Vision Research 112 (2015) 26–32

Contents lists available at ScienceDirect

Vision Research

journal homepage: www.elsevier.com/locate/visres

# Dynamic composite faces are processed holistically

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ARTICLE INFO

*Article history:*
Received 5 November 2014
Received in revised form 24 April 2015
Available online 14 May 2015

*Keywords:*
Familiar face perception
Composite effect
Holistic processing
Dynamic faces

ABSTRACT

Holistic processing is considered one of the hallmarks of face recognition. Recent studies using the composite task claim to show a lack of holistic processing for dynamic faces, however they only presented moving faces in the learning phase and tested with static composite images. So while previous research has addressed the question of whether moving faces influence the processing of subsequently viewed static faces, the question of whether moving faces are processed holistically remains unanswered. We address that question here. In our study participants learned faces in motion and were tested on moving composite faces, or learned static faces and were tested on static composite faces. We found a clear composite effect for both upright static and dynamic faces, with no significant difference in the magnitude of those effects. Further, there was no evidence of composite or motion effects in inverted conditions, ruling out low level or other motion signal properties as explanations of performance in upright faces. Together, these results show that upright moving faces are processed holistically, in a similar manner to static faces, extending decades of research with static faces and confirming the importance of holistic processing to familiar face recognition.



## 1. Introduction

Faces, as we encounter them in the real world, are typically seen in motion. As such, there is an obvious ecological validity to studying faces in motion. Although much research has investigated the utility of motion for face recognition (e.g., O'Toole, Roark, & Abdi, 2002; Roark et al., 2003; Xiao et al., 2014), little has investigated how motion influences the *way* in which faces are processed. Further, the little research there is has led to inconsistent results.

Although there is often disagreement on exactly what holistic processing is, and whether it can only be applied to faces, there is general agreement that holistic processing is fundamental to face recognition (see Piepers & Robbins, 2012). Holistic processing is defined here as the perceptual integration of information across the whole face. The most common direct measure of holistic processing is the composite face effect, in which recognition of a target face half is much harder when it is aligned with a complementary face half than when the halves are misaligned. The new "identity" created when two face halves are aligned is processed holistically, making it difficult to attend to and identify the target face half while ignoring the other half (see Rossion, 2013, for review). However the vast majority of studies examining holistic face processing have only tested static faces, whereas real faces move. Facial motion may be rigid, involving changes in orientation to the head, or elastic, involving non-rigid transformation of muscles as occurs during speech and expressions. Recently, Xiao et al. (2012, 2013) published two studies employing the composite task, which they claim show that holistic processing is absent or significantly reduced for rigid and non-rigid moving faces. If true, this would require a fundamental re-think of face perception. However we argue that while these studies may answer the question of how motion in a previously seen face influences recognition in a static image, they leave open the question of whether information across moving faces is integrated in a holistic fashion. In this paper we directly address this issue by testing whether faces in motion are susceptible to the composite illusion to a similar degree to static faces.

In both of their studies, Xiao et al. (2012, 2013) had participants learn whole faces in motion or in "multi-static" conditions but tested recognition accuracy of the target face half with *static* composite images using a front view. Xiao et al. (2012) used rigid motion in the familiarisation phase, comparing a head turn (coherent motion rotating from profile to profile) with a multi-static condition in which the same static image frames were presented in randomised order, thus providing only incoherent

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http://dx.doi.org/10.1016/j.visres.2015.05.002

motion (Experiment 1) or a multi-static condition in which the same images were presented in sequence with large intervals between images to prevent apparent motion (Experiments 2 and 3). Results showed a significant composite effect when target faces were learned in the multi-static condition, but none when learned with rigid motion, suggesting that rigid motion somehow disrupted the ability to process subsequently seen test faces holistically, whereas presenting the same images without coherent motion did not interfere with holistic processing. Xiao et al. (2012) argued that rigid motion provides stable viewing conditions that allow attention to parts, however the typical composite task shows a stable single static image (or a pair of static images), and this is where holistic processing is typically found. In a subsequent study, Xiao et al. (2013) compared the composite effect when faces were learned in elastic motion (a front view face chewing and blinking) with a multi-static condition (in which six frames from the motion sequence were presented in random order, similar to the multi-static condition in their previous study, but confusingly called "static" in this paper). Xiao et al. (2013), unlike Xiao et al. (2012), found a significant composite face effect when faces were learned in elastic motion, although it was smaller than the multi-static condition.

Despite finding an alignment effect for faces learned in elastic motion conditions, