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Chen, Wenfeng, Ren, Naixin, Young, Andrew William orcid.org/0000-0002-1202-6297 et al. (1 more author) (2017) Interaction between social categories in the composite face paradigm. Journal of Experimental Psychology: Learning, Memory, and Cognition. ISSN 1939-1285

https://doi.org/10.1037/xlm0000418

Authors' final copy of manuscript accepted for publication in *Journal of Experimental Psychology: Learning, Memory and Cognition*.

Date of acceptance 22nd March 2017.

Interaction Between Social Categories in the Composite Face Paradigm

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Keywords: composite face, holistic processing, face perception, face gender, face identity

Abstract

The composite face paradigm (Young, Hellawell & Hay, 1987) is widely used to demonstrate holistic perception of faces (Rossion, 2013). In the paradigm, parts from different faces (usually the top and bottom halves) are recombined. The principal criterion for holistic perception is that responses involving the component parts of composites in which the parts are aligned into a face-like configuration are slower and less accurate than responses to the same parts in a misaligned (not face-like) format. This is often taken as evidence that seeing a whole face in the aligned condition interferes with perceiving its separate parts, but it remains unclear to what extent the composite face effect also reflects contributions from other potential sources of interference. We present a new variant of the paradigm involving composites created from top and bottom parts of familiar faces drawn from orthogonal social categories of gender and occupation. This allows us to examine the contributions of differences in relatively visual properties (gender) or relatively semantic properties (occupation) to composite interference and to measure whether variation in a task-irrelevant category (e.g., differences in gender across the parts of the composite when the task is to categorize the occupation of one of the parts) will influence the size of the composite effect. Our findings show that the composite face effect can be modulated by task-irrelevant social categories and that this interference is primarily visual in nature because the influence of face gender is more direct and more consistent than the influence of occupation.

Interaction Between Social Categories in the Composite Face Paradigm

Many studies of holistic perception of faces use variants of the composite face paradigm introduced by Young, Hellawell, and Hay (1987) which is now widely considered to be one of the key techniques for demonstrating holistic perception (Tanaka & Gordon, 2011; Rossion, 2013; Murphy, Gray & Cook, 2016) and even taken as a 'gold standard' for this purpose (McKone & Robbins, 2011).

In the composite face paradigm, parts from different faces (usually the top and bottom halves) are recombined. So, for example, the original study by Young et al. (1987) combined the top half of one familiar face (person A) with the bottom half of another familiar face (person B) and asked participants to recognize the identity of either the top half (in our example, as person A) or the bottom half (as person B) of each stimulus. When the top and bottom halves were aligned into a face-like aligned configuration (see Figure 1), responses were slower and less accurate than responses to the same parts in a misaligned (not face-like) format. This was taken as evidence that seeing a whole face in the aligned condition interferes with perceiving its separate parts. In effect, Young et al. (1987) thought that holistic perception of faces leads to the perception of a novel identity in the aligned condition, and this novel identity makes it more difficult to recognize the constituent parts. In the misaligned condition there is no perception of a novel face identity, and this makes recognition of the component parts an easier task.

As the reviews by Rossion (2013) and Murphy et al. (2016) demonstrate, many subsequent studies have found differences between responses to aligned and misaligned stimuli, so the reliability of this finding is not in doubt. However, its precise interpretation has been disputed because the composite paradigm involves a measure that is based on the extent to which the perception of a whole face in the aligned condition interferes with responses to its constituent parts. Hence the composite effect may reflect contributions from different sources of interference that range from the presence of a novel holistic perceptual representation of the composite in the aligned condition to problems in selectively attending and responding to information from the different parts of the aligned stimuli. Recent studies have shown the importance of such factors by linking the composite effect to other phenomena involving selective attention (Chua, Richler & Gauthier 2014, 2015; Chua & Gauthier 2015; Fitousi 2015, 2016) or object-based attention and perceptual grouping (Retter & Rossion, 2015; Curby, Goldstein & Ritter, 2013; Curby & Entenman, 2016; Curby, Entenman & Fleming, 2016). As Murphy et al. (2016) point out, such findings imply that whilst the composite effect involves holistic perception of faces it is not in itself a process-pure measure.

The majority of studies have adopted a variant of the composite face paradigm devised by Hole (1994) that uses unfamiliar faces as stimuli and a part-matching task (for example, asking participants to judge whether the top halves are same or different). This variant in particular, but also the logic of the composite face paradigm in general, has been criticized on a number of grounds by Richler, Gauthier and their colleagues (Richler, Gauthier, Wenger, & Palmeri, 2008a; Richler, Tanaka, Brown, & Gauthier, 2008b; Richler & Gauthier, 2014). The key point in this debate (see Rossion, 2013; Richler & Gauthier, 2013) concerns the extent to which the composite face effect reflects the presence of a holistic perceptual representation of the composite in the aligned condition (the view favoured by Young et al., 1987, and Rossion, 2013), a problem in selectively attending and responding to the parts of the aligned composite stimulus (Richler et al., 2008b), or contributions from both factors. As Richler and Gauthier (2014, p.1281) emphasise, "the concept of holistic processing is a cornerstone of face recognition research", and disentangling these different potential sources of composite interference is therefore critical to arriving at a usable metric.

Note that overall problems of selective attention or response competition *per se* cannot in themselves fully explain the classic composite effect because the same combinations of parts (and hence the same combinations of potential responses) can be used to create the aligned and misaligned stimuli, but the difficulty in identifying the face parts is only found for the aligned condition. So any problems in selectively attending or responding to the stimulus parts derive exclusively from the aligned condition in which the constituent parts form a face-like whole.

Understanding what underlies the composite face effect is therefore a question of substantial theoretical importance, as exemplified by the debate between Rossion (2013) and Richler and Gauthier (2013). In this debate Rossion (2013) came down strongly in favour of a holistic perceptual locus for composite interference whereas Richler and Gauthier (2013, p.255) summarised their position as being that "the jury is still out" on the question of "whether holistic processing has a perceptual or a decisional locus" and restated their opinion that in the most widely used method a "response bias is confounded with the critical conditions".

Here, we therefore introduce an informative new variant of the paradigm that can separate perceptual from other contributions to composite interference. Our method draws on an interesting but often neglected finding from a study by Calder, Young, Keane and Dean (2000). Using images from the Ekman and Friesen (1976) set of facial expressions, Calder et al. (2000) created composite expressions by aligning the top half of one expression (e.g., anger) with the bottom half of another (e.g., happiness). They found a composite expression effect in which participants were slower to identify the expression in either half of these composite images relative to a misaligned control condition. This composite expression effect has been replicated in subsequent studies (Calder & Jansen, 2005; Tanaka et al., 2012; Yan, Young & Andrews, in press), but the neglected finding is that when Calder et al. (2000) investigated the relation between the composite expression effect and the composite effect for face identity, they found that these were independent of one another. In other words, the expression composite effect was not affected by differences in the identities of the constituent parts, and conversely when participants were asked to recognize face identity the composite effect was no longer affected by differences in the expressions.

Our new variant of the composite face paradigm takes Calder et al.'s (2000) demonstration a step further by asking whether other face properties can create independent sources of composite face interference? Analysis of the images from the Ekman and Friesen (1976) set used by Calder et al. (2000) has shown that the recognition of face identity and facial expression involves quasi-independent visual properties (Calder et al., 2001), and we were interested in whether independent sources of composite interference might arise in circumstances where categorization depends on relatively semantic (rather than visual) properties. To create a contrast between relatively visual and relatively semantic properties we created composites from top and bottom parts of familiar faces which were themselves drawn from orthogonal social categories of gender and occupation. The importance of this manipulation is that gender is easily determined on a purely visual basis (Bruce & Young, 2012), whereas occupation can only be determined reliably through recognizing the face as it involves identity-specific semantic information (Bruce & Young, 1986; Young et al., 1987). By using familiar faces and social categories of gender and occupation we were thus able to investigate how the composite effect is influenced by a category that can be determined on a largely visual basis (gender) compared to the influence of a category (occupation) that involves identity-specific information.

Our key criterion for demonstrating the influence of gender or occupation on the composite effect is an interaction between gender congruence or occupation congruence and stimulus alignment. So, for example, if the aligned and misaligned stimuli are created from top and bottom face parts with the same (i.e. congruent) or different (incongruent) gender, we are interested in whether there is an overall gender congruence × alignment interaction such that participants experience the greatest difficulty in responding to the stimuli with incongruent parts when these are presented in the aligned format. This criterion can be applied to examine congruence × alignment interactions when the characteristic participants are asked to categorize is task-relevant (e.g. gender congruence of the parts when participants categorize gender) or task-irrelevant (e.g. gender congruence when participants categorize occupation).

In Experiment 1, then, we introduced a new variant of the composite face paradigm. We created gender-congruent (male top half and male bottom half, or female top half and female bottom half) and gender-incongruent (male top half and female bottom half, or female top half and male bottom half) aligned and misaligned stimuli from the faces of movie stars and asked participants to recognize the gender (male or female) of the top or bottom halves. In this way we were able to establish the impact of congruent and incongruent gender on the composite effect for familiar faces, so that we could use this as a point of comparison in further experiments. In Experiment 2, we asked participants to recognize the identities of the top or bottom halves of the same stimuli as were used in Experiment 1, allowing us to see whether the congruent or incongruent gender of the face part still influenced responses when the participant's task was to recognize identity. In Experiments 3 and 4, we orthogonally varied the gender (male or female) and occupation (movie star or athlete) of the face parts and asked participants to recognize their gender (Experiment 3) or their occupation (Experiment 4). The findings confirmed that the composite effect is modulated by gender congruence and produced evidence that it can to a limited extent be influenced by occupation. This led us to look further in Experiments 5 and 6 at whether occupation would also influence the composite effect when the participant's task was to classify identity. In Experiment 5 we varied the occupation (movie star or athlete) of the face parts across congruent genders (parts of two male or of two female faces) and asked participants to recognize their identity, allowing us to establish whether the composite effect in the identity task would be modulated by the congruent or incongruent occupations. Experiment 5 was thus similar in overall design to Experiment 2, but with the difference that whereas Experiment 2 manipulated the visual property of gender typical masculine or feminine appearance, Experiment 5 varied the semantic property of occupation. Because we did not find any evidence of an influence of occupation congruence on the composite effect for recognizing face identity in Experiment 5, we investigated whether there might none the less be an effect of occupation congruence if this was made more salient for participants in Experiment 6. Again, though, we did not find any evidence of an influence of occupation on the composite effect for recognizing face identity in Experiment 6.

Taken together, these findings increase our understanding of the sources of influence operating in the composite face paradigm and underscore the importance of holistic perceptual processing through the novel demonstration that whilst visual sources of interference exert a consistent influence, semantic sources of interference are weaker and more labile.

Experiment 1

Our paradigm for Experiment 1 was adapted from the work of Baudouin and Humphreys (2006) and involved creating gender-congruent and gender-incongruent aligned and misaligned stimuli. However, whereas Baudouin and Humphreys (2006) created their stimuli from unfamiliar faces, we used familiar faces (celebrities) so that what Bruce and Young (1986) called identity-specific semantic information (familiar face identity) would potentially be present in the stimuli alongside the visually-derived semantic information (gender) required by the gender categorization task. We pretested the stimuli with each participant to ensure that the familiar identities were recognized and that both the top and bottom halves of each face could be reliably classified as male or female in order to establish the impact of combining parts with congruent or incongruent gender on the composite effect for familiar faces.

Method

Participants. Twenty-four Chinese university students (Mean age 23.3 years, range 20-32 years, 12 females) participated in the experiment for a small payment. All had normal or corrected-to-normal vision. The study was conducted in accordance with the APA's guidelines on the treatment of human participants and was approved by the Institutional Review Board of the Institute of Psychology, Chinese Academy of Sciences.

Materials. Eight photographs of different Chinese movie stars (one photo per movie star) with neutral expression and as near full-face pose as possible, with equal number of males and females, were obtained from the internet. The mean age of these stars was 37.5 years, range 31-42 years. These photographs were further divided into two sets, with each containing 2 male and 2 female stars. Only one of these two sets was used to create the stimuli shown to each participant. Each set was then shown to an equal number of participants. We used two different sets of faces to minimise the risk that specific cues inherent in only some of the images might limit the generality of our findings.

The photographs were converted to grayscale images and were edited in Photoshop to remove hair and external features. The background was then replaced with a uniform neutral grey. The overall image size was then normalized to 120 × 164 pixels, which subtended 3.61 × 4.84° of visual angle. The resulting images were used to create the experimental stimuli.

Figure 1 near here, please

Examples of how face stimuli in each condition were created are illustrated in Figure 1. Each original face was divided into top and bottom halves by cutting the face along a horizontal line through the bridge of the nose. Normally aligned composite images were then created by aligning the top half of one face with the bottom half of a different face. Following a recommendation by Rossion (2013), a small gap (0.1°) was kept between the two halves, so that the line separating top from bottom parts of the composite faces would be clear to participants. Corresponding misaligned stimuli were then created from the same halves by misaligning the top and bottom face parts, such that the center of the bottom half was shifted to one edge of the top half (see Figure 1).

In the main experimental trials, participants were asked to judge the gender of either the top half or the bottom half of aligned composite and misaligned images. When the top half was to be judged, it was always presented across the horizontal midline of the screen (for both aligned and misaligned stimuli), whereas the bottom half of the misaligned stimuli was either shifted to the left or to the right, with the two directions of shift counterbalanced. When the task was switched to judging the bottom half, the bottom half was always presented across the horizontal midline of the screen, whereas the top half of misaligned stimuli was either shifted to the left or to the right. In this way, the location of the part of the stimuli to be judged was always the same for the top half judgements and always the same for the bottom half judgements. Moreover, the specific combinations of top and bottom half image pairings were the same for the aligned composite and misaligned conditions, so that any differences must be directly attributable to this variable.

Half of the aligned and half the misaligned stimuli consisted of face parts of congruent gender (for example, the top part of a male face and the bottom part of a different male face), and the other half of the stimuli consisted of faces of incongruent gender (for example, the top part of a male face and the bottom part of a female face). All four possible congruent gender combinations of top and bottom halves were included, i.e., M1 (Male face identity 1) top with M2 (Male face identity 2) bottom, M2 top with M1 bottom, F1 (Female face identity 1) top with F2 (Female face identity 2) bottom, and F2 top F1 bottom. We also used four combinations of top and bottom halves for incongruent gender combinations in each stimulus set, e.g., M1 top with F2 bottom, M2 top with F1 bottom, F1 top with M2 bottom, and F2 top with M1 bottom. However, these were randomly chosen from the eight possible combinations. By following these combinations, each set of faces led to a total of 16 stimulus images (2 gender congruence × 2 alignments × 4 combinations).

Design and procedure. The experiment began with a pretest task to ensure participants knew the celebrity faces used to create stimuli. There were 8 trials, in which the original version of each of the 4 celebrity faces was shown twice. The order of the trials was random, with the constraint that the same face was not presented in consecutive trials. Each trial began with a 300ms fixation, followed by a face presented until the participant entered the name of the face. Participants had to score 100% correct in order to be included in data analysis for the main experiment. All participants met this criterion.

Gender categorization. The pretest task was followed by a gender categorization task involving a block of trials in which participants categorized (as male or female) the top or bottom halves of the faces presented in isolation, to familiarize them with the main experimental task. Finally, in the main blocks of experimental trials, participants categorized as male or female the top or bottom halves of the aligned and misaligned stimuli.

The participant was told to judge the gender of the top or the bottom half of the face as quickly and accurately as possible by pressing one of two designated keys on the keyboard. The keys associated with male and female responses were counterbalanced across participants. The task was executed in two separate blocks of trials, where participants either judged the top or the bottom half of the face stimuli. The order of these top and bottom blocks was counterbalanced across participants. Prior to each block, an instruction screen informed the participants whether they were expected to judge the top half or the bottom half of the face.

All trials in the two blocks followed the same procedure, whereby a 500ms fixation screen was followed by the stimulus to be categorized. Each stimulus was presented until a response was made. There was a 1-s inter-trial interval following each response. As noted above, each block was itself divided into two sessions. The first session showed isolated halves of faces, and was intended as a check that participants could correctly classify the top and bottom part of each face as male or female. The second session was the main experimental trials involving aligned composite or misaligned face parts.

Isolated halves: Only the top or the bottom half of a face was presented in this session, depending on whether the block required judging the gender of the top or the bottom half. Each stimulus was repeated four times to give a total of 16 trials in a random order, with the constraint that no image was repeated twice in a row.

Combined halves: Aligned composite and misaligned halves were presented in this session. There were 8 aligned and 8 misaligned images. Each of them was repeated 6 times, which resulted in a total of 96 trials in this session (16 images × 6 repetitions). The participant's task was to categorize the gender of the top part of each stimulus or the bottom part of each stimulus in the separate blocks of trials. Participants were asked to do this as quickly and accurately as possible, whilst ignoring the irrelevant part (i.e. ignoring the bottom part when asked to classify the top part, and vice versa). To familiarize participants with the task, this session was preceded by 16 practice trials. The order of trials was otherwise random with the following constraints; the same face image was not allowed to appear repeatedly in two consecutive trials, and the same correct response key was only allowed to repeat up to five times in a row.

In sum, for the main experimental trials we employed three within-participant factors, Gender Congruence (congruent or incongruent face parts), Alignment (aligned or misaligned stimulus arrangement) and Position to be categorized (top-half or bottom-half).

Results

Pretest. All participants identified the full set of original faces correctly, showing that they knew the faces used to create the experimental stimuli.

Isolated halves. The accuracies of judging the gender of a face based on the top or bottom half of the face alone were 98% (*SD* = 3.9) and 99% (*SD* = 3.2), respectively. The performances for the two conditions were comparable, $t(23) = .90$, $p = .377$. There was also no difference between correct response times for the top (*M* = 688*ms*, *SD* = 207) and bottom (*M* = 692*ms, SD* = 165) half of the faces, $t(23) =.075$, $p = .941$. From this we conclude that the top and bottom halves of each of the images used to create the experimental stimuli contained cues that allowed them to be accurately classified as male or as female.

Combined halves. The purpose of these main experimental trials was to compare reaction times for categorizing the gender of the top or bottom halves of aligned composite and misaligned composite stimuli created from gender-congruent or gender-incongruent parts. Since the overall error rate was lower than 3%, we will only focus on the reaction time data. Reaction times from trials with incorrect responses and outliers of more than 3 SDs were excluded in the calculation of mean RTs in each condition.

Table 1 near here, please

Table 1 shows the details of a three-factor repeated-measure analysis of variance (ANOVA). Significant main effects of Gender Congruence (gender-congruent vs gender-incongruent parts), Alignment (aligned composite vs misaligned arrangement), and Position (top or bottom half categorization) showed that participants were quicker for congruent than for incongruent gender pairings, for misaligned than for aligned halves, and for the top than for the bottom halves. However, these main effects were qualified by significant two-way interactions between Gender Congruence and Alignment, and between Alignment and Position.

Figure 2 near here, please

The most important finding for present purposes is the interaction between Gender Congruence and Alignment, which is illustrated in Figure 2A. Simple effect analyses of this interaction revealed a significant effect of Alignment for incongruent-gender pairings, $F(1, 23) = 24.47$, $p < .001$, $\eta^2_p = .516$, where RTs for the aligned halves were slower than for the misaligned halves. In contrast, there was no effect of Alignment for congruent-gender pairings, $F(1, 23) = .61$, $p = .441$, $\eta^2_p = .026$. Another way to analyze the interaction is to look at the effect of Gender Congruence on aligned vs misaligned halves. This resulted in a significant effect for aligned halves, $F(1, 23) = 14.56$, $p = .001$, $\eta^2_p = .388$, where RTs for incongruent gender were slower than for congruent gender. In contrast, there was no effect of Gender Congruence for misaligned halves, $F(1, 23) = .01$, $p = .925$, $\eta^2_p < .001$.

The interaction between Alignment and Position is also illustrated in Figure 2B. Although effects of Alignment were significant for both top- and bottom-halves, F's$(1, 23) \geq$

6.54, p's ≤ .018, η^2_p's ≥ .221, the Alignment effect for bottom-halves was larger.

As expected, then, we found a clear composite effect in the gender task, where judgments about the gender of the top or bottom of a face were slower when the two halves were aligned than misaligned. However, this effect was only evident when the gender of the halves was incongruent. The results showed that gender congruence between the top and bottom halves eliminated the composite effect in gender categorization of faces.

Discussion

The aim of Experiment 1 was to validate a new variant of the composite face task based on the salient social category of male vs female gender with stimuli created from familiar faces. The composite effect (in the form of slower responses to aligned than misaligned stimuli) was only evident when participants had to classify the parts of gender-incongruent stimuli that combined the top and bottom parts of male and female faces. This result is in line with Baudouin and Humphreys' (2006) findings with unfamiliar faces.

It is likely, of course, that congruent pairings of aligned male top and bottom or of aligned female top and bottom parts create novel-looking faces that remain obviously male or female, whereas the incongruent pairs will be more ambiguous. This relatively indeterminate gender of the aligned composites made from incongruent face parts may contribute to the composite effect we found in Experiment 1, as participants were asked to classify the gender of the constituent parts. However, we can now use the same stimuli to look at the impact of the gender of the face parts when they are irrelevant to the participant's task. In Experiment 1, all stimuli were created by combing the top and bottom halves of different faces, so that recognition of the identities of the face parts would be irrelevant to the gender classification task. In Experiment 2 we made the face gender task-irrelevant by using the same stimuli and asking participants to recognize the identities of the top or bottom parts.

Experiment 2

In Experiment 2, we asked participants to recognize the identities of the top or bottom halves of the stimuli from Experiment 1. This allowed us to investigate whether the congruent or incongruent gender of the task-irrelevant face part would influence responses when the participant's task was to recognize identity.

Method

Participants. Twenty-four Chinese university students (mean age 23.1 years, range 18-30 years, 12 females) participated in the experiment for a small payment. All had normal or corrected-to-normal vision.

Materials. The stimuli were identical to those created for Experiment 1.

Design and procedure. These were also identical to Experiment 1, except that the gender categorization task was now changed to an identity recognition task. Participants were required to classify the top or bottom part of each image in terms of the celebrity's identity. The names of the four celebrities along with the associated keys for each identity were displayed at the bottom of the screen in all trials. The participant pressed one of the four keys to indicate the name of the celebrity's face in each trial.

In Experiment 2, then, participants identified (by celebrity name) the top or bottom parts of aligned composite or misaligned images. All stimuli were created by combining top and bottom face parts with different identities, but for half the stimuli the different parts were gender-congruent (a male face part with another male face part from a different person, or a female face part with another female face part from a different person) and for the other half of the stimuli the different parts were gender-incongruent (a male face part with a female face part).

Results

Pretest. All participants identified the full set of original faces correctly, showing that they knew the individuals concerned.

Isolated halves. The mean accuracies for recognizing face identity from the top and bottom halves were 96% (*SD* = 6.2) and 98% (*SD* = 3.3), respectively. These performances were comparable, $t(23) = 1.8$, $p = .085$. Correct reaction time data for bottom (*M* = 1152*ms*, *SD* = 378) and top (*M* = 1143*ms*, *SD* = 356) halves showed a similar pattern, $t(23) = .078$, $p = .938$.

Combined halves. The overall error rate in this session was less than 5%. We have therefore again focused on the reaction time data. Table 2 shows the details of the three-factor repeated-measures ANOVA of correct RTs. There were significant main effects of Gender Congruence and Alignment, where responses were faster for stimuli with congruent than for incongruent gender, and for misaligned than for aligned halves.

Table 2 near here, please

Our principal interest, however, is in the interaction between Gender Congruence and Alignment. This reached a borderline level of statistical significance; the trend is illustrated in Figure 3. Simple effect analyses revealed a significant effect of Gender Congruence for aligned, $F(1, 23) = 5.12$, $p = .033$, $\eta^2_p = .182$, but not for misaligned halves, $F(1, 23) = .01$, $p = .938$, $\eta^2_p < .001$. Effects of Alignment in both congruent- and incongruent-gender conditions were significant, F's$(1, 23) \geq 9.14$, p's $\leq .006$, $\eta^2_p \geq .284$.

Figure 3 near here, please

Discussion

The main effect of stimulus alignment, with faster identification of the parts of misaligned than aligned stimuli, is a replication of the original pattern reported by Young et al. (1987). What is new here is the use of pairings involving congruent or incongruent genders; in Young et al.'s study only congruent pairings were used.

In Experiment 1, we found no significant difference in RTs for gender categorization between aligned and misaligned gender-congruent stimuli, but in Experiment 2 a significant composite effect was evident for recognizing identity in the gender-congruent as well as the gender-incongruent stimuli, with only a marginal interaction. The composite effect in face identity recognition found in Experiment 2 was therefore less affected by gender congruence between the stimulus parts, although the marginal interaction suggested that the effect might none the less be larger for the gender-incongruent stimuli, as in Experiment 1.

This pattern clearly suggests that a task-irrelevant social category (in this case, gender) can influence the size of the composite effect for a different categorization (identity). However, the task demands were not fully balanced across experiments because Experiment 1 involved a binary (male vs female) classification whereas in Experiment 2 there were 4 response alternatives (the four identities). We therefore designed the next two experiments to allow orthogonal manipulation of two different social categories (male vs female and movie star vs athlete) in creating the stimuli. Participants then performed binary classification of gender (male vs female) in Experiment 3 or of occupation (movie star vs athlete) in Experiment 4 of the top and bottom parts of aligned or misaligned stimuli. In this way we were able to evaluate the influences of gender congruence and occupation congruence on the composite face effect.

Experiment 3

In Experiment 3 we orthogonally varied the gender (male or female) and occupation (movie star or athlete) of the face parts and asked participants to recognize their gender. Our interest was in whether the composite effect would be modulated by the task-relevant gender congruence and by the task-irrelevant occupation congruence.

Method

Participants. Thirty Chinese university students (mean age 22.8 years, *SD* = 2.6 years, range 19-30 years, 15 females) participated in the experiment for a small payment.

Materials. These were grayscale face images of 4 Chinese movie stars from Experiment 1, and of 4 additional famous Chinese athletes. Athletes were selected as a category with similar potential age and popularity to the movie stars used in Experiment 1. The mean ages were 34.5 years, range 29-37 years for athletes, and 38.2 years, range 33-42 years for movie stars.

The numbers of male and female celebrities in each category were identical. The four male celebrity faces were coded as MA1, MA2, MS1, MS2 and four female celebrity faces as FA1, FA2, FS1, FS2, where M = male, F = female, A = athlete, S = star, 1 = model 1, 2 = model 2.

All the top-halves and bottom-halves of these eight faces were used to construct aligned composite and misaligned stimuli. As for Experiments 1 and 2, all stimuli for the main experimental trials involved top and bottom parts of different faces, but the pairings of congruent or incongruent gender and congruent or incongruent occupation were now varied orthogonally, resulting in four types of pairs: 1) Congruent gender, congruent occupation (for example, the top half of a male movie star and the bottom half of a male movie star); 2) Congruent gender, incongruent occupation (for example, the top half of a male movie star and the bottom half of a male athlete); 3) Incongruent gender, congruent occupation (for example, the top half of a male movie star and the bottom half of a female movie star); 4) Incongruent gender, incongruent occupation (for example, the top half of a male movie star and the bottom half of a female athlete).

Every face was used once as a top half and once as a bottom half in each combination of gender and occupation congruence, and all stimuli were created from different identity top and bottom parts. This resulted in 32 pairings. All pairings had two versions (aligned composite or misaligned), leading to a total of 64 stimuli. Figure 4 illustrates aligned versions of congruent and incongruent pairings of the eight celebrities' half-faces.

Figure 4 near here, please

Design and procedure. This was a within-participant design. The factors were Gender Congruence (congruent-gender vs. incongruent-gender pairings), Occupation Congruence (congruent-occupation vs. incongruent-occupation pairings), Alignment (aligned composite vs. misaligned arrangement), and Position (top-half vs. bottom-half classification).

The procedure was essentially identical to Experiment 1. Only two aspects of this experiment were different. First, the number of pretest trials increased from 8 to 16 due to the increased number of celebrity faces from 4 to 8. The number of trials for the isolated-halves practice sessions also increased from 16 to 32 for the same reason. Second, for the main experimental trials with aligned and misaligned stimuli in each block, each of the 64 stimuli was repeated twice, leading to a total of 128 experimental trials instead of 96. Because there were two blocks, one for judging the top half, one for judging the bottom half, the experiment had a total of 256 trials in these sessions.

Results

Two participants performed more than 2.5 *SD*s below the grand mean accuracy (97.6%). As this was intended as a reaction time task, their data were excluded from further analyses because of the higher error rates.

Pretest. All participants identified the full set of original faces correctly, showing that they recognized these individuals.

Isolated halves. The mean accuracies for top and bottom halves were 98.3% (*SD* = 4.4) and 96.4% (*SD* = 4.4), respectively. A t-test showed no significant difference between top and bottom halves, t (27) = 1.89, p = .07. These findings were sufficient to demonstrate that the half-faces could be accurately classified by gender. However, we note that response times for the top halves (M = 680*ms*, *SD* = 165) were faster than for the bottom halves (M = 1057*ms*, *SD* = 376), t (27) = 4.90, $p < .001$.

Combined halves. The overall error rate was 2.4% in the task. As the previous experiments, we have focused on the response time data.

Table 3 near here, please

Table 3 shows the four-way ANOVA results. The significant main effects of Gender Congruence, Alignment, and Position suggest a speed advantage for congruent gender, misaligned halves, and top half classification. However, these main effects were qualified by significant three-way and two-way interactions.

In terms of our focus of interest, the most important findings are those involving the interactions between Gender Congruence or Occupation Congruence and the Alignment factor, as these indicate whether the composite face effect is modulated by gender or occupation congruence.

Analysis of the two-way interaction between Gender Congruence and Alignment showed slower RTs for Incongruent Gender than Congruent gender when the two halves were aligned, $F(1, 27) = 8.32$, $p = .008$. No effect of Gender Congruence was found when the two halves were misaligned, $F(1, 27) = 1.51$, $p = .229$. This interaction is consistent with findings from Experiment 1.

Figure 5 near here, please

The Occupation Congruence × Alignment interaction was non-significant (see Table 3), but there was a three-way interaction of Occupation Congruence × Alignment × Position. We therefore identified the source of this interaction (see Figure 5) by conducting simple effect analyses for the Top and Bottom positions. ANOVA for the Top half classification showed no effect of Occupation Congruence, $F(1, 27) = 0.01$, $p = .919$, $\eta^2_p < .001$, but there was a significant effect of Alignment, $F(1, 27) = 4.98$, $p = .034$, $\eta^2_p = .156$, and an interaction between Occupation Congruence and Alignment, $F(1, 27) = 6.16$, $p = .020$, $\eta^2_p = .186$. RTs for Congruent Occupation were slower when the halves were aligned than misaligned, $t(27) = 3.17$, $p = .004$. No effect of Alignment was found for Incongruent Occupation, $t(27) = 1.03$, $p = .314$.

ANOVA for the Bottom half classification also showed no effect of Occupation Congruence, $F(1, 27) = 0.10$, $p = .751$, $\eta^2_p = .004$, but there was again a significant effect of Alignment, $F(1, 27) = 40.30$, $p < .001$. The interaction between the two factors was only marginally significant this time, $F(1, 27) = 3.19$, $p = .085$, $\eta^2_p = .106$. Responses were slower when the halves were aligned than misaligned for both Congruent Occupation, $t(27) = 6.30$, $p < .001$, and Incongruent Occupation, $t(27) = 5.86$, $p < .001$, although Incongruent Occupation created a slightly larger Alignment effect (110ms) than that created by Congruent Occupation (90ms).

Thus the three-way interaction between Occupation Congruence, Alignment, and Position was driven by differential alignment effects for classifying Top and Bottom halves. Overall, the alignment effects (i.e. the interference from the face-like aligned composite stimulus arrangement) were about 90-110ms for congruent and incongruent occupations when the bottom half was judged, but only about 30ms for the congruent occupation when the top half was judged. The alignment effect in classifying the gender of the top half was absent when the two persons in a composite had different occupations. In contrast, the alignment effect on classifying gender was found for congruent and incongruent occupations when the bottom half of the stimuli was judged.

Finally, we analysed the marginal three-way interaction between Gender Congruence, Occupation Congruence, and Position (Figure 6), again using separate ANOVAs for Top and Bottom conditions.

Figure 6 near here, please

For the Top condition, responses for Incongruent Gender were slower than for

Congruent Gender, *F*(1, 27) = 5.28, p = .029, η^2_p = .164. The main effect of Occupation Congruence was not significant, *F*(1, 27) = 0. 1, p = .919, η^2_p < .001. There was a marginal interaction, *F*(1, 27) = 3.30, p = .080, η^2_p = .109, where the mean response was slower when both Gender and Occupation were incongruent than when only Gender was incongruent, *t*(27) = 3.22, p = .003. However, no difference was found between results of congruent and incongruent gender when Occupation was congruent, *t*(27) = 0.55, p = .585.

For the Bottom condition, responses for Incongruent Gender were slower than Congruent Gender, *F*(1, 27) = 5.72, p = .024, η^2_p = .175. No significant effect was found for Occupation Congruence, *F*(1, 27) = 0.10, p = .751, η^2_p = .004, or interaction between the two variables, *F*(1, 27) = 1.10, p = .303, η^2_p = .039.

Discussion

The effect of gender congruence between the face parts was again evident in this task, where incongruent gender between the parts produced interference with gender judgements, leading to slower reaction times. As for Experiment 1, the impact of gender congruence was mainly manifested in the aligned composites. Also as in previous experiments, clear composite effects were found in almost all conditions.

The data did not show a significant interaction of Occupation Congruence and Alignment, but this interaction was subsumed under the three-way interaction between Occupation Congruence, Alignment, and Position (see Figure 5). Decomposition of this interaction showed that even when the task was judging the gender of the top half, the alignment effect depended on whether the task-irrelevant occupation of the other half was congruent with it: RTs to top halves were slower for the aligned than for misaligned stimuli when both halves had the same occupation. In contrast, Alignment created no difference in response speed for the top halves when the two parts of the stimuli had incongruent occupations. When the task was judging the gender of the bottom half, on the other hand, a much larger alignment effect was found for both congruent and incongruent gender conditions. The magnitude of the composite effect was also greater when participants judged the gender of the bottom half. Judging the bottom half was substantially slower than judging the top in the gender task. This could be due to relatively less information in our bottom-half stimuli for discriminating gender. This is evident from the isolated-half analysis, which showed that the time taking to identify gender from the bottom half (1057ms) was substantially slower than from the top half (680ms). However, despite these differences between results for the top and bottom halves, both positions showed some evidence of modulation by the task-irrelevant occupation when the task was gender classification.

Responses for incongruent gender were generally slower than congruent gender, although when the top half was judged, the variable also showed a weak dependence on occupation congruence. This was likely the cause of the marginal three-way interaction illustrated in Figure 6, which shows a slower mean response when both gender and occupation were incongruent in a composite relative to when only gender was incongruent. Although only found for the top position, this interaction effect again presents evidence for some involvement of occupation processing which was task-irrelevant in this experiment.

In sum, Experiment 3 showed a clear influence of the task-relevant gender congruence on the composite effect and some more limited evidence of an influence of the task-irrelevant occupations.

Experiment 4

Experiment 4 used the same stimuli as Experiment 3, which orthogonally varied the gender (male or female) and occupation (movie star or athlete) of the face parts. This time however we asked participants to recognize their occupation. Our interest was in whether the composite effect for recognizing occupation would be modulated by the task-relevant occupation congruence and the task-irrelevant gender congruence.

Method

Participants. Thirty Chinese university students (mean age 22.7 years, *SD* = 2.3 years, range 20-29 years, 15 females) participated in the experiment for a small payment.

Materials. These were identical to Experiment 3.

Design and procedure. These were also identical to Experiment 3 except that participants were asked to categorize the occupation, rather than the gender of the appropriate face part, using two response keys labelled “star” and “athlete”.

Results

Two participants performed more than 2.5 *SD*s below the grand mean accuracy (95.7%). Their data were excluded from further analyses.

Pretest. All participants identified the full set of original faces correctly, showing that they recognized these individuals.

Isolated halves. The mean accuracies for top and bottom halves were 95.9% (*SD* = 4.7) and 95.7% (*SD* = 7.8), respectively. A t-test showed no significant difference between top and bottom halves, $t(27) = 0.14$, $p = .887$. These accuracies were sufficient to demonstrate that the half-faces could be accurately classified by occupation. Response times for the top halves (*M* = 1287*ms*, *SD* = 578) were comparable to for the bottom halves (*M* = 1483*ms*, *SD* = 729), $t(27) = 1.11$, $p = .276$.

Combined halves. The overall error rates were 4.3% for the occupation-categorization task. As for the previous experiments, we focused on the data for correct RTs.

Table 4 near here, please

Table 4 shows the results of a four-way ANOVA. The only significant main effect was Alignment, which showed slower RTs for aligned than for misaligned halves; the classic composite effect. Of more interest in the present context, however, was the significant interaction between Gender Congruence and Alignment (see Table 4), showing that the composite effect was influenced by the task-irrelevant gender congruence. In contrast, the task-relevant occupations did not create an overall Occupation Congruence × Alignment interaction (Table 4). However, these results were qualified by a significant three-way interaction between Gender Congruence, Occupation Congruence, and Alignment.

Figure 7 near here, please

To decompose this three-way interaction, we conducted separate ANOVAs for congruent and incongruent occupations. For Congruent Occupation conditions (Figure 7A), there was no effect of Gender Congruence, $F(1, 27) = 0.83$, $p = .369$, $\eta^2_p = .030$. However, there was a significant effect of Alignment, $F(1, 27) = 19.33$, $p < .001$, $\eta^2_p = .417$, and an interaction between Gender Congruence and Alignment, $F(1, 27) = 13.42$, $p = .001$, $\eta^2_p = .332$, in which the effect of Alignment was greater for Incongruent Gender (106ms), $t(27) = 5.96$, $p < .001$, than for Congruent Gender (86ms), $t(27) = 1.89$, $p = .070$. For Incongruent Occupation conditions (Figure 7B), the only significant result was the main effect of Alignment, $F(1, 27) = 24.48$, $p < .001$, $\eta^2_p = .476$. There was no main effect of Gender Congruence, $F(1, 27) = 0.45$, $p = .507$, $\eta^2_p = .016$, and no interaction, $F(1, 27) = 0.17$, $p = .681$, $\eta^2_p = .006$.

Discussion

The most striking finding in this experiment was the influence of the task-irrelevant gender congruence. Although participants were only required to judge the occupation of a face part, their performance with aligned composite stimuli was affected by whether or not the parts were congruent or incongruent in gender. However, this interference effect also depended to some extent on Occupation Congruence. When the two halves of an aligned composite were of the same occupation and same gender, the effect of Alignment was smaller than when the two halves were of the same occupation but different gender (Figure 7A). In contrast, when the two halves were of different occupations, Gender Congruence did not modulate the effect of Alignment (Figure 7B).

Hence the interference effect due to task-irrelevant gender processing was associated with a specific combination of occupation and gender information. When a composite consisted of parts with the same occupation and gender, it resulted in a weaker composite effect than for other combinations. The reduced composite effect suggests less interference from the task-irrelevant half because it contained no conflict with the gender or occupation information. However, we note that the effect of occupation congruence was only evident in this three-way interaction; the two-way interaction of Occupation Congruence and Position was not significant (see Table 4).

Consistent with Experiment 2, then, this experiment showed that irrelevant gender information could modulate classification of another, task-relevant category. Experiment 2 required judging identity whereas this experiment required judging occupation. Because of the initial matching of the athletes and movie stars' faces for general appearance, participants in Experiment 4 would have to first access identity-specific semantic information in order to achieve classification by occupation (Bruce & Young, 1986; Young et al., 1986b). In contrast, gender can be determined from purely visual properties without needing the face's identity to be recognized (Bruce et al., 1987).

Taking the findings of Experiments 3 and 4 together, we can see strong evidence that gender congruence influences the composite effect but only weaker evidence of an influence of occupation congruence. To investigate further the potential role of occupation congruence we conducted Experiments 5 and 6, in which any influence of gender congruence was eliminated by creating aligned and misaligned stimuli using top and bottom halves of consistent gender. These experiments were therefore similar in overall design to Experiment

2, but with the difference that whereas Experiment 2 manipulated the visual property of gender typical masculine or feminine appearance, Experiments 5 and 6 varied the semantic property of occupation.

Experiment 5

In Experiment 5 we used stimuli which varied the occupation (movie star or athlete) of the face parts across congruent genders (parts of two male or of two female faces) and asked participants to recognize their identity. Our interest was in whether the composite effect in the identity task would be modulated by the congruent or incongruent occupations.

Method

Participants. Thirty-one Chinese university students (mean age 22.1 years, *SD* = 2.1 years, range 19-28 years, 16 females) participated in the experiment for a small payment.

Materials. These were identical to Experiment 3 except that only pairings with congruent genders were used. This led to two sets of stimuli: one set with pairings created from two female stars and two female athletes, the other set with pairings created from two male stars and two male athletes.

Design and procedure. These were identical to Experiment 2 except for the following details. The program had two versions: one version used the set of female stimuli and 15 participants were tested, the other version used the set of male stimuli and 16 participants were tested. In each version, the four celebrities were of the same gender and the independent factors were occupation congruence, alignment and position. Data from both versions were combined for analysis.

Results

Pretest. All participants identified the full set of original faces correctly, showing that they recognized these individuals.

Isolated halves. The mean accuracies for top and bottom halves were 96.8% (*SD* = 4.0) and 97.2% (*SD* = 3.5), respectively. A t-test showed no significant difference between top and bottom halves, $t(30) = 0.58$, $p = .565$. These accuracies were sufficient to demonstrate that the half-faces could be accurately classified by identity. Response times for the top halves (*M* = 1035*ms*, *SD* = 143) were comparable to the bottom halves (*M* = 1029*ms*, *SD* = 168), $t(30) = 0.17$, $p = .865$.

Combined halves. The overall error rates were 2.5% for the identity-categorization task. As for the previous experiments, we focused on the data for correct RTs.

Table 5 near here, please

Table 5 shows the results of a three-way ANOVA of the effects of Occupation Congruence, Alignment, and Position. The only significant main effect was Alignment, with slower RTs for aligned than for misaligned halves (Figure 8). No significant effects involving Occupation Congruence were observed.

Figure 8 near here, please

Discussion

The effect of occupation congruence between the face parts was absent in this task. That is, incongruent occupations between the parts did not produce interference with identity judgments. As in previous experiments, however, clear composite effects were found in all conditions.

Experiment 6

Although Experiment 5 found no effect of occupation congruence on identity judgements, the training procedure used to ensure participants could recognize the face parts only involved recognizing their identities. In Experiment 6 we investigated whether there might be an effect of occupation congruence if this was made more salient for participants. To achieve this increased salience of the occupations, we asked the participants to give the occupations as well as the identities of the celebrities in the pretest. Our principal interest was in whether there would be an effect of occupation congruence on the composite effect for identity classification when occupation was explicitly emphasized in the training.

Method

Participants. Twenty Chinese university students (mean age 22.5 years, SD = 1.8 years, range 20-28 years, 12 females) participated in the experiment for a small payment.

Materials. These were identical to Experiment 5.

Design and procedure. These were also identical to Experiment 5 except that to ensure the salience of the different occupations participants were asked to provide both the identities and the occupations of the celebrities in the initial pretest.

Results

One participant performed more than 2.5 *SD*s below the grand mean accuracy (97.1%) and was excluded from further analyses.

Pretest. All participants identified the full set of original faces and their occupations correctly, showing that they recognized these individuals.

Isolated halves. The mean accuracies for recognizing the identities of top and bottom halves were 96.4% (SD = 4.5) and 96.5% (SD = 4.0), respectively. A t-test showed no significant difference between top and bottom halves, $t(18) = 0.08$, $p = .940$. These accuracies were sufficient to demonstrate that the half-faces could be accurately classified by identity. Response times for the top halves (M = 1052*ms*, SD = 131) were comparable to for the bottom halves (M = 1007*ms*, SD = 161), $t(18) = 0.98$, $p = .340$.

Combined halves. The overall error rates were 4.3% for the identity-categorization task. As for the previous experiments, we focused on the data for correct RTs.

Table 6 near here, please

Table 6 shows the results of a three-way ANOVA. The only significant main effect was Alignment, which showed slower RTs for aligned than for misaligned halves (Figure 9). As for Experiment 5, there were no significant effects involving Occupation Congruence.

Figure 9 near here, please

Discussion

As for Experiment 5, no effect of occupation congruence between the face parts was evident in this task, indicating that the occupation congruence did not influence the composite effect for identity classification even when occupation was emphasized in the training. As in previous experiments, clear composite effects were found in all conditions.

General Discussion

The background to our study lies in recent demonstrations and theoretical analyses that emphasise the possibility that the composite face effect measured in current behavioural paradigms might be driven by more than one underlying factor (Chua et al. 2014, 2015; Chua & Gauthier 2015; Fitousi 2015, 2016; Curby & Entenman, 2016; Curby et al. 2013, 2016; Murphy et al., 2016). This is not to deny that the composite effect represents a compelling perceptual illusion, as was noted by Young et al. (1987) and emphasised more recently by Rossion (2013) and by Murphy et al. (2016). The point is rather to do with whether existing procedures can offer a fully process-pure measure of the illusion, or are also to some extent influenced by other factors. Our findings show that whilst decisional and attentional factors may contribute to the composite effect, the perceptually based source of interference predominates in the new variant of the paradigm we developed and therefore considerably strengthen the evidence for involvement of holistic perceptual processing.

Our experiments drew on Calder et al.'s (2000) demonstration of independent sources of interference across identity and expression categorization tasks to ask whether a similar pattern might hold for other types of information perceivers derive from faces. By using familiar faces we were able to orthogonally manipulate the relatively visual property of face gender and the relatively semantic property of occupation to investigate how these influenced the composite face effect. At the same time, we were able to ask whether the composite effect would be influenced by the congruence of task-relevant or task-irrelevant properties of the face parts. Across six experiments we manipulated either the gender congruence of top and bottom face halves, the occupation congruence, or both and looked at their impact on recognizing or categorizing the identity, gender or occupation of these face parts in aligned and misaligned stimuli. For convenience, the main findings are summarised in Table 7.

Table 7 near here, please

Our principal criterion for demonstrating that gender congruence influenced the composite effect was the presence of a Gender Congruence × Alignment interaction in which it was more difficult to respond to the parts of stimuli created from incongruent genders when these were presented in an aligned (face-like) than a misaligned (not face-like) format. As Table 7 shows, this pattern was evident in all four of the experiments where gender congruence was manipulated, although the significance level fell slightly above the conventional .05 criterion in Experiment 2 and the effect size was somewhat lower. Importantly, an effect of gender congruence on the composite effect was noted whether gender was itself task-relevant (Experiments 1 and 3) or task-irrelevant (Experiments 2 and

4).

Using the same logic, our principal criterion for determining whether occupation congruence influenced the composite effect was the presence of an Occupation Congruence × Alignment interaction in which it was more difficult to respond to the parts of stimuli created from incongruent occupations when these were presented in an aligned (face-like) than a misaligned (not face-like) format. As Table 7 makes clear, this criterion was not met in any of the four experiments that manipulated occupation congruence. Instead, for two experiments (Experiments 5 and 6) there were no discernible effects of occupation congruence and for the other two experiments (Experiments 3 and 4) the Occupation Congruence × Alignment interaction was entirely subsumed under interactions with other (and in each case different) variables. This happened both when occupation was task-relevant (Experiment 4) and task-irrelevant (Experiment 3). On this basis we can conclude that whilst there was some evidence of an impact of occupation congruence, it was sufficiently weak to be easily influenced by other factors.

To understand the implications of these findings it is useful to draw on Bruce and Young's (1986) distinction between visually-derived and identity-specific semantic information. Gender can be visually-derived because the physical differences between male and female faces are sufficient to make it easy to tell whether most faces are those of men or women on a purely visual basis (Bruce and Young, 2012). The faces we used here were of gender-typical appearance and pretesting showed that their top and bottom halves were easily categorized as male or female.

In contrast to gender, occupation cannot be reliably inferred from appearance alone. To be confident that a face belongs to an athlete or a movie star you have to recognize the person's identity; there are no consistent overall differences in facial appearance across these categories and the faces we used here were matched for age and gender. In Bruce and Young's (1986) terms occupation is a form of identity-specific semantic information that requires the face to be recognised before it can be determined. Even so, there is abundant evidence that face recognition is to some extent a mandatory process (Young et al., 1986a; Lavie, Ro & Russell, 2003) and that identity-specific properties such as occupation are readily accessed from familiar faces (Young et al., 1986b). Indeed, recent work strongly emphasizes the role of conceptual information (such as occupations) in underpinning our learning and excellent recognition of familiar faces (Schwartz & Yovel, in press).

A particularly compelling demonstration of how readily identity-specific information is usually accessed from familiar faces comes from interference effects, where incongruent occupations of distractor faces that participants are instructed to ignore none the less influence the categorization latencies for simultaneously presented target names (Young et al. 1986a). For example, if participants are asked to classify printed names as those of politicians or television presenters their correct 'politician' responses are faster if a politician's name is accompanied by a different politician's face (the congruent occupation condition) than if a politician's name is accompanied by a television presenter's face (incongruent occupation condition). This shows that participants cannot ignore face occupations even when they are explicitly asked to do so. In fact, these kinds of interference effects on name categorization from the incongruent occupations of to-be-ignored faces are found even for prosopagnosic participants who are unable overtly to recognize either the identities or the occupations of the distractor faces (de Haan, Young & Newcombe, 1987a, 1987b; Young & Burton, 1999; Young, 2011).

These face-name interference effects based on occupation incongruencies clearly arise at decision and response stages, because there is no visual overlap between the faces and names to create perceptual input interference. The consistent pattern of interference from incongruent occupations in face-name interference studies is strikingly different from the relatively limited influence of occupation congruence on the composite face effect we noted in Experiments 3 to 6. This implies that occupation congruence in the composite face paradigm does not strongly influence decision or response stages implicated in the quite different pattern created by face-name interference.

The pattern of composite face interference found in the experiments reported here differs substantially from that found by Calder et al. (2000) for identity and expression. They found largely task-driven effects in which categorizing identity created composite interference that was unaffected by incongruities of expression and categorizing expression created composite interference that was unaffected by incongruent identity. In contrast, we report here strong interference between gender and identity and more limited effects involving occupation that were not strongly task-related. Incongruent gender of the face parts, for example, could create composite interference whether participants were asked to categorize gender, identity or occupation.

In everyday life, of course, identity and expression are dissociable; any face can in principle have any expression and most theoretical models therefore propose a significant degree of separation between processes needed to recognise identity and expression (Bruce & Young, 1986; Haxby, Hoffman & Gobbini, 2000; Calder & Young, 2005). The position for gender, identity and occupation is different. Although we were able to vary gender and occupation orthogonally in the sense that male or female faces could have different occupations, these characteristics are none the less linked through the face's identity. In fact interactions between gender and identity are evident in data from face learning tasks (Baudouin & Tiberghien, 2002) and statistical analyses of face images show that gender can be derived incidentally from learning to categorise face identity (Kramer, Young, Day & Burton, 2017).

So the pervasive influence of gender congruence on composite face interference in our experiments is consistent with the source of this interference originating in a relatively early perceptual locus and the inconsistency of occupation congruence effects points to a more minor role for decision and response factors. These data thus directly address the important theoretical issues highlighted by Richler and Gauthier (2013, 2014; Richler et al., 2008a, 2008b) in a novel way. They underscore the likely importance of holistic perceptual processing in making selective attention or responses to the constituent parts of aligned stimuli more difficult than performing the same tasks with misaligned stimuli. Moreover, clear composite effects (in terms of longer RTs to aligned than misaligned stimuli) were evident in all our experiments and the size of these effects was consistent across manipulations of task-relevance. These again point to the substantial role of relatively perceptual stages.

Our paradigm derived from Young et al. (1987) and Calder et al. (2000) differs in significant ways from the more widely used composite face paradigm derived from Hole (1994) in which participants are asked to make 'same or different' perceptual matches of parts of unfamiliar faces presented in aligned or misaligned formats (see Rossion, 2013). These differences include our use of familiar (rather than unfamiliar) faces and our use of different tasks (recognizing gender, identity, or occupation, instead of perceptual matching). We also used a response time measure with stimuli that were visible until participants made their responses, whereas matching studies often use time-limited presentations to try to minimize feature comparison strategies. It is therefore important not to extrapolate our conclusions to the matching studies too freely, and additional work that could permit more direct comparisons would be desirable. None the less, we note that our conclusions implicating relatively perceptual factors as making the major contribution are consistent with those reached by Rossion (2013) and others from the composite face matching studies.

In this respect it is important to remember that other paradigms such as the part-whole effect also demonstrate the importance of holistic perception of faces (Tanaka & Farah, 1993; Tanaka & Gordon, 2011; McKone & Robbins, 2011). Indeed the idea that some stimuli form perceptual wholes with properties over and above those of their constituent parts can of course be traced back to Gestalt Psychology and beyond. None the less it is now accepted that perceptual organization can influence attentional selection, and that an object formed by perceptual organization can capture attention which may facilitate or interfere with task performance object-based attention and perceptual grouping (Kimchi, 2009; Retter & Rossion, 2015; Curby & Entenman, 2016; Curby et al., 2013, 2016). For example, Kimchi, Yeshurun and Cohen-Savransky (2007) showed that a task-irrelevant diamond-like object (a contour object formed by four rotated “L” letters) evoked an object-based attention effect. With contours that group together, selective attention to one constituent element whilst ignoring another becomes difficult (Pomerantz et al., 2003). In the same way, a face-like object formed by the aligned stimuli may capture attention, making it difficult to ignore the whole in favor of one of the constituent parts, as required by the composite face paradigm. The misaligned stimuli, in contrast, do not form a strong perceptual grouping, making it easier to attend to the different parts.

Holistic perception therefore remains fundamental to the composite face paradigm, even if the paradigm does not at present offer a completely process-pure measure. The question of whether the composite face paradigm can be adapted to offer a process-pure measure of holistic perception is important to studies that seek to measure individual differences and to investigate the problems experienced by participants from clinical populations (Richler & Gauthier, 2014). Our findings and those of other recent studies discussed here suggest that achieving a completely process-pure measure will not be easy with exclusively behavioural paradigms, but our novel method of pitting different potential sources of interference against each other has promise for deriving a measure of the relatively perceptual component.

A complementary alternative to behavioural paradigms may also be to look for neurophysiological indices that do not involve some of the components needed in behavioural tasks. For example fMRI has shown release from adaptation based on the composite face illusion in visual areas selective to faces in the ventral stream (Schiltz & Rossion, 2006; Andrews et al., 2010; Schiltz et al., 2010). Since these effects arise even with completely incidental tasks (such as detecting a red dot superimposed on some stimuli) in regions considered to be primarily 'visual' in nature, it seems unlikely that decision processes play a significant role. Similarly, there are effects involving the face-sensitive N170 ERP (Jacques & Rossion, 2009; Kuefner et al., 2010), and the steady-state visual evoked potential has obvious promise (Norcia et al., 2015; Alp et al., 2016; Rossion, 2017). Whilst these neurophysiological findings are at present based mainly on studies involving unfamiliar faces (but see Andrews et al., 2010) they converge with our demonstration from familiar faces of a strong underlying perceptual basis for the composite face effect.

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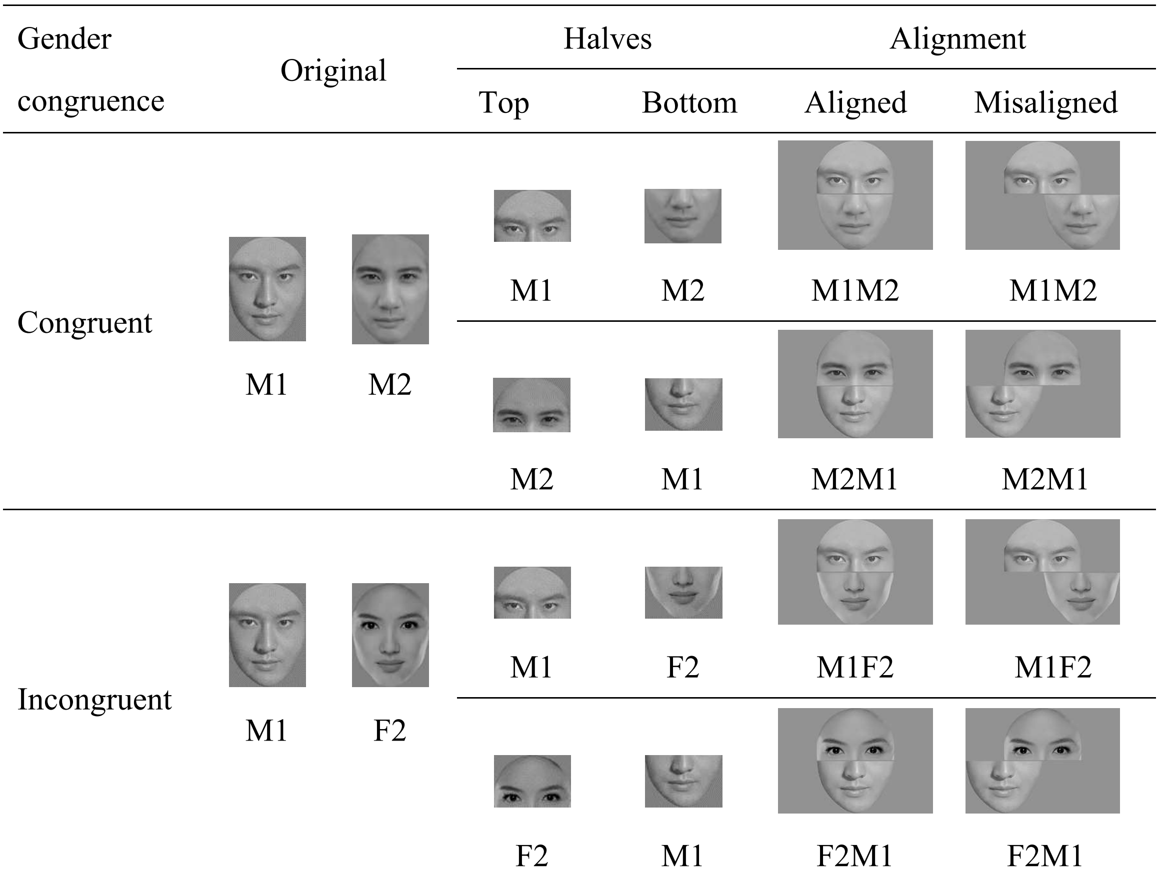

Figure 1. Examples showing face stimuli used for top half judgements in Experiments 1 and 2: 'original' stimuli, top and bottom halves, aligned composite and misaligned stimuli created from the halves. The misaligned stimuli in the first and third rows are examples with the bottom half shifted to the right, and those in the second and fourth rows are examples with the bottom half shifted to the left. The coding used for the aligned and misaligned stimuli lists the top part of each stimulus, followed by the bottom part, using the following convention: M = male, F = female; 1 = model 1, 2 = model 2.

