
Face perception is whole or none: disentangling the role of spatial contiguity and interfeature distances in the composite face illusion

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Abstract. Compelling evidence that faces are perceived holistically or configurally comes from the composite face illusion: identical top halves of a face are perceived as being different if they are aligned with different bottom halves. The visual illusion disappears when the top and bottom face halves are spatially misaligned. Whether this is because the two halves no longer form a whole face (ie they form two segmented parts), or because of an increase in interfeatures distance in the misaligned condition (eg eyes–mouth distance) remains unclear. Here, thirty-four participants performed a delayed matching composite task in which the amount of spatial misalignment between face halves varied parametrically (from 8.33% of face width to 100%). The difference in performance between aligned and misaligned faces (ie the composite face effect) was already of full magnitude at the smallest level of misalignment. These results imply that a small spatial misalignment is sufficient to measure the composite face effect. From a theoretical standpoint, they indicate that it is the breaking of a whole configuration rather than the increase in relative distance between the face parts that explains the presence or absence of the composite face effect, clarifying an outstanding issue concerning the nature of holistic face perception.

Keywords: face perception, holistic perception, configuration, composite face effect

1 Introduction

Face recognition is difficult because faces form a visually homogenous category with numerous exemplars: these exemplars must be individually discriminated correctly and rapidly, and individualisation of a face can be potentially based on multiple parts, which make a face unique only when they are considered altogether.

In order to cope with the difficulty of face recognition, it is widely acknowledged that humans have developed the ability to see a face immediately as a whole configuration, rather than having to decompose it part by part (eg Biederman and Kalocsa 1997; McKone et al 2003; Rhodes et al 1993; Rossion 2013; Sengco 1986; Tanaka and Farah 1993; Tanaka and Gordon 2011; Young et al 1987).

The most compelling illustration of this unforced perceptual integration—usually referred to as holistic or configural perception—is a visual illusion that originates from the composite face effect (CFE). The CFE was first reported as a difficulty to name the top or bottom half of a famous face aligned with the bottom or top half of another famous face, respectively (ie a composite face) (Young et al 1987). For unfamiliar faces, this effect emerges as a result of a powerful visual illusion: identical top halves of faces are perceived as being different when they are aligned with different bottom halves (Hole 1994; see also Rossion 2008, 2013 for compelling illustrations; and figure 1). This visual illusion shows that facial parts (here the two halves of the face) cannot be perceived independently from one another. Rather, the face is perceived as an integrated whole.

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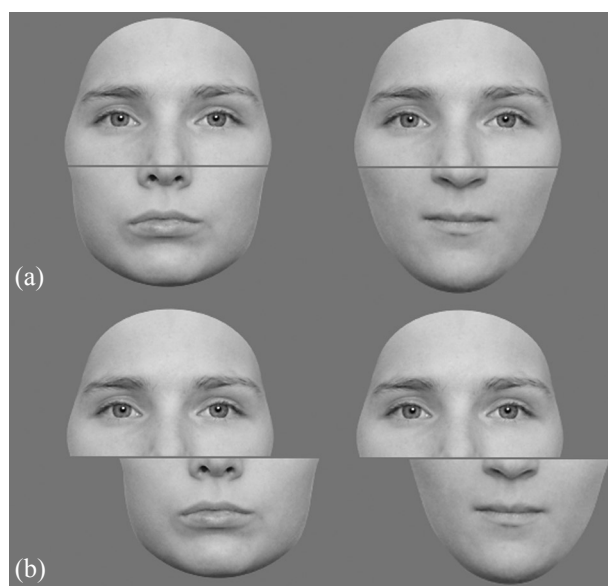


Figure 1. The composite face illusion. (a) The two identical top halves are perceived as being different because they are aligned with different bottom halves. Misaligning the bottom halves as in (b) breaks the illusion. This powerful visual illusion indicates that our visual system integrates automatically the two halves of a face into a global configuration.

Following Young et al (1987), the typical way to disrupt the visual illusion is to misalign horizontally the two halves of the face (figure 1). This spatial misalignment breaks the whole configuration by moving the two face halves away from each other. Hence, two identical top halves of an unfamiliar face are more likely to be judged as ‘different’ when they are aligned with different bottom halves than when they are misaligned with these different bottom halves (eg Goffaux and Rossion 2006; Le Grand et al 2004; Robbins and McKone 2007; Rossion and Boremanse 2008; Taubert and Alais 2009). The CFE is thus first and foremost a spatial alignment effect [see Rossion (2013) for an extensive review of the CFE].

Despite all the attention dedicated to the CFE, an outstanding issue concerns the nature of the effect due to spatial misalignment: does performance recover in this condition because (i) this manipulation breaks the whole configuration into two parts or (ii) because it changes the metric distances between the facial parts of the top and bottom halves, such as the distance between the eyes and the mouth (Young and Bruce 2011, page 263)?

According to the first view, the CFE is disrupted by the physical, horizontal separation of the face halves. When the face halves are aligned, they follow the Gestalt law of *continuity*, which states that oriented units/points tend to be integrated into perceptual wholes if they are connected or aligned with each other in straight or smoothly curving lines (Wertheimer 1925/1967; see Pomerantz and Kubovy 1986). When the face halves are spatially misaligned, they break the continuity of the contour/shape of the face and no longer respect the law of continuity. It is a manipulation of the stimulus that goes directly against perceptual integration of its parts. Moreover, spatial misalignment in the composite face paradigm is not just *any kind* of part separation: segmenting the two parts by moving one of the parts laterally creates a stimulus that is physically implausible, has never been experienced, and cannot fit any holistic template.

According to the second view, the disruption of the illusion/effect with spatial misalignment rather comes from the increased relative distance between the parts of the two halves of the face, such as the eyes (in the top half) and the mouth (in the bottom half). Relative distances between face parts are thought to be important for individualising faces (Carey 1992; Diamond and Carey 1986; Haig 1984; Le Grand et al 2001; Mondloch et al 2003). Hence, the CFE may disappear with spatial misalignment because the distances between face parts are dramatically increased.

The resolution of this outstanding issue (Young and Bruce 2011, page 263) could go a long way towards the identification of the nature of holistic/configural perception, and perhaps help to develop a more integrated framework of this mode of processing (McKone and Yovel 2009; Rossion 2009). Importantly, inversion of the stimulus—a manipulation that is sometimes used as an alternative control to spatial misalignment (eg Hole 1994)—cannot help resolving this issue either because this manipulation impairs both holistic perception (measured as an interdependence between facial parts, eg Sergent 1984; Tanaka and Farah 1993) *and* the perception of relative distances between facial parts [eg Freire et al 2000; see Rossion (2008, 2009) for reviews and the proposal that the second impairment is the consequence of the first].

Two behavioural studies have brought data that are especially relevant to this debate. Taubert and Alais (2009) found that the magnitude of the CFE did not differ for the two levels of misalignment (quarter-width and half-width of the face), suggesting a minimal role for relative distances between face parts in the CFE. However, since the smaller level of misalignment was already quite substantial (25% of face width), these results do not clarify the role of relative distances between face parts as opposed to a break in the overall configuration of the face. Also, because there was no gap between the top and bottom halves in the aligned condition of that study, the CFE might have been increased because the difference with the quarter-width face concerned both the relative distances between face halves and the segmentation in two parts (see Rossion 2013 for a discussion about the importance of including a small gap between the two face halves). More recently, de Heering and Maurer (2012) showed that changing relative distances between internal parts of the face by elevating the eyes, even by a substantial amount, had little or no significant effect on the magnitude of the CFE. However, such a dramatic change of the height of the eyes should also impair the matching of the face to a holistic template. Hence, these results are not only difficult to understand—the CFE would have been expected to decrease when the height of the eyes was increased by an abnormal amount—but also they cannot be taken as clear evidence for or against one of the two views outlined above. More generally, these two studies did not manipulate distances between face halves or face parts parametrically, in order to assess precisely the role of these factors in accounting for the CFE.

To shed light on this issue, we designed a parametric experiment by varying gradually the amount of spatial misalignment between two face halves—from fully aligned to fully misaligned (figure 2).

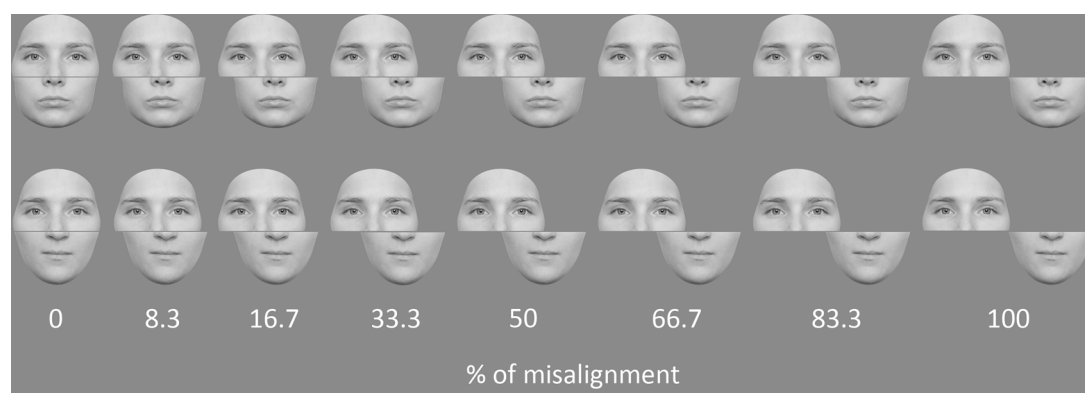


Figure 2. Two examples of stimuli used in this study: identical top faces are associated with different bottom faces. There are eight levels of (mis)alignment between the top and bottom halves.

This manipulation allows us to explore two predictions. First, if the loss of the CFE for misaligned faces is the result of an increase in the distance between face parts, then the effect should still be substantial for a minimal amount of spatial misalignment and decrease progressively with the increase in spatial misalignment between the top and bottom halves. Alternatively, if the effect is primarily the result of the breaking of the whole face configuration, most if not all of the effect should disappear with a minimal amount of spatial misalignment, with no further increase associated with increasing degrees of spatial misalignment. To test this latest account fully to the test, we also added an extra minimal step of misalignment, corresponding to 8.33% (1/12) of face width, or 0.46 deg. With such a small degree of misalignment, the distance between the eyes and mouth has barely changed compared with an aligned face. Yet, the whole face configuration has clearly changed (figure 2), so that it may affect (ie increase) performance in the task.

2 Materials and methods

2.1 Participants

Thirty-four undergraduate students (mean age = 22.6 ± 3.41 years, eight males) took part in the study in exchange for course credits. All participants had normal or corrected-to-normal vision.

2.2 Stimuli

The task was a same/different task in which subjects had to judge whether the top halves of two consecutively presented faces were the same or different. The faces were presented in one of the eight alignment conditions. To create these conditions, coloured photographs of 23 full-front faces were used (neutral expression, nine males, no glasses or facial hair). The faces were approximately 5.5 cm wide and 6.7 cm high (at a distance of 70 cm, the aligned faces were approximately 5.47 deg wide and 5.3 deg high). Each original face was separated into a top and bottom half by inserting a small gap (1.8 mm, 2.7% of face height) under the tip of the nose using Adobe Photoshop. For each face, six parametric levels of misalignment (from completely aligned to completely misaligned, see figure 2) were then created by shifting the bottom part to the right in six equal steps of 16.66% of face width (1/6 of face width or 0.91 deg). An additional misalignment level of 8.3% of face width (1/12 of face width, 0.46 deg) was also used to test whether the effect could be disrupted by the slightest misalignment of the two halves (about 3.1 mm of increase for the distance between the left corner of the eye and the left corner of the mouth, or 8% of that distance). For aligned faces and for each level of misalignment (ie 8 kinds of faces in total), the top part of each face was then paired with the bottom part of another face to create 23 composite faces (top01–bottom02, top02–bottom03, etc). Pairings were made carefully so that the nose aligned well with the top and bottom halves for all faces, and the width of the bottom half was adjusted to fit the top half when necessary (see Rossion 2013).

2.3 Procedure

Each trial started with a fixation cross (300 ms), followed 200 ms later by a first face presented for 200 ms. After a 350 ms interval, a second face stimulus was presented until the participant gave a response (figure 3).

The first stimulus was always the original face (top and bottom from the same face), for all trial types. The second face always had the same level of (mis)alignment of its two halves as the first face (eg 33.33% to 33.33%, 83.33% to 83.33%, etc). Trials requiring a ‘same’ response on the top half could have either the same bottom half (‘same’ condition: eg top01–bottom01 followed by top01–bottom01) or a different bottom half (‘same–bottom-different’ condition: eg top01–bottom01 followed by top01–bottom02).

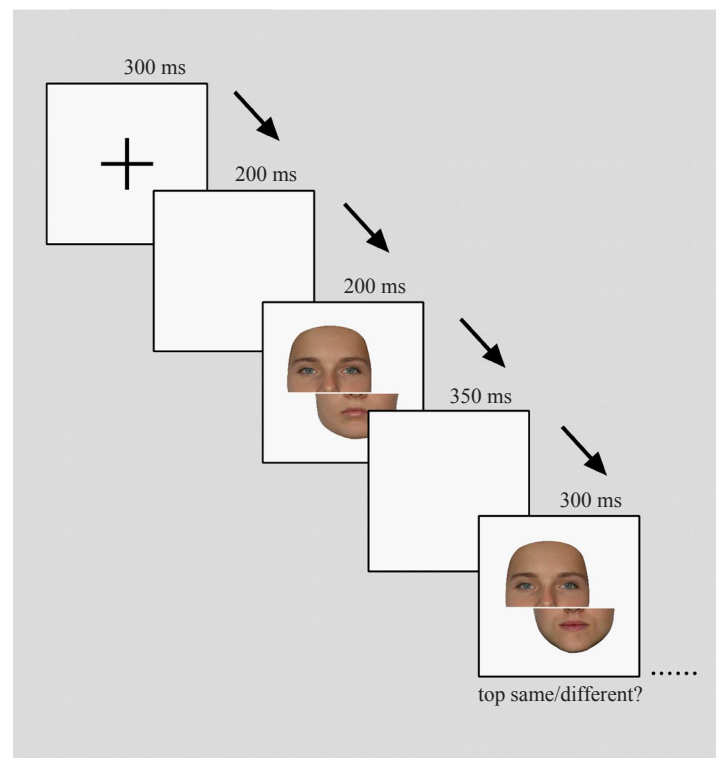


Figure 3. [In colour online, see <http://dx.doi.org/10.1068/p7534>] The paradigm used in the study. Subjects always had to match the top halves of the two faces presented in succession. As in almost all previous studies, the top part only was used as the target, for a couple of reasons. First, because information in the top half of a face is more diagnostic than in the bottom half (eg Haig 1985; Sadr et al 2003); and, second, because human observers naturally and firstly fixate the top half of a face rather than the bottom half (eg Henderson et al 2005; Hsiao and Cottrell 2008; Orban de Xivry et al 2008; see Rossion 2013 for a discussion of this issue).

In trials requiring a ‘different’ response, the faces always differed in both halves (‘different’ condition: eg top01–bottom01 followed by top02–bottom02).⁽¹⁾ In total, there were 23 trials for each *alignment* level and *identity* (‘same’, ‘same–bottom-different’, ‘different’), resulting in a total of 552 trials ($23 \times 8 \times 3$).

Participants were instructed to ignore the bottom half and to focus on the top part of the face throughout the whole experiment. They were asked to indicate whether the top parts of the faces were identical or different by pressing one of two keys on a computer keyboard. After 8 practice trials, participants completed four blocks of 138 trials. They were asked to answer as accurately and as quickly as possible. Stimuli were presented and accuracy and response times were collecting using E-Prime 2 (Psychology Software Tools Inc, Sharpsburg, PA).

2.4 Data analysis

The CFE is usually measured by comparing aligned and misaligned conditions for which the top half is identical—requiring a ‘same’ response—and the bottom half is different (eg Goffaux and Rossion 2006; Le Grand et al 2004; Michel et al 2006; Robbins and McKone 2007). In addition, ‘same’ trials in which *both* the top and bottom halves are identical can be used as a

⁽¹⁾ This paradigm has sometimes erroneously been referred to as a ‘partial’ design because there are no trials in which the target (top) half differs and the bottom halves are identical. However, this ‘partial’ labeling is misleading because the present paradigm is as complete as possible to measure the CFE. Adding such trials is only carried out to measure a general ‘Stroop-like’ congruency/interference effect that could be the result of decisional and response conflict processes (Rossion 2013).

baseline as they require the same kind of process and response as ‘same–bottom-different’ trials (eg Jiang et al 2011). These trials were thus analysed here, together with the ‘same–bottom-different’ trials. The performance for the ‘different’ trials, in which both the top and bottom halves differ, is not taken into account in the analysis (eg Le Grand et al 2004; see Rossion 2013). Based on previous studies, in order to collect a large amount of data directly relevant for the CFE while limiting the total duration of the experiment, only one third of trials required a ‘different’ response and two thirds required a ‘same’ response from the participants (eg Michel et al 2006; Rossion and Boremanse 2008). Participants were not aware of this manipulation.

For each participant, accuracy rates and correct response times (RTs) were computed for the two conditions of interest (‘same’ and ‘same–bottom-different’) and (mis)alignment level. Since the CFE is usually observed both in accuracy rates and correct RTs, inverse efficiency (IE) was also computed for each participant (correct RTs divided by accuracy rates; Townsend and Ashby 1983).

3 Results

3.1 Accuracy

Accuracy rates were very high, ranging from 93.6% to 98.2% in the different conditions, except for the aligned condition on ‘same–bottom-different’ trials for which the performance decreased (89.5%) (figure 4).

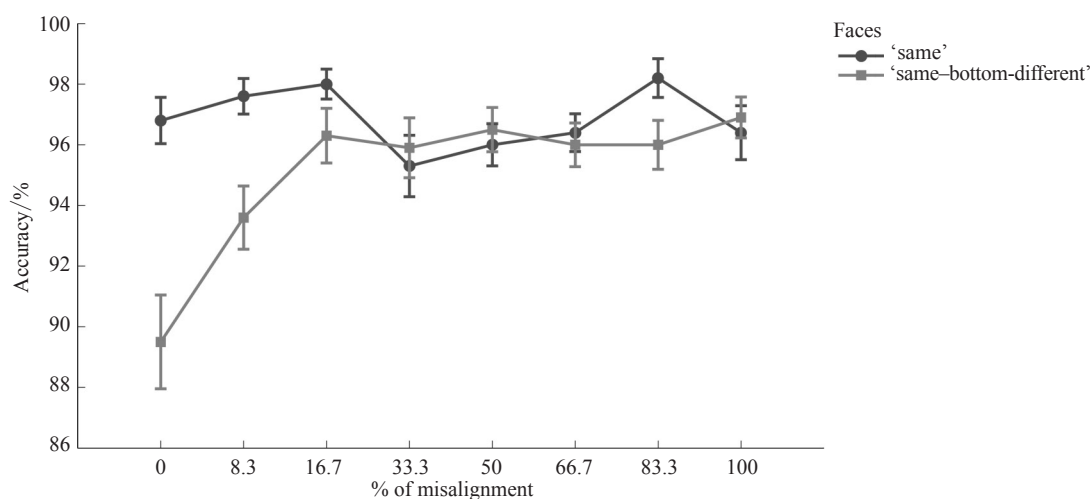


Figure 4. Results: accuracy rates (% of correct responses). Error bars = standard errors of the mean. ‘Same–bottom-different’ = faces for which the top halves were the same and the bottom halves differed. ‘Same’ = faces that were identical both for the top and bottom halves.

A two-way repeated-measures ANOVA with identity (same, or ‘same–bottom-different’) and alignment (8 levels) as within-subjects factors showed a main effect of identity ($F_{1,33} = 16.5, p < 0.001$) and of alignment ($F_{7,231} = 6.4, p < 0.001$). These two effects were qualified by a significant interaction between identity and alignment ($F_{7,231} = 7.6, p < 0.001$), indicating that the drop in performance for same–bottom-different as compared with same trials was of different magnitude for the levels of misalignment.

In order to explore this interaction, the two-way ANOVA was split into two one-way ANOVAs (8 levels of alignment) for same and same–bottom-different trials separately.

For same–bottom-different trials, there was a highly significant effect of alignment ($F_{7,231} = 10.26, p < 0.001$). Although polynomial a posteriori contrasts indicated a significant linear contrast ($F_{1,33} = 25.778, p < 0.001$), an additional highly significant quadratic component

($F_{1,33} = 21.202$, $p < 0.001$) is necessary to explain the data. This indicates that performance increases linearly with misalignment, but levels off rapidly. A posteriori Scheffé tests indicate that this levelling off takes place as early as the second data point (8.33% misalignment): there was a significant difference between the aligned condition and all other conditions: ($p = 0.05$) in comparison with the lowest level of misalignment (all other $ps < 0.001$) but no significant differences between all other levels (all $ps > 0.24$). For same trials, there was a significant effect of alignment ($F_{7,231} = 2.4$, $p = 0.021$), even though performance was close to ceiling (95% to 98%, figure 4). However, a posteriori tests failed to show any significant effect for pairwise comparisons (all $ps > 0.18$).

3.2 Response times (RTs)

A relative increase of RTs was found only for the aligned ‘composite’ condition relative to all other conditions (figure 5).

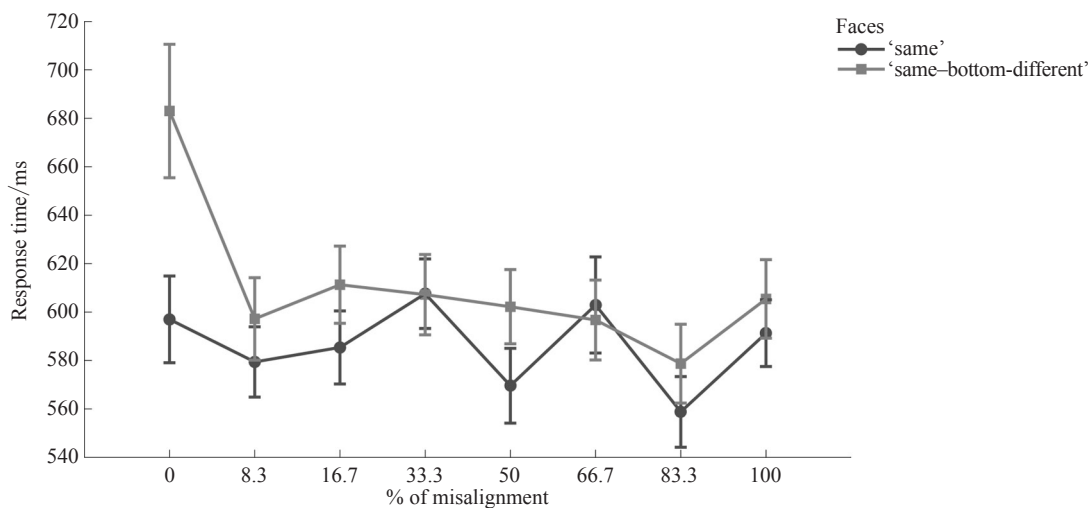


Figure 5. Results: correct RTs. Error bars = standard errors of the mean. ‘Same–bottom–different’ = faces for which the top halves were the same and the bottom halves differed. ‘Same’ = faces that were identical both for the top and bottom halves.

There was a main effect of identity ($F_{1,33} = 50.9$, $p < 0.001$), and of alignment ($F_{7,231} = 16.25$, $p < 0.001$), qualified again by a significant interaction between identity and alignment ($F_{7,231} = 10.43$, $p < 0.001$).

Again, two one-way ANOVAs were used to explore this interaction. For same–bottom–different trials, there was a highly significant effect of alignment ($F_{7,271} = 17.15$, $p < 0.001$). Although a posteriori polynomial contrasts indicated a significant linear contrast ($F_{1,33} = 22.42$, $p < 0.001$), an additional highly significant quadratic component ($F_{1,33} = 22.687$, $p < 0.001$) is necessary to explain the data. This indicates that performance increases linearly with misalignment, but levels off rapidly. This was confirmed by a posteriori contrasts (Scheffé), indicating a significant difference between the aligned condition, associated with the slowest RTs, and all other conditions (all $ps < 0.001$) but no significant differences between all other levels (all $ps > 0.4$) (figure 5). For same trials, there was also an effect of alignment ($F_{7,271} = 8.22$, $p > 0.001$). However, unlike for same–bottom–different trials, this effect was not due to aligned trials showing slower responses than all other trials, but to slight variations of RTs, without a consistent pattern: shorter RTs at level 6 (83.3 %) of misalignment than four other levels (aligned, 50%, 66%, and 100%, $ps < 0.03$), and the 50% level of misalignment being slower than the 66.6% ($p < 0.025$).

3.3 Inverse efficiency (IE)

To give a full account of the results, we analysed the IE by dividing correct RTs by the proportion of correct trials (higher IE values indicate lower performance) (figure 6).

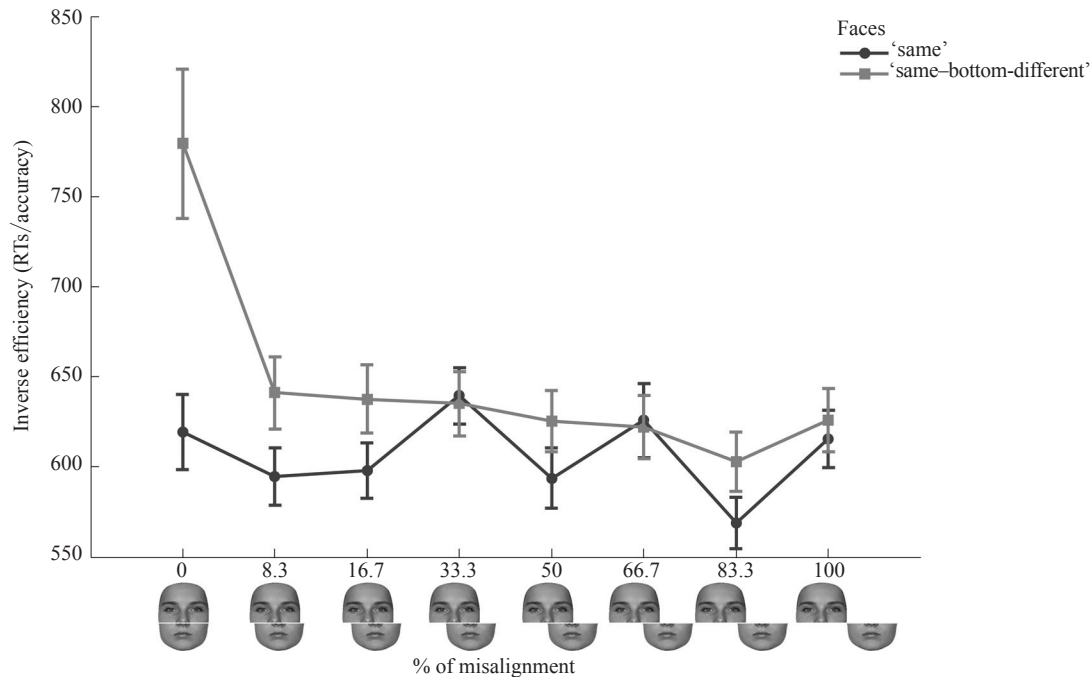


Figure 6. Inverse efficiency scores, summarising the performance in all the conditions. Error bars = standard errors of the mean. 'Same-bottom-different' = faces for which the top halves were the same and the bottom halves differed. 'Same' = faces that were identical both for the top and bottom halves.

There was a main effect of *identity* ($F_{1,33} = 45.46$, $p < 0.001$), and of alignment ($F_{7,231} = 18.43$, $p < 0.001$), qualified by a significant interaction between identity and alignment ($F_{7,231} = 16.33$, $p < 0.001$). For same-bottom-different trials, there was a highly significant effect of alignment ($F_{7,271} = 17.15$, $p < 0.001$). Again, there was a polynomial significant linear component ($F_{1,33} = 26.800$, $p < 0.001$), with an additional highly significant quadratic component ($F_{1,33} = 26.921$, $p < 0.001$) to explain the data. This indicates that performance increases linearly with misalignment, but levels off rapidly. Accordingly, there was a significant difference between the aligned condition, associated with the highest inverse efficiency, and all other conditions (all $ps < 0.001$). There were no significant differences between all other levels (all $ps > 0.67$). For same trials, there was an effect of alignment ($F_{7,231} = 20.61$, $p > 0.001$). Again, unlike for same-bottom-different trials, this effect was not the result of aligned trials showing slower responses than all other trials, but of slight variations of IEs (driven entirely by RTs), without a consistent pattern: lower IE at level 6 (83.3%) of misalignment than at four other levels (aligned, 50%, 66%, 100%, $ps < 0.007$), and the 33% level of misalignment being associated with higher IE than four other levels (16.66%, 50%, 66.6%, 100%, $ps < 0.027$).

In summary, the effect of alignment in the CFE is not at all related to the amount of spatial misalignment between the top and bottom halves of the face. In critical same-bottom-different trials, there was only a difference between the aligned condition—associated with poorer performance—and all other conditions, without any difference between the different levels of misalignment.

3.4 Correlation analysis

Finally, to assess whether the slight drop in accuracy at the smallest level of misalignment (8.33% of face width; figure 4) could reflect a small CFE, we tested for a relationship between accuracy in this condition and accuracy in the aligned condition. The difference between same and same-bottom-different trials was computed for each of the thirty-four participants, for the two kinds of trials separately, and correlated across participants. Our rationale was that if the small difference for the 8.33% condition is related to the effect found for the aligned condition, there should be a significant correlation across participants (ie a participant showing a large effect for aligned faces would also show an effect for the 8.33% condition, etc). However, neither for accuracy rates ($r_{34} = 0.01$, $p = 0.95$), RTs ($r_{34} = 0.12$, $p = 0.49$), or for inverse efficiency ($r_{34} = 0.24$, $p = 0.18$), were there significant correlations, indicating that any slight drop in performance at this level of misalignment (8.33%) was not related to the effect found for aligned faces. Note that this lack of effect cannot be attributed to the small number of data points, as our sample size was reasonably high ($N = 34$) and each participant's data is based on an average of 23 trials. To strengthen this latter point, we also defined two samples based on even and odd trials (split half technique, 11 trials only to make an average for each sample) for the aligned condition only and computed a difference (same – same-bottom-different) for each participant, for each sample. The correlation between the two samples based on interindividual variance was highly significant both for RTs and for IE ($r_{11} = 0.53$, $p = 0.001$; $r_{11} = 0.52$, $p = 0.002$). This correlation reflects the fact that participants presenting with a large (small) effect for half of the trials in the aligned condition also have a large (small) effect for the other trials of this aligned condition.

4 Discussion

In the critical trials (identical top halves aligned with different bottom halves), we found an increase of performance for misaligned as compared to aligned faces (ie a CFE) as soon as the two halves were spatially misaligned by 8.33% of face width. Critically, performance did not increase further with further increases of spatial misalignment, so that the magnitude of the CFE did not differ at all between the different levels of spatial misalignment. This finding has both important practical and theoretical implications.

From a practical point of view, the results indicate that future studies can use a minimal amount of spatial misalignment between face halves to measure the composite effect (an effect that is widely used in face perception research, see Rossion 2013). Rather surprisingly, this factor has been neglected in previous studies, in which the amount of misalignment between face halves in the misaligned control condition can vary substantially. Yet, using aligned (ie experimental) and misaligned (ie control) conditions that differ as little as possible in this paradigm is always preferable to minimise the potential contribution of additional factors to the difference between conditions. In fact, given that performance fully recovered with a spatial misalignment of 8.33% face width, it may be that even smaller values could be used. In future studies, a more fine-grained manipulation, with a staircase procedure, could be performed to identify the threshold at which the CFE is maximal. Note that the misalignment of 8.33% face width that gave rise to a full recovery of performance in the present study is valid for faces presented at a given size and distance from the observer (here, at a distance of 70 cm, the aligned faces were about 5.47 deg wide). This 8.33% value may not be valid if faces are made much smaller, for instance. Unfortunately, the size-invariance of the CFE remains unknown, so that it is difficult to speculate about the putative interaction between stimulus size and the amount of spatial misalignment between face halves that is necessary to recover

full performance in this paradigm.⁽²⁾ A conservative approach would be to use a spatial misalignment factor of 16.66% of face width.

From a theoretical point of view, our observations support the view that the CFE is due to a break of the global contour, changing dramatically the overall shape of the face, rather than to an increase of relative distances between face parts of the top and bottom halves. Thus, they help to clarify an important issue in the face perception literature (see Young and Bruce 2011, page 263). These observations are in line with findings that the CFE is driven primarily by shape rather than by surface-based information (Jiang et al 2011), and the observation that the visual illusion decreases when the overall contour of the face is normalised, or ‘ovalised’ (Rossion 2013, Figure 42).

Why is the integrity of the global contour, and of the overall shape of the face, so important? As noted in the introduction, spatial misalignment of the face halves breaks the Gestalt law of continuity, which states that oriented units/points tend to be integrated into perceptual wholes if they are connected or aligned with each other in straight or smoothly curving lines (Pomerantz and Kubovy 1986). A modern view of this manipulation is that horizontal misalignment of the two halves of a face breaks the continuity of the contour of the face by introducing an *edge*, or a *nonaccidental property* (NAP, Biederman and Shiffrar 1987; Lowe 1985).⁽³⁾ Therefore, spatial misalignment corresponds to a physical separation of the whole face into two distinct parts.⁽⁴⁾ Importantly, spatial misalignment in the composite face paradigm is not just *any kind* of part separation: segmenting the two parts by moving laterally one of the parts creates a stimulus that is physically implausible, has never been experienced, and cannot match a whole-based face representation (contrary to half of a face presented in isolation, or a single face part). Such a whole template-based matching, as opposed to a feature-based matching, seems essential for the initial encoding of a face. Indeed, spatially misaligning the top and bottom halves of a face increases the amplitude and delays the latency of the earliest face-selective response recorded on the human scalp (occipito-temporal N170, see Jacques and Rossion 2010; Letourneau and Mitchell 2008). This effect is similar to the effect of inversion on the N170, and has been attributed to an increase of difficulty of encoding and/or the recruitment of additional object-related processes for inverted or misaligned face stimuli (Jacques and Rossion 2010; Rossion et al 1999).

Our observations do not support the view that the CFE is primarily, or even substantially, due to an increase in relative distance between the parts of the two halves of the face, such as the eyes and the mouth. This conclusion is in agreement with the findings of previous studies mentioned in the introduction (de Heering and Maurer 2012; Taubert and Alais 2009), although the results of these studies were left open to interpretation regarding the question asked specifically in the present study. Interestingly, in the study of Taubert and Alais (2009), the authors found a disappearance of the CFE by laterally misaligning

⁽²⁾ McKone (2009) has investigated the range of stimulus size suitable for holistic face perception. However, this was carried out with face detection tasks (ie detection of a generic ‘Mooney’ face in a display, dominance of an upright over an inverted face on a transparent display) rather than a face individualisation task as in the CFE, this latter task requiring finer grained visual information.

⁽³⁾ Although it has been suggested that face recognition is relatively less impaired by a change in NAP than a change in metric distances (Biederman and Kalocsai 1997; Cooper and Wojan 2000), this may be valid as long as the NAP change, such as elevating one eye in the face, does not change the outer contour of the face, breaking it into two distinct parts.

⁽⁴⁾ The small gap between the two halves, which was used also for aligned faces, is not an issue because the human visual system tends to enclose a line or a space by completing a contour and ignoring such gaps in a figure, the so-called Gestaltist law of *closure* (Pomerantz and Kubovy 1986; Wagemans et al 2012; Wertheimer 1925/1967). In fact, without a gap, there is a more salient contiguous border, defined by a small variation of luminance and texture gradient, between the top and bottom halves (see Rossion 2013).

the two face halves by 25% of face width while the effect was still present for a the same magnitude of misalignment applied vertically (see Figure 1 in Taubert and Alais 2009)—a finding that also goes against the role of distances between face halves in the CFE. However, in that study, the vertical 25%-width modified face was also compared to a face without any gap at all (unsegmented halves), so that the CFE might have been artificially increased. Moreover, the vertical 25%-width was so substantial that it modified the overall shape of the face, and the contour was normalised ('ovalised') in all conditions (see Rossion 2013 for a discussion of these issues). Nevertheless, this is a manipulation⁽⁵⁾ that can be applied to our face stimuli with preserved overall shape and a gap, using the minimal value of 8.33% of face width as determined in the present study. Interestingly, if the gap between the two halves is increased vertically to provide the exact same distance between the eyes and the mouth as in the 8.33% face width, the composite face illusion is quite substantial (figure 7). This observation supports the conclusion that elongating the distance between the eyes and the mouth, at least to an extent that is compatible with real-world interattribute distances, is not a critical factor in the CFE.

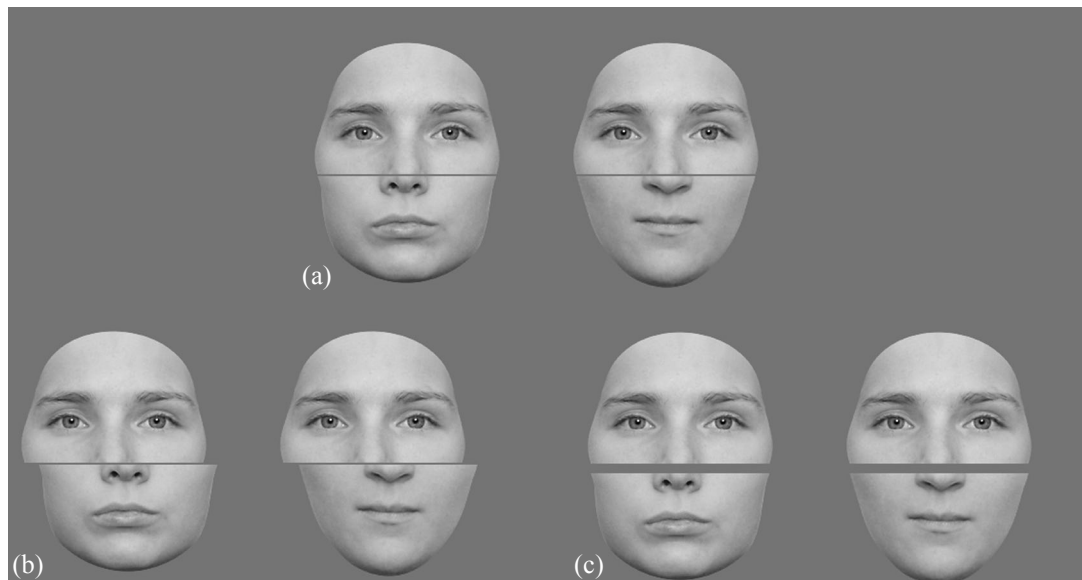


Figure 7. Here the illusion presented in figure 1, and which is reproduced in part (a) is displayed on (b) with a small misalignment of 8.33% face width, the minimal amount of misalignment between face halves used in the study. (c) On the right, the distance between the two face halves has been increased without moving the bottom half laterally. Relative to the display in (a), the amount of distance change between the eyes and the mouth is the same in (b) and (c). Yet, the illusion is still clearly present in (c) but vanishes in (b) (at least when focusing on the centre of the faces).

This observation also brings us to comment briefly on the role of relative distances between face parts in face perception, which may be less important than initially thought. The importance of such cues is due to Haig's (1984) observation that the sensitivity of human adults to slight alterations in the positions of the features of a set of faces is excellent, evidence that children do not perform very well at extracting relative distance between face parts (eg Mondloch et al 2002), and findings that face inversion also impairs the perception

⁽⁵⁾ Although this is an interesting manipulation, in itself it cannot answer the question asked in the present study because one could always argue that the features are spatially aligned in the vertical axis in one case (vertical shift) and not in the other case (horizontal shift). Another confounding factor is that all the distances between the features increase uniformly with a vertical shift, while some distances increase (eg left eye vs mouth) and others decrease (eg right eye vs mouth) in the horizontal shift.

of these relative distances (eg Freire et al 2000). However, these latter two sources of evidence do not necessarily imply that relative distances are important for upright face perception in adults. And, in Haig's (1984) study, the ranges of these manipulations were arbitrary with respect to normal variations of face part positions in real life, and there was no assessment of the critical role of such manipulations in actual face identification tasks. In fact, when human observers are required to recognise faces solely on the basis of real-world interattribute distances, they perform poorly across a broad range of viewing distances (Taschereau-Dumouchel et al 2010).

Finally, since our data indicate that the critical factor in the CFE is the break of the face contour that makes two separate face parts in the misaligned condition, and because ignoring a distractor that is located in a different object than the target is easier than if both distractor and target are embedded in the same object (eg Kramer and Jacobson 1991), one could argue that the source of the CFE is attentional: (covert) attention would be reduced for the misaligned bottom half as compared with the aligned bottom half. To put it differently, because perceptual organisation constrains attentional selectivity (eg Chen 2012; Kimchi 2009; Kramer and Jacobson 1991), it may be argued that the composite effect is due to a difference in object-based attention between aligned and misaligned trials. However, a putative difference in attention between aligned and misaligned faces does not necessarily mean that object-based attention *accounts* for the composite effect. Rather, it is likely that perceptual integration takes place *before* any attentional process, and would instead influence the *subsequent* allocation of attention (see Kimchi 2009).

In summary, we observed a full CFE (misaligned > aligned) already with a 8.33% face misalignment width, indicating that the critical factor subtending the effect is the introduction of a break in the overall face contour, rather than an increment in spatial distance between face halves. These findings suggest that the CFE is primarily due to a mismatch between a face stimulus with misaligned halves and a whole-based face template during perceptual encoding of the face.

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