANOVA was conducted on the combined data set.[1] This yielded a significant effect of Judgment, $F(2, 336) = 29.99$, $p < .001$, $\eta_p^2 = 0.150$ (see Fig. 6). Follow-up *t*-tests (two-tailed) revealed a significant repetition advantage when responses were the same across the two phases of the task ($t(168) = -6.78$, $p < .001$, $d = 0.52$, $BF_{+0} > 1000$), but a repetition cost when the responses differed ($t(168) = 2.74$, $p = .007$, $d = 0.21$, $BF_{+0} = 3$). These findings are consistent with the viewpoint that repetition priming reflects the retrieval of stimulus-response (S-R) bindings (Henson et al., 2014). According to this account, the initial response made on a stimulus is bound to the item such that, when the stimulus is repeated, the same response can be generated without invoking additional cognitive processing. When, however, a new response is generated, prior S-R bindings impede processing and elevate reaction times.

Collectively, the findings reported thus far reveal that repetition priming only emerged when participants were explicitly instructed to judge the dominance of the faces. Simply passively registering the presentation of the stimuli did not trigger the spontaneous extraction of first impressions (Quinn & Macrae, 2005). What this implies is that generating first impressions is not an obligatory facet of person perception, but rather a task-dependent product of face processing (cf. Cook et al., 2022; Sutherland & Young, 2022; Todorov et al., 2015). It should be noted, however, that a feature of the current paradigm potentially

[1] Across the combined data set, identical responses were generated on 68% ($SD = 13\%$) of the trials.

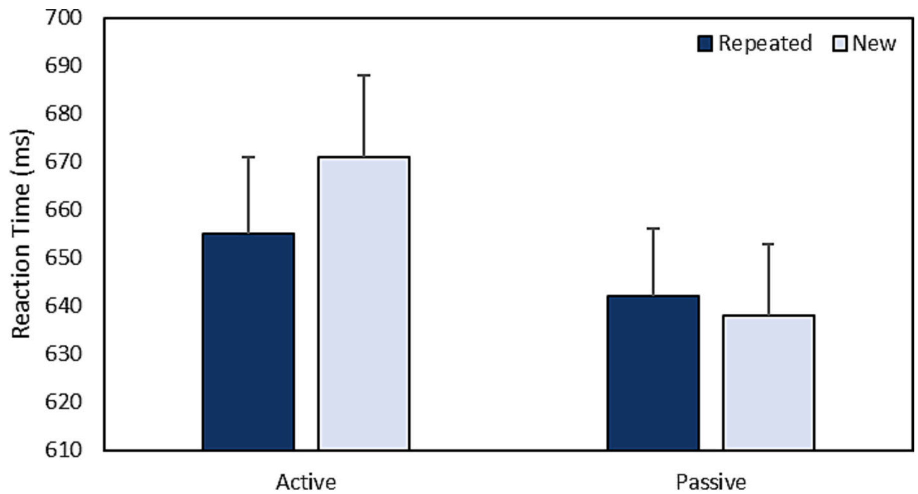

Fig. 3. Mean reaction time (ms) as a function of Initial Processing and Faces. Error bars represent +1 SEM (Expt. 2).

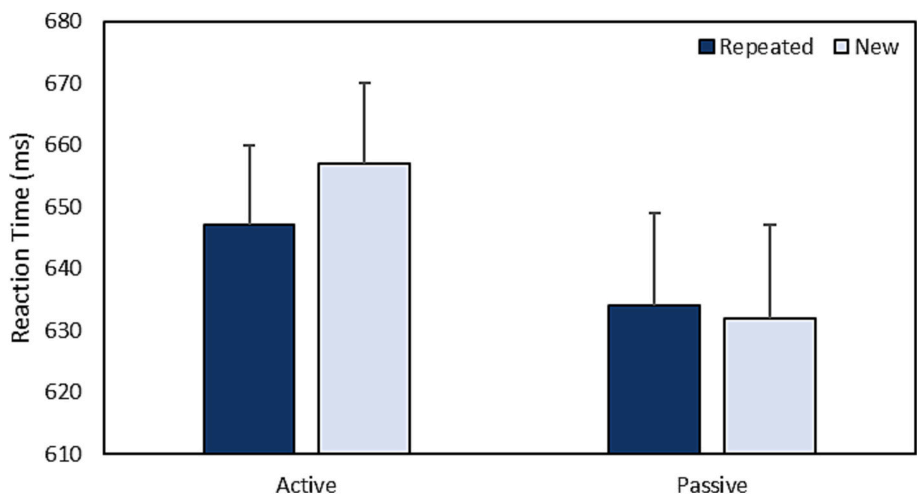

Fig. 4. Mean reaction time (ms) as a function of Initial Processing and Faces. Error bars represent +1 SEM (Expt. 3).

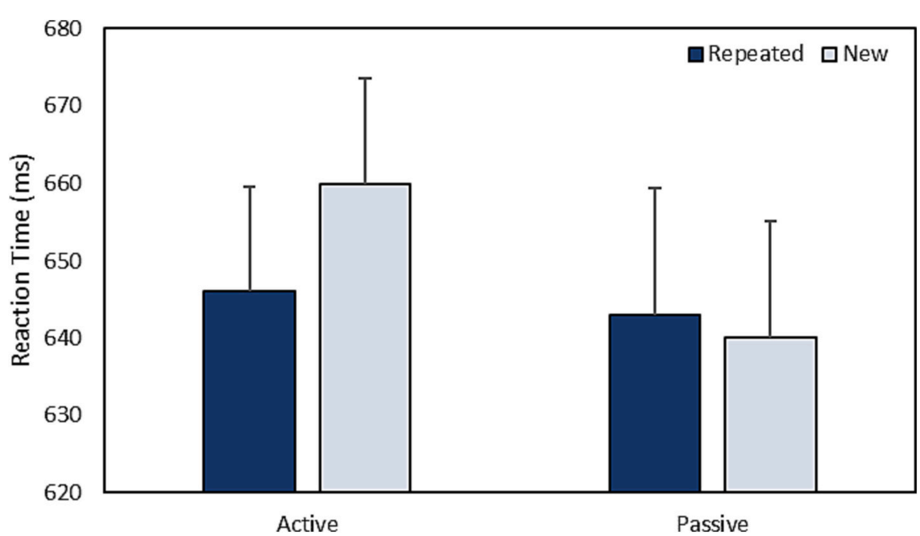

Fig. 5. Mean reaction time (ms) as a function of Initial Processing and Faces. Error bars represent +1 SEM (combined data, Expts. 1–3).

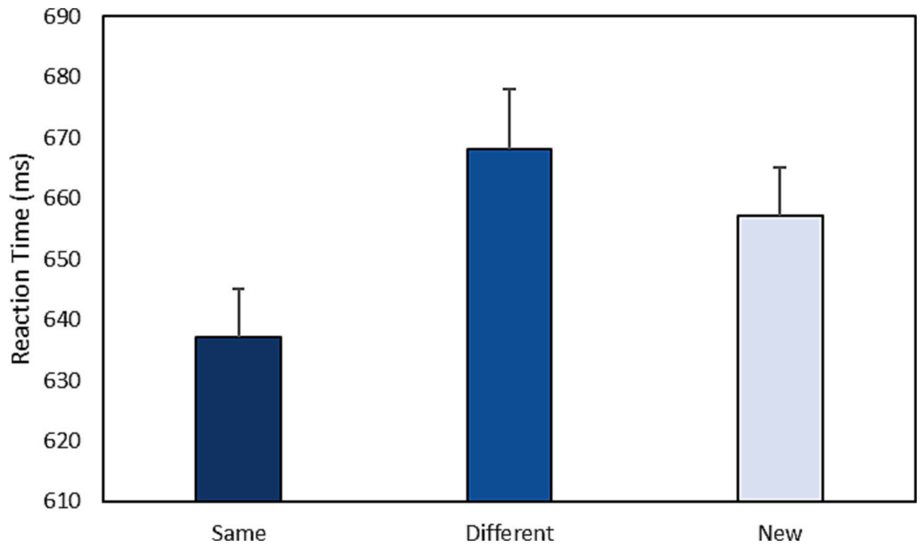

Fig. 6. Mean reaction time (ms) as a function of Judgment. Error bars represent +1 SEM (combined data, Expts. 1–3).

challenges this viewpoint. Given basic differences in the complexity of the judgments that participants were instructed to make during the initial phase of Experiments 1–3 (i.e., active vs. passive), it is possible that processing in the passive condition was simply too shallow to elicit face reading (i.e., faces were insufficiently task relevant). Perhaps the extraction of personality characteristics necessitates that attention be at least minimally directed toward the face, as for example would be the case when making various low-level perceptual judgments.

Elsewhere, aspects of person perception — notably stereotype activation — have been shown to be highly sensitive to people's processing goals (Blair, 2002; Bodenhausen & Macrae, 1998: Macrae & Bodenhausen, 2000; Quadflieg & Macrae, 2011). Critically however in this regard, perceptual (vs. conceptual) task sets reliably fail to prompt higher-level construal (Macrae, Bodenhausen, Milne, Thorn, & Castelli, 1997;Quadflieg et al., 2011; Wheeler & Fiske, 2005). For example, using a sequential priming task and images of faces and objects, Macrae et al. (1997) demonstrated that stereotype activation was contingent on the processing operation that was undertaken on the primes. Specifically, whereas a conceptual processing goal (i.e., Is the priming stimulus animate or inanimate?) triggered the activation of gender stereotypes, implementation of a low-level perceptual goal (i.e., Is a dot present or absent on the priming stimulus?) failed to generate an equivalent effect. Extending this latter finding, subsequent research has revealed that perceptual processing goals also eliminate activity in core cortical areas associated with person construal (Quadflieg et al., 2011; Wheeler & Fiske, 2005).

Notwithstanding the aforementioned findings, quite how low-level processing goals impact face reading has yet to be established. Indeed, given the supposed importance of first impressions (Fiske et al., 2007; Oosterhof & Todorov, 2008; Sutherland & Young, 2022; Zebrowitz, 2004), it is possible that perceptual processing objectives may be sufficient to trigger the extraction of trait characteristics from faces. That is, face-related but personality-irrelevant processing goals may have the capacity to trigger face reading. Again using a repetition priming paradigm, we explored this possibility in a task context in which participants initially judged facial primes either in terms of dominance (i.e., high/low) or hair length (i.e., long/short). Of theoretical interest was whether a low-level processing goal (i.e., judging hair length) would prompt the extraction of impressions of dominance.

6. Experiment 4

6.1. Method

6.1.1. Participants and design

One hundred and twenty participants (61 females, 59 males, M_{age} = 24.55, SD = 2.61), with normal or corrected-to-normal visual acuity took part in the experiment. Four participants (2 females) failed attention checks, thus were excluded from the analysis. The experiment was conducted online using Prolific Academic (www.prolific.co), with each participant receiving compensation at the rate of £8.00 (~$10) per hour. Informed consent was obtained from participants prior to the commencement of the experiment and the protocol was reviewed and approved by the Ethics Committee at the School of Psychology, University of Aberdeen. The experiment had a 2 (Initial Judgment: dominance or hair length) X 2 (Faces: repeated or new) mixed design with repeated measures on the second factor.

6.1.2. Stimulus materials and procedure

The study comprised a modified version of Experiments 1–3. During the initial phase of the task, as previously, one group of participants reported whether faces were high or low in dominance. In contrast, another group judged whether the faces had long or short hair (using the C & V buttons on the keyboard). During the subsequent test phase, all participants reported whether faces (i.e., repeated & new) were high/low in dominance. In all other respects, the procedure was identical to the previous experiments.

6.2. Results and discussion

Responses faster than 200 ms and slower than 1100 ms were excluded from the analysis, eliminating approximately 7% of the overall number of trials. A 2 (Initial Judgment: dominance or hair length) X 2 (Faces: repeated or new) mixed model ANOVA was conducted on participants' mean response times. The analysis yielded only a significant Initial Judgment X Faces interaction, $F(1, 114) = 4.78$, $p = .031$, $\eta_p^2 = 0.040$ (see Fig. 7). Follow-up t-tests (one-tailed) indicated that, in the dominance condition, responses were faster to repeated compared to new faces, $t(58) = 3.22$, $p = .001$, $d = 0.42$, $BF_{+0} = 28$. In contrast, repetition priming was not observed in the hair-length condition, $t(56) = -0.27$, $p = .605$, $BF_{0+} = 8$.

Replicating Experiments 1–3, the current findings failed to furnish evidence for the mandatory extraction of first impressions from faces

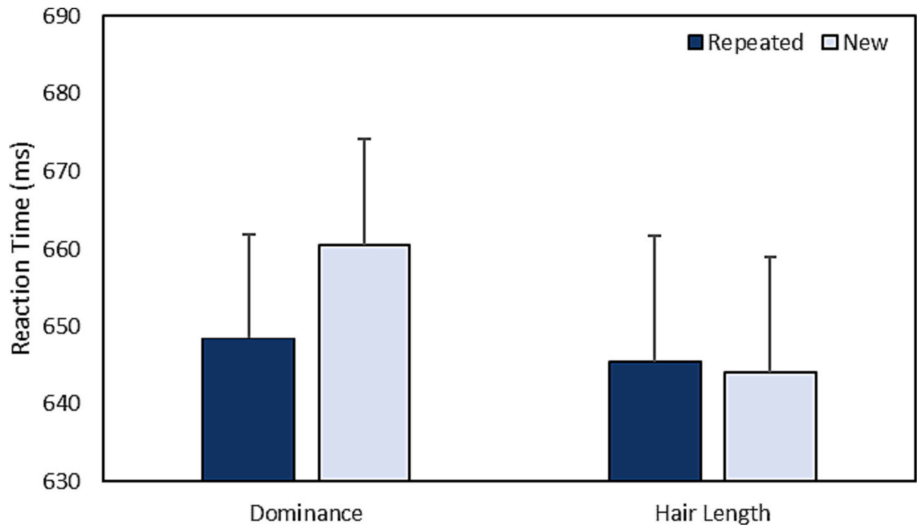

Fig. 7. Mean reaction time (ms) as a function of Initial Judgment and Faces. Error bars represent +1 SEM (Expt. 4).

(Cook et al., 2022; Sutherland & Young, 2022; Todorov et al., 2015). As previously, only when participants were initially instructed to categorize faces according to dominance did a repetition priming effect emerge. When tasked with reporting whether faces had long or short hair, repetition priming was not detected. Instead, moderate evidence for the null hypothesis was observed in this condition. Thus, when attention was directed toward the faces — but associated personality-related information was irrelevant to the task at hand — face reading was not activated. Corroborating previous research, this confirms that person construal is sensitive to the processing goals in operation during face processing (Macrae et al., 1997; Quadflieg et al., 2011; Wheeler & Fiske, 2005).

So, are impressions of dominance only generated when people have been instructed to judge faces in terms of this specific personality characteristic? While Experiment 4 revealed that a face-related but personality-irrelevant processing goal (i.e., judge hair length) failed to trigger face reading, what would happen if participants were required to judge faces in an unambiguously social (i.e., person-related) way, for example in terms of a different personality characteristic (e.g., trustworthiness, intelligence, competence)? This turns out to be an interesting question as, based on influential accounts of person perception, it is possible that once attention has been explicitly directed toward the detection of a particular trait, other personality-related information associated with the face also becomes available (Bodenhausen & Macrae, 1998; Freeman & Ambady, 2011; Kunda & Thagard, 1996; Macrae & Bodenhausen, 2000). For example, instructing participants to construe faces in terms of their intelligence may also elicit estimates of dominance. Driving this viewpoint is the contention that, during the early stages of person construal, multiple strands of target-related information are simultaneously extracted from faces (Freeman & Ambady, 2011). To explore this possibility, in our final experiment we therefore probed the emergence of repetition priming in a task setting in which participants initially judged faces either in terms of dominance (i.e., high/low) or intelligence (i.e., high/low). Of interest was whether impressions of dominance would be extracted when intelligence comprised the to-be-judged personality characteristic.

7. Experiment 5

7.1. Method

7.1.1. Participants and design

One hundred and twenty participants (47 females, 73 males, $M_{age} = 23.87$, $SD = 2.86$), with normal or corrected-to-normal visual acuity took part in the experiment. One participant (male) failed the attention checks, thus was excluded from the analysis. The experiment was conducted online using Prolific Academic (www.prolific.co), with each participant receiving compensation at the rate of £8.00 (~$10) per hour. Informed consent was obtained from participants prior to the commencement of the experiment and the protocol was reviewed and approved by the Ethics Committee at the School of Psychology, University of Aberdeen. The experiment had a 2 (Initial Judgment: dominance or intelligence) X 2 (Faces: repeated or new) mixed design with repeated measures on the second factor.

7.1.2. Stimulus materials and procedure

The study comprised a modified version of Experiments 4. During the initial phase of the task, as previously, one group of participants reported whether the faces were high or low in dominance. In contrast, another group judged whether the faces were high or low intelligence (using the C & V buttons on the keyboard). During the subsequent test phase, all participants reported whether the faces (i.e., repeated & new) were high/low in dominance. In all other respects, the procedure was identical to Experiment 4.

7.2. Results and discussion

Responses faster than 200 ms and slower than 1100 ms were excluded from the analysis, eliminating approximately 8% of the overall number of trials. A 2 (Initial Judgment: dominance or intelligence) X 2 (Faces: repeated or new) mixed model ANOVA was conducted on participants' mean response times. The analysis yielded a main effect of Faces, $F(1, 117) = 6.55$, $p = .012$, $\eta_p^2 = 0.053$, and a significant Initial Judgment X Faces interaction, $F(1, 117) = 5.94$, $p = .016$, $\eta_p^2 = 0.048$ (see Fig. 8). Follow-up t-tests (one-tailed) indicated that, in the dominance condition, responses were faster to repeated compared to new faces, $t(58) = 3.51$, $p < .001$, $d = 0.46$, $BF_{+0} = 61$. In contrast, no such repetition priming effect was observed in the intelligence condition, $t(59) = 0.09$, $p = .465$, $BF_{0+} = 7$.

Extending Experiment 4, despite all participants making high-level personality-related judgments in the initial phase of the task, repetition priming only emerged when estimates of dominance were furnished twice. That is, initially judging the intelligence of faces did not elicit simultaneous impressions of dominance (cf. Bodenhausen & Macrae, 1998; Freeman & Ambady, 2011; Kunda & Thagard, 1996; Macrae & Bodenhausen, 2000). In fact, moderate evidence for the null hypothesis was observed in this condition. Thus, at least when probed using repetition priming, the extraction of first impressions from faces appears to

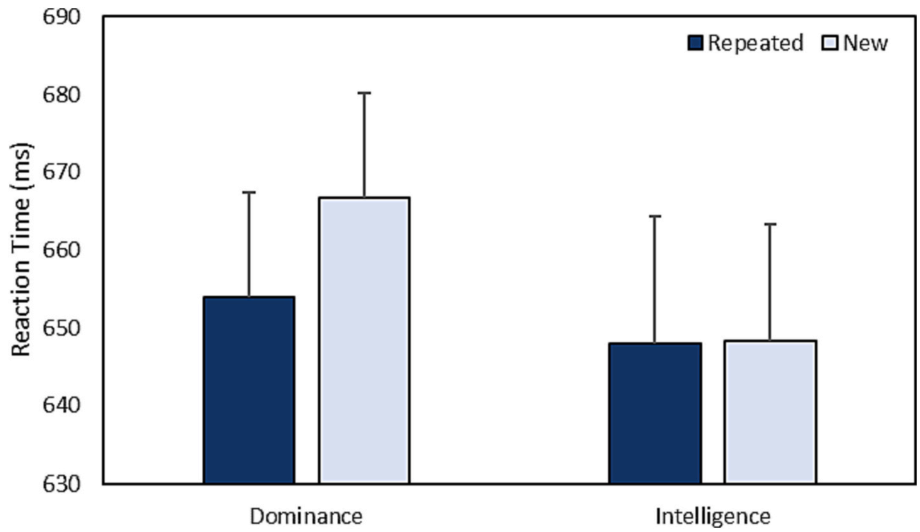

Fig. 8. Mean reaction time (ms) as a function of Initial Judgment and Faces. Error bars represent +1 SEM (Expt. 5).

be anything but mandatory, thereby demonstrating the task-dependent nature of core facets of person construal (Kidder et al., 2018; Macrae et al., 1997; Persson et al., 2021; Persson, Falbén, Tsamadi, & Macrae, 2023; Quinn & Macrae, 2005; Tsamadi et al., 2020).

8. General discussion

Despite widespread endorsement of the viewpoint that first impressions are spontaneously extracted from faces (Cook et al., 2022; Sutherland & Young, 2022; Todorov et al., 2015), here we repeatedly failed to uncover evidence for the emergence of this effect. Using repetition priming to index face reading — at least for judgments of dominance — impressions were only extracted when participants were explicitly instructed to evaluate the faces in this way. In Experiments 1–3, regardless of how obvious the trait characteristic of interest was made during the task, mere exposure to a face was insufficient to generate a repetition priming effect (Quinn & Macrae, 2005). Additionally, when attention was explicitly directed toward the faces to make either low-level (i.e., hair length - Expt. 4) or high-level (i.e., intelligence - Expt. 5) judgments, once again repetition priming failed to emerge. Collectively, these findings suggest that face reading is a malleable aspect of person perception, arising only under certain task conditions.

8.1. The pliability of person perception

Given the current findings together with limitations in the existing literature, it is perhaps surprising that the obligatory nature of face reading is a viewpoint that has been advanced with such enthusiasm (Cook et al., 2022; Sutherland & Young, 2022; Todorov et al., 2015). It is worth noting, however, that the contention that first impressions are extracted spontaneously from faces resonates closely with claims concerning other social-cognitive effects. Take, for example, stereotyping. For many years, with neither people's awareness nor consent, stereotype activation was maintained to guide fundamental facets of daily life, including impression formation, person understanding/memory, and social interaction (e.g., Brewer, 1988; Fiske & Neuberg, 1990; Freeman & Ambady, 2011). These effects, moreover, were believed to be inescapable (Bargh, 1999). Encounter a target, and stereotype activation would inevitably follow (Allport, 1954). Crucially, however, this characterization of stereotyping is overly rigid and simplistic. Rather than reflecting a compulsory component of person perception, stereotype activation is a conditionally automatic mental operation. As an extensive literature has revealed, whether stereotype activation occurs at all is determined by the complex interplay of cognitive, motivational, and contextual factors (Blair, 2002; Macrae & Bodenhausen, 2000; Moskowitz, 2010; Quadflieg & Macrae, 2011; Quinn & Macrae, 2011). In other words, in the service of people's interests, person perception is inherently pliable (Fiske, 1992, 1993).

Mirroring stereotype activation (e.g., Gilbert & Hixon, 1991; Macrae et al., 1997; Wittenbrink, Judd, & Park, 1997), we suspect the extraction of first impressions from faces should similarly be susceptible to cognitive, motivational, and contextual moderation. That is, person-related impressions should only be generated when this information is goal-relevant or situationally pertinent, thus potentially useful (Fiske, 1992; Macrae & Bodenhausen, 2000). A difficulty with the assertion that facial first impressions comprise a mandatory product of person perception is that this viewpoint imposes a purposeless and excessive burden on a resource limited information-processing system (Marois & Ivanoff, 2005; Oberauer, 2019). Consider, for example, a stroll along a busy sidewalk in an unfamiliar city. During one's journey numerous pedestrians would be encountered, with each displaying facial cues that signal myriad personality characteristics (not to mention applicable social categories and temporary emotional states). In such a situation, it makes little functional sense to extract multiple impressions (or indeed other person-related material) from these individuals in a compulsory manner, as this information is entirely inconsequential and does not justify the associated computational expenditure (cf. Freeman & Ambady, 2011). Rather, in a flexible processing system, the extraction of first impressions should be driven by a combination of current processing goals (e.g., looking for a 'competent' individual to ask for directions to a restaurant) and the salience/relevance of individuals in particular settings (e.g., encountering a 'dominant' stranger in a dimly lit alleyway). Such plasticity would both economize and optimize the person perception process.

Underscoring the pliability of first impressions, recent research has demonstrated that, much like perceptions of facial emotions (Aviezer et al., 2008; Barrett & Kensinger, 2010; Righart & de Gelder, 2008), contextual factors moderate the products of person construal. Using a mouse-tracking paradigm, Brambilla et al. (2018) required participants to categorize the trustworthiness of faces (i.e., computer-generated images) that were presented in either threatening, negative-but-unthreatening, or neutral scenes. Importantly, the trajectory of hand movements was influenced by the context in which the faces were encountered, such that trajectories were facilitated when targets were located in compatible settings (e.g., an untrustworthy face in a threatening scene). In incompatible contexts (e.g., a trustworthy face in a threatening scene), in contrast, trajectories were attracted to the scene-compatible response. Thus, the visual context in which targets were encountered impacted perceptions of trust. Extending this finding, Brambilla et al. (2021) showed that auditory contexts wield a comparable influence. Specifically, faces (again computer-generated images) were judged to be more untrustworthy when accompanied by threatening compared to unthreatening auditory information. Collectively, these findings highlight the contextual sensitivity of perceptions of trust, hence the malleability of first impressions.

Three decades ago, re-emphasizing the observation that thinking is first and foremost for doing, Fiske (1992, 1993) reminded researchers of social cognition's pragmatic heritage. In striving to make sense of others, and with finite available resources, the person perception process must be responsive to people's goals, motives, and needs and the practical requirements of everyday life. As a pivotal product of person construal, first impressions should therefore be generated only when they are applicable or at least potentially useful in a particular setting (i.e., first impressions are extracted in the service of social behavior). For example, assessing the trustworthiness of a face may be highly relevant when interacting with a salesperson regarding the purchase of a car, but much less so when selecting a new member for the village tug of war team. To avoid the elicitation of unwanted impressions for every individual one encounters (a natural consequence of the 'mandatory first impressions' viewpoint; Cook et al., 2022; Sutherland & Young, 2022; Todorov et al., 2015), person perception must be finely tuned to the complex exigencies of daily living. Quite when and how this tuning takes place, however, are issues that merit clarification.

8.2. Limitations and future directions

Despite demonstrating the malleability of face reading across five experiments, the current investigation is not without limitations. First, only a single priming paradigm (i.e., repetition priming) was adopted to explore whether first impressions are spontaneously extracted from faces. Although repetition priming is well suited to the task at hand (Bruce et al., 1998; Burton et al., 1998; Goshen-Gottstein & Ganel, 2000; Lewis & Ellis, 1999; Quinn & Macrae, 2005), other priming approaches could be used to explore the question of interest (Wentura & Rothermund, 2014). Elsewhere, for example, in combination with computational modeling, semantic and response-priming methodologies have been utilized to elucidate exactly when and through which precise cognitive pathway (i.e., stimulus and/or response-bias) stereotype-based beliefs impact decisional processing (Falbén et al., 2019; Persson et al., 2021; Persson et al., 2023; Tsamadi et al., 2020). Similar approaches could be used to inform understanding of the dynamics of face reading. Additionally, having established their value in closely related research (Le Gal & Bruce, 2002; Quinn & Macrae, 2005; Schweinberger, Burton, & Kelly, 1999), various selective attention tasks (e.g., flanker tasks, Garner paradigm) also have the capacity to explicate the extent to which first impressions are extracted from faces in an involuntary manner.

Second, in highlighting the pliability of first impressions, here only judgments of dominance were explored. Although revealing, it is unclear whether comparable effects would emerge for other core personality characteristics (e.g., trustworthiness, competence). Additionally, it would be interesting to investigate the ways in which non-facial markers (e.g., body shape, voice, clothing, belongings) of personality influence person perception. As a case in point, consider clothing. It is widely accepted that items of attire are used both to infer the personalities and characteristics of others and to regulate impression management (Aiken, 1963; Gillath, Bahns, Ge, & Crandall, 2012; Oh, Shafir, & Todorov, 2020; Rosenbusch, Aghaei, Evans, & Zeelenberg, 2021; Wei, Yan, Huang, & Nie, 2017; Wiedemann, Burt, Hill, & Barton, 2015). In the realm of shoes, for example, whereas heels signal emotional lability, pointy toes suggest the possession of a disagreeable temperament (Gillath et al., 2012). Relatedly, the color of clothing has also been shown to bias person perception, such that red (vs. blue or gray) garments are associated with aggression, anger, and dominance (Wiedemann et al., 2015). A useful task for future research will therefore be to explore whether information of this kind triggers the involuntary extraction of personality-related material, as it is possible that some cues may operate more implicitly than others.