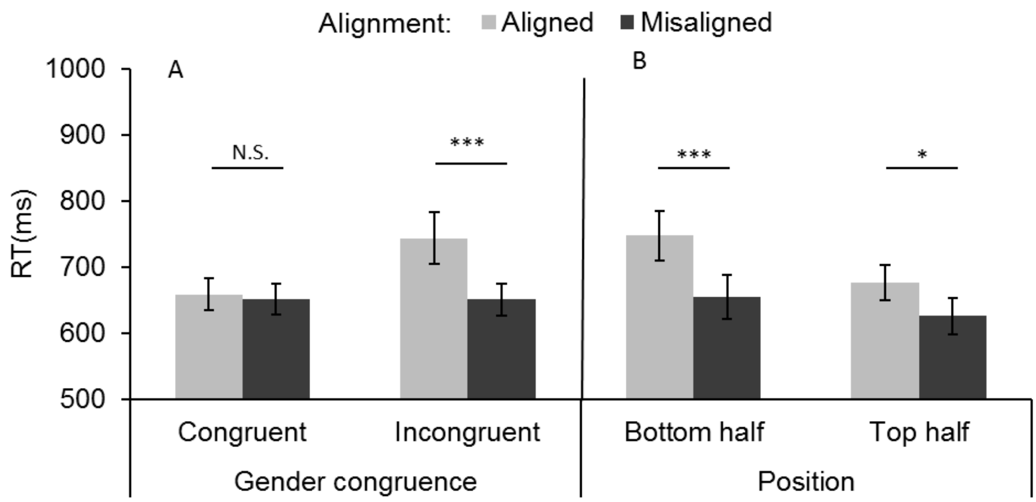

Figure 2. Mean correct reaction times for gender categorization of top and bottom face halves as a function of Alignment and Gender Congruence (A), and of Alignment and Position (B) in Experiment 1. Error bars represent one standard error of the means. *** $p < .001$, * $p < .05$, N.S. Not Significant.

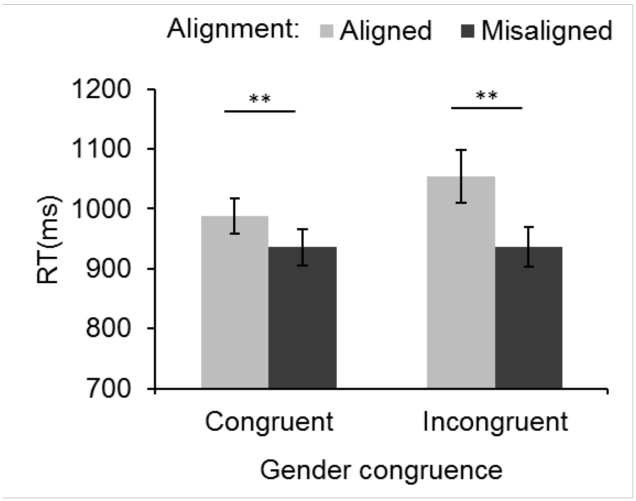

Figure 3. Mean correct reaction times for recognising the identities of face halves as a function of Alignment and Gender Congruence in Experiment 2. Error bars represent one standard error of the means. ** $p < .01$.

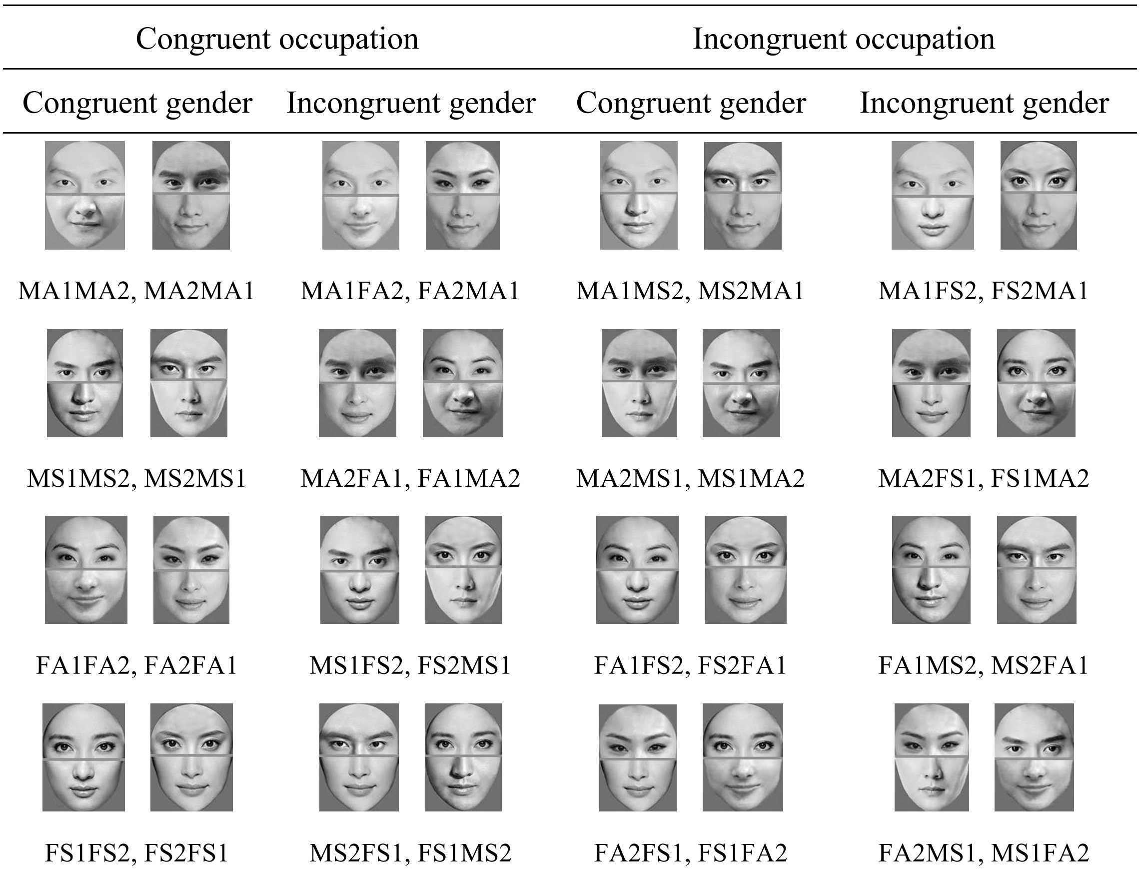

Figure 4. Illustration of aligned stimuli used in Experiments 3 and 4, with orthogonal manipulation of congruent and incongruent occupation and gender. The coding lists the top part of each stimulus, followed by the bottom part, using the following convention: M = male, F = female; A = athlete, S = Star; 1 = model 1, 2 = model 2. Equivalent misaligned stimuli were created in the same way as for Experiments 1 and 2 (see Figure 1).

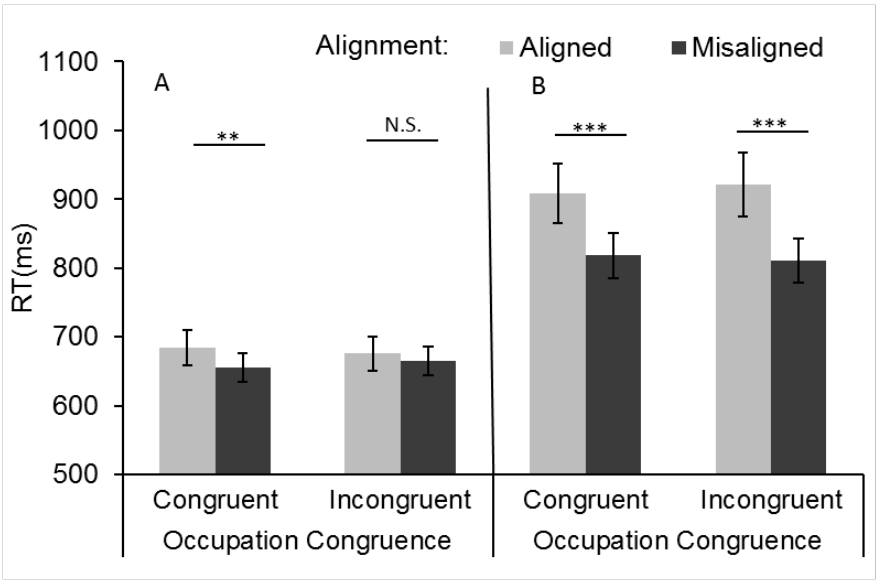

Figure 5. Mean correct reaction times for gender categorization of face halves as a function of Occupation Congruence and Alignment (A: Top position, B: Bottom position) in Experiment 3. Error bars represent one standard error of the means. *** $p < .001$, ** $p < .01$, N.S. Not Significant.

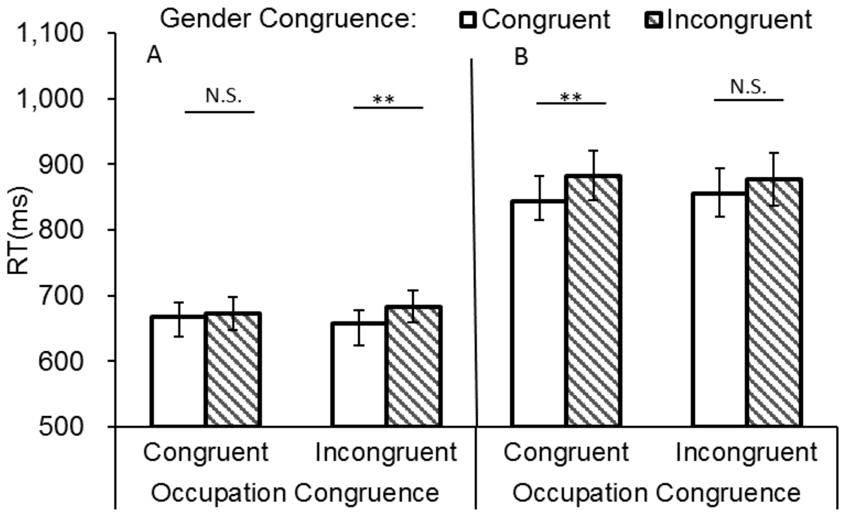

Figure 6. Mean correct reaction times for gender categorization of top and bottom face halves as a function of Gender Congruence and Occupation Congruence in Experiment 3. A: Top halves, B: Bottom halves. Error bars represent one standard error of the means. ** $p < .01$, N.S. Not Significant

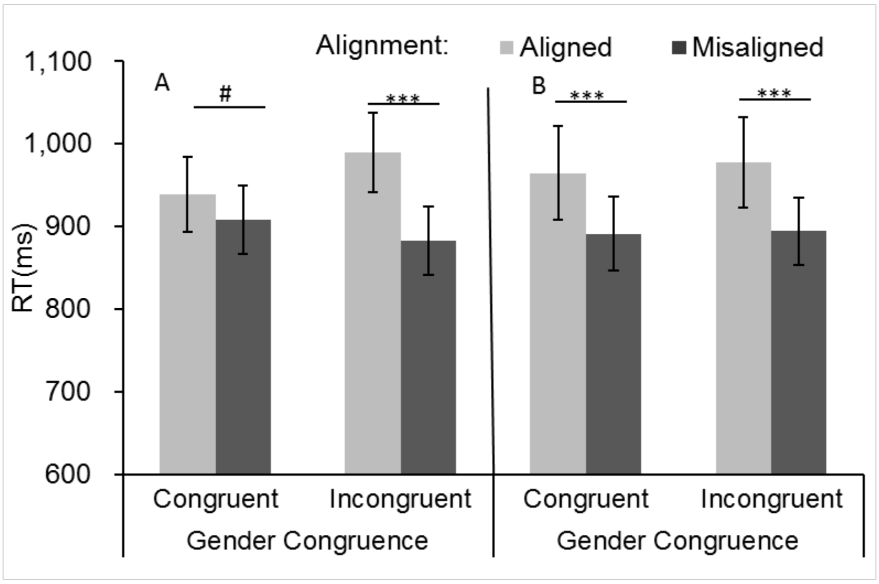

Figure 7. Mean correct reaction times for occupation categorization of face halves as a function of Gender Congruence and Alignment in Experiment 4. A: Congruent Occupation, B: Incongruent Occupation. Error bars represent one standard error of the means. # $p = .07$, *** $p < .001$.

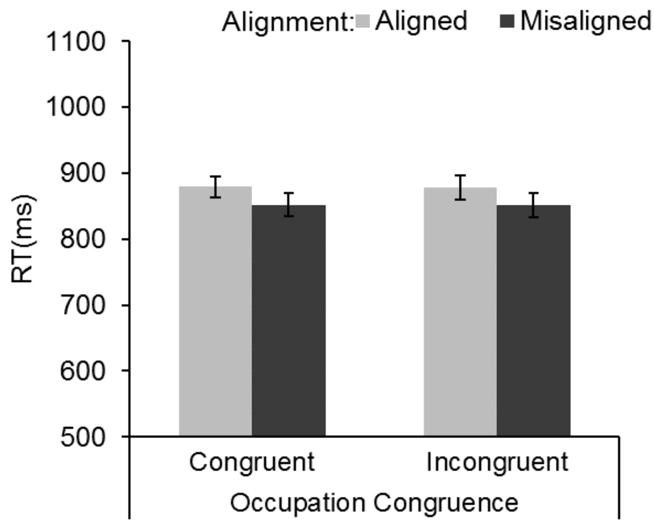

Figure 8. Mean correct reaction times for recognising the identities of face halves as a function of Occupation Congruence and Alignment in Experiment 5. Error bars represent one standard error of the means. Only the main effect of Alignment was significant, but the plot shows the Occupation Congruence x Alignment interaction because of its theoretical importance.

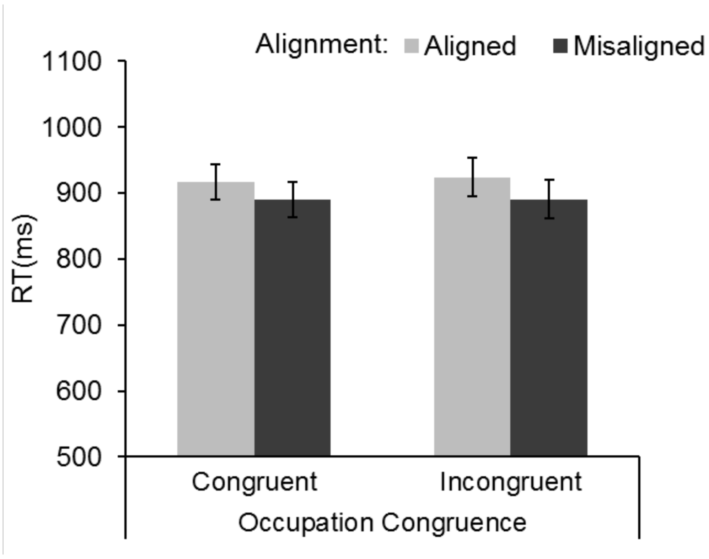

Figure 9. Mean correct reaction times for recognising the identities of face halves as a function of Occupation Congruence and Alignment in Experiment 6. Error bars represent one standard error of the means. Only the main effect of Alignment was significant, but the plot shows the Occupation Congruence x Alignment interaction because of its theoretical importance.

Table 1

ANOVA of the correct reaction times for gender categorization of aligned and misaligned top and bottom face halves from Experiment 1.

Source	*df*	*MSE*	*F*	*p*	η^2_p
Gender congruence (GC)	1	7077	12.13	.002	.345
Alignment	1	4842	24.45	<.001	.515
Position	1	43271	5.71	.025	.199
GC × Alignment	1	5404	16.23	.001	.414
GC × Position	1	2710	0.96	.338	.040
Alignment × Position	1	4343	5.06	.034	.180
GC × Alignment × Position	1	2874	1.95	.176	.078
Error	23				

Table 2

ANOVA of the correct reaction times for recognising the identities of aligned and misaligned top and bottom face halves from Experiment 2.

Source	*df*	MSE	*F*	*p*	η^2_p
Gender congruence (GC)	1	11550	4.77	.039	.172
Alignment	1	18135	18.90	<.001	.451
Position	1	133173	0.20	.660	.009
GC × Alignment	1	14699	3.49	.074	.132
GC × Position	1	22047	0.17	.683	.007
Alignment × Position	1	30566	0.04	.841	.002
GC × Alignment × Position	1	18026	0.30	.586	.013
Error	23				

Table 3

ANOVA of the correct reaction times for gender categorization of aligned and misaligned top and bottom face halves from Experiment 3.

Source	*df*	MSE	*F*	*p*	η^2_p
Gender Congruence (GC)	1	8030	7.35	.012	.214
Occupation Congruence (OC)	1	3606	0.09	.767	.003
Alignment (A)	1	9858	40.69	<.001	.601
Position (P)	1	106747	39.75	<.001	.596
GC * OC	1	2410	0.03	.855	.001
GC * A	1	3976	7.16	.012	.210
OC * A	1	960	0.01	.940	<.001
GC * P	1	3587	1.75	.197	.061
OC * P	1	2588	0.05	.822	.002
A * P	1	8365	21.83	<.001	.447
GC * OC * A	1	2546	0.76	.391	.027
GC * OC * P	1	3040	3.23	.084	.107
GC * A * P	1	4683	2.72	.111	.091
OC * A * P	1	1502	6.79	.015	.201
GC * OC * A * P	1	2602	1.00	.326	.036
Error	27				

Table 4

ANOVA of the correct reaction times for occupation categorization of aligned and misaligned top and bottom face halves from Experiment 4.

Source	*df*	MSE	*F*	*p*	η^2_p
Gender Congruence (GC)	1	14609	0.83	.372	.030
Occupation Congruence (OC)	1	6645	0.06	.804	.002
Alignment (A)	1	23617	25.58	<.001	.486
Position (P)	1	234191	2.61	.118	.088
GC * OC	1	4219	0.16	.695	.006
GC * A	1	6518	7.74	.010	.223
OC * A	1	4033	0.68	.418	.024
GC * P	1	7014	0.09	.764	.003
OC * P	1	3326	0.62	.439	.022
A * P	1	14339	2.69	.113	.090
GC * OC * A	1	6213	5.01	.034	.156
GC * OC * P	1	12768	1.67	.208	.058
GC * A * P	1	5728	1.64	.211	.057
OC * A * P	1	13911	1.57	.221	.055
GC * OC * A * P	1	6527	0.01	.942	<.001
Error	27				

Table 5.

ANOVA of the correct reaction times for recognising the identities of aligned and misaligned top and bottom face halves from Experiment 5.

Source	*df*	MSE	*F*	*p*	η^2_p
Occupation congruence (OC)	1	19.09	0.004	.951	<.001
Alignment	1	44730	11.00	.002	.268
Position	1	74397	2.15	.153	.067
OC × Alignment	1	3	0.002	.969	<.001
OC × Position	1	6	0.01	.947	<.001
Alignment × Position	1	537	0.11	.737	.004
OC × Alignment × Position	1	1077	0.36	.553	.012
Error	30				

Table 6.

ANOVA of the correct reaction times for recognising the identities of aligned and misaligned top and bottom face halves from Experiment 6.

Source	*df*	MSE	*F*	*p*	η^2_p
Occupation congruence (OC)	1	539	0.41	.531	.022
Alignment	1	34920	4.52	.048	.201
Position	1	87339	3.65	.072	.168
OC × Alignment	1	353	0.13	.724	.007
OC × Position	1	1301	0.60	.448	.032
Alignment × Position	1	4110	0.87	.363	.046
OC × Alignment × Position	1	784	0.38	.544	.021
Error	18				

Table 7

Summary of principal findings. Cells are left blank when the relevant factor was not manipulated. Note that Gender Congruence x Alignment interactions are present whether Gender Congruence is task-relevant or task-irrelevant. In contrast there are no significant interactions of Occupation Congruence x Alignment. Higher-order interactions involving these variables are seen, but not consistently.

Expt.	Task	Response	Congruence effect			
			Gender Congruence		Occupation Congruence	
			Present	Evidence	Present	Evidence
1	Gender	2AFC	Yes	Gender Congruence x Alignment p = .001, η^2_p = .41		
2	Identity	4AFC	Yes	Gender Congruence x Alignment p = .074, η^2_p = .13		
3	Gender	2AFC	Yes	Gender Congruence x Alignment p = .012, η^2_p = .21	Partly	Occupation Congruence x Alignment p = .94, η^2_p = .00 Occupation Comgruence x Alignment x Position p = .015, η^2_p = .20
4	Occupation	2AFC	Yes	Gender Congruence x Alignment p = .010, η^2_p = .22	Partly	Occupation Congruence x Alignment p = .42, η^2_p = .02 Occupation Comgruence x Alignment x Gender Congruence p = .034, η^2_p = .16
5	Identity	4AFC			No	No significant effects involving Occupation: Occupation Congruence x Alignment p = .97, η^2_p = .00
6	Identity	4AFC			No	No significant effects involving Occupation: Occupation Congruence x Alignment p = .72, η^2_p = .01