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# Electrophysiological correlates of the composite face illusion: Disentangling perceptual and decisional components of holistic face processing in the human brain

Dana Kuefner [a,*], Corentin Jacques [a,b], Esther Alonso Prieto [a], Bruno Rossion [a]

[a] Université Catholique de Louvain, Louvain-la-Neuve, Belgium
[b] Department of Psychology, Stanford University, Stanford, USA

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ABSTRACT

When the bottom halves of two faces differ, people's behavioral judgment of the identical top halves of those faces is impaired: they report that the top halves are different, and/or take more time than usual to provide a response. This behavioral measure is known as the composite face effect (CFE) and has traditionally been taken as evidence that faces are *perceived* holistically. Recently, however, it has been claimed that this effect is driven almost entirely by decisional, rather than perceptual, factors (Richler, Gauthier, Wenger, & Palmeri, 2008). To disentangle the contribution of perceptual and decisional brain processes, we aimed to obtain an event-related potential (ERP) measure of the CFE at a stage of face encoding (Jacques & Rossion, 2009) in the absence of a behavioral CFE effect. Sixteen participants performed a go/no-go task in an oddball paradigm, lifting a finger of their right or left hand when the top half of a face changed identity. This change of identity of the top of the face was associated with an increased ERP signal on occipito-temporal electrode sites at the N170 face-sensitive component (~160 ms), the later decisional P3b component, and the lateralized readiness potential (LRP) starting at ~350 ms. The N170 effect was observed equally early when only the unattended bottom part of the face changed, indicating that an identity change was perceived across the whole face in this condition. Importantly, there was no behavioral response bias for the bottom change trials, and no evidence of decisional biases from electrophysiological data (no P3b and LRP deflection in no-go trials). These data show that an early CFE can be measured in ERPs in the absence of any decisional response bias, indicating that the CFE reflects primarily the visual perception of the whole face.



## 1. Introduction

The efficiency with which human adults are able to recognize hundreds or perhaps even thousands of faces has been proposed to depend on the ability to process faces in a *holistic* manner. To process a face holistically means that rather than processing local facial features (eye, nose, mouth, ears...) independently, the face is processed as a single global perceptual representation, i.e. as a whole. This implies that a modification to a subset of features, or even to one feature, is capable of altering the perception of the overall face (Galton, 1883). This dependant relationship between the processing of local features and of the entire face has been demonstrated in a number of classical behavioral experiments (e.g., Sergent, 1984; Tanaka & Farah, 1993; Tanaka & Sengco, 1997). However, the most compelling evidence favoring the idea that faces are processed holistically comes from the composite face effect (CFE, Young, Hellawell, & Hay 1987).

The CFE was first described (Young et al., 1987) as an increase in the time needed to name the top part of a familiar face (cut below the eyes) when it is aligned with the bottom part of another face, relative to the time needed to name the top part when the same top and bottom parts are laterally offset (i.e. misaligned). With respect to unfamiliar faces, this effect emerges as a result of a visual illusion: identical top halves of faces are perceived as being slightly different when they are aligned with different bottom halves (see Fig. 1; see also Rossion, 2008; Rossion & Boremanse, 2008). This visual illusion nicely demonstrates that facial features (here the two halves of the face) cannot be perceived independently from one another, but rather that the face is perceived as a whole.

Since originally being reported, the CFE has been observed consistently in matching tasks that require discrimination of individual, unfamiliar, composite faces (see Hole (1994) for a first demonstration). In these tasks, participants are more likely to judge two identical top halves of a face as being different when they are presented with different bottom parts that are aligned with the top parts, in comparison to when the top and bottom

* Corresponding author. Address: Université Catholique de Louvain (UCL), Institute of Research in Psychology (IPSY), and Institute of Neuroscience (IoNS), Center for Cognitive and Systems Neuroscience, Place Cardinal Mercier, 10, B-1348 Louvain-la-Neuve, Belgium. Fax: +32 (0) 10 47 37 74.
*E-mail address:* dana.kuefner@uclouvain.be (D. Kuefner).

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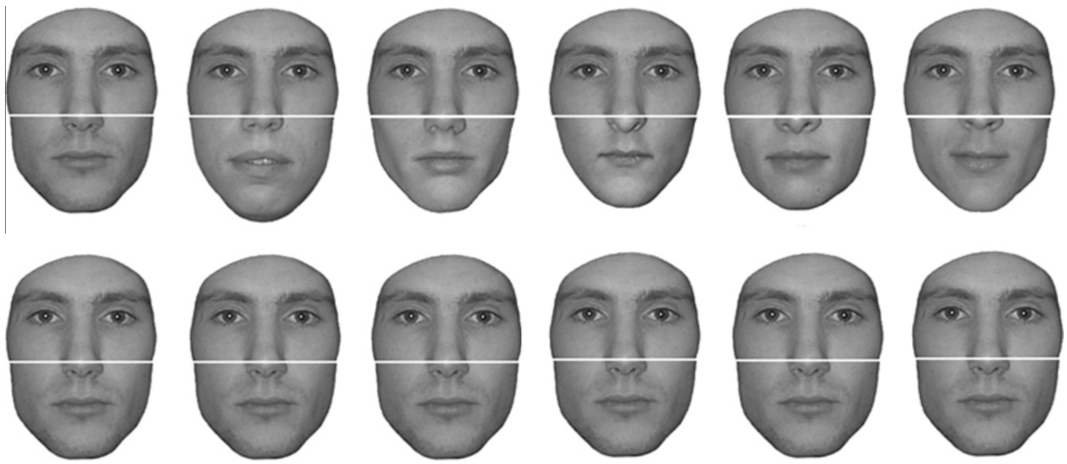

**Fig. 1.** Illustration of the composite face illusion. All top halves (above the white line) are identical, but when aligned with distinct bottom parts (top row), they appear slightly different. This illusion reflects the perception of the face stimulus as an integrated whole. When the two halves of the face are aligned with identical bottom parts (bottom row), it becomes obvious that the top parts are the same.

parts are misaligned. This happens despite the fact that the bottom parts of the face are irrelevant for the task, (e.g., Goffaux & Rossion, 2006; Le Grand, Mondloch, Maurer, & Brent, 2004; Michel, Rossion, Han, Chung, & Caldara, 2006; Robbins & McKone, 2007; Taubert & Alais, 2009) and that eye gaze remains fixed on the top parts of the faces (de Heering, Rossion, Turati, & Simion, 2008). When faces are inverted, the composite effect either disappears or is strongly attenuated (e.g., Goffaux & Rossion, 2006; Hole, 1994; Hole, George, & Dunsmore, 1999; Rossion & Boremanse, 2008; Young et al., 1987).

### *1.1. Is the composite face effect driven by decisional response biases?*

Overall, the existing evidence demonstrating interdependent processing of the top and bottom halves of composite faces has led researchers to propose that the functional locus of the CFE is perceptual (Farah, Wilson, Drain, & Tanaka, 1998; Rossion, 2008, 2009). That is, that faces are *perceived* holistically. However, the perceptual nature of holistic face processing in general (Wenger & Ingvalson, 2002), and of the CFE in particular, has recently been challenged (Richler, Gauthier, Wenger, & Palmeri, 2008; see also Cheung, Richler, Palmeri, & Gauthier, 2008; Richler, Tanaka, Brown, & Gauthier, 2008). Specifically, Richler, Gauthier, et al. (2008) used the multidimensional generalization of signal detection theory known as *general recognition theory* (GRT; e.g., Ashby & Townsend, 1986; Kadlec & Townsend, 1992; Thomas, 1995) to analyze data from a behavioral same/different discrimination task with composite faces. Using GRT, the authors inferred that the composite effect is driven both by perceptual, as well as decisional (i.e. response related) factors, with the most consistent evidence pointing to a decisional locus of the effect. Although the authors admitted that signal detection theory could not speak to *how* decisional factors may influence the outcome of a composite face task, they suggested that decisional biases may be gained through experience. In particular, the authors postulated that extensive experience with faces may cause people to develop a deeply ingrained assumption that face parts change together. The strength of this assumption would make it difficult to override during an experiment, even when participants are instructed to selectively attend only to the top half of the face. This bias, in turn, would affect the percept of the face, as measured by the composite face task. Richler, Gauthier and colleagues (2008) suggested that such a decisional bias, because it relates to a domain of expertise, may be deeply ingrained and relatively immune to task influences.

### *1.2. Neuroimaging and electrophysiological evidence for a perceptual locus of the composite face effect*

It is reasonable to assume that decisional response biases may arise as a consequence of the perception of the composite face illusion. That is, when observers are presented with two identical top halves of faces each paired with a different bottom half, they tend to make more errors (i.e. respond "different") and/or take more time when having to match the face halves. However, the claim that holistic face processing is *driven* by decisional factors (Richler, Gauthier, et al., 2008) seems difficult to reconcile with the available neuroimaging and electrophysiological evidence from studies of the CFE. For example, fMRI studies have shown that following adaptation to an aligned composite face, there was a significantly larger response to the same top part of a face when it was aligned with a different bottom part as compared to when it was aligned with the same bottom part. This "neural CFE" was found particularly in the right middle fusiform gyrus (rMFG), as well as less strongly in the right inferior occipital gyrus (IOG) (Schiltz, Dricot, Goebel, & Rossion, 2010; Schiltz & Rossion, 2006) two areas of the human visual cortex that have been shown to respond preferentially to faces ("FFA" and "OFA" respectively; Gauthier et al., 2000; Kanwisher, McDermott, & Chun, 1997; Puce, Allison, Gore, & McCarthy 1995; Sergent, Ohta, & Macdonald 1992). These results, which were not found when faces were spatially misaligned or inverted, suggests that neurons in these visual areas integrate information from the two aligned face halves into a single representation of the whole face.

Most recently, evidence from scalp event-related potentials (ERPs) showed that following adaptation, top halves of faces with different aligned bottoms produced larger responses than the same top halves of faces with the same bottoms, as early as 160 ms post-stimulus onset (Jacques & Rossion, 2009),[1] on the face-sensitive N170 component (Bentin, McCarthy, Perez, Puce, & Allison, 1996; see Rossion & Jacques, 2008, 2010). Again, this was not the case when the faces where spatially misaligned. Since the face-sensitive N170 component at occipito-temporal recording sites is independent of

[1] Other recent studies have reported modulations of the N170 to aligned and misaligned halves of faces as in the composite face effect (Ishizu, Ayabe, & Kojima, 2008; Jacques & Rossion, 2010; Letourneau & Mitchell, 2008). These studies reported an increased and delayed N170 when face halves were spatially misaligned. However, they did not test the composite face effect in face individualization, by measuring how a perceived change of identity in the top part of the face affects the ERP signal, the N170 amplitude in particular, during face identity adaptation/repetition.