Third, in keeping with previous research on the topic, the current inquiry considered only the extent to which first impressions are extracted from faces unintentionally (i.e., without instruction). Automatic processes, of course, can be characterized in several other ways. Notably, they are capacity free, non-conscious, and uncontrollable (Bargh, 1989; Moors & De Houwer, 2006). Of significance, therefore, are the following questions: (i) Are first impressions extracted from faces under conditions of elevated perceptual and cognitive load? (ii) Is stimulus awareness a critical precursor of face reading? and (iii) Once triggered is face reading unstoppable? Although these matters have attracted a modicum of theoretical and empirical attention (Eggleston, Flavell, Tipper, Cook, & Over, 2021; Freeman, Stollier, Ingbretsen, & Hehman, 2014; Shen, Mann, & Ferguson, 2020; Stewart et al., 2012), additional work is required to identify the precise conditions under which personality-related material is (and is not) extracted from faces (Palermo & Rhodes, 2007).

Finally, the current experiments utilized a blocked methodology in which an initial face priming phase was followed by a test phase. This gives rise to an interesting possibility. Perhaps repetition priming failed to emerge in the critical conditions in each of the reported experiments because any impressions of dominance extracted from the faces were too short lived to generate a priming effect (Mueller, Utz, Carbon, & Strobach, 2020). That is, the temporal interval between the priming and test phases of the task was sufficient to eliminate any evidence of face reading (i.e., the extraction of impressions of dominance). We consider this to be unlikely, however, as repetition priming effects have been shown to persist for extended periods of time, including hours, days, and months (e.g., Lewis & Ellis, 1999; Maylor, 1998). Nevertheless, to corroborate the current findings, it would be useful to explore the extraction of first impressions from faces using a trial-by-trial methodology in which the interval between the priming and test phases of the task (e.g., milliseconds, seconds, minutes) can be manipulated and tightly controlled (Ellis, Burton, Young, & Flude, 1997; Ellis, Ellis, & Hosie, 1993; Walther, Schweinberger, Kaiser, & Kovacs, 2013). Work of this kind is important as it will inform understanding of the temporal characteristics, hence robustness, of face reading.

Extending the current investigation, further demonstrations of the conditional automaticity of face reading will help to integrate work on this topic with closely related social-cognitive lines of inquiry. A popular theoretical viewpoint is that, through a combination of direct experience and social learning, people acquire face-trait associations that may (or may not) characterize the individuals they encounter. That is, face-trait associations function as 'potential trait profiles' (see Cook et al., 2022). Unsurprisingly, therefore, just as group-trait associations (i.e., stereotypes - female = emotional, male = ambitious) frequently serve as unreliable predictors of behavior, so too potential trait profiles do not guarantee possession of the specific underlying personality characteristics. Operating in this way, face-trait associations comprise a form of culturally transmitted stereotypic knowledge that influences thinking and doing in much the same way as other stereotype-related beliefs (Bin Meshar, Stolier, & Freeman, 2022; Hester, Xie, Bertin, & Hehman, 2023). In particular, rather than impacting impressions automatically (Todorov et al., 2015), face-trait associations shape person construal only under certain task/processing conditions, a reflection of the malleability of social-cognitive functioning (Blair, 2002; Macrae & Bodenhausen, 2000). Crucially however, in no sense are we disputing the importance that first impressions exert in daily life (Todorov, 2017), simply that the extraction of trait-related information from faces may be less spontaneous than has hitherto been assumed.

In sum, given the claimed inevitability of face reading, here we considered whether judgments of dominance are extracted from stimuli in an involuntary manner. Across five experiments, no evidence for the emergence of this effect was observed, instead first impressions were only generated when participants were explicitly instructed to report whether faces were high or low in dominance. Thus, at least when probed with a priming methodology, there is little to suggest that face reading comprises a mandatory facet of person perception.

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Conflicts of interest/Competing interests

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Yadvi Sharma: Conceptualization, Methodology, Formal analysis, Writing – review & editing. **Linn M. Persson:** Conceptualization, Methodology, Writing - review & editing. **Marius Golubickis:** Conceptualization, Methodology, Formal analysis, Writing - review & editing. **Parnian Jalalian:** Conceptualization, Methodology, Writing - review & editing. **Johanna K. Falbén:** Conceptualization, Methodology, Writing - review & editing. **C. Neil Macrae:** Supervision, Conceptualization, Methodology, Writing – review & editing.

Data availability

Available on OSF https://osf.io/pr4hm/

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.cognition.2023.105620.

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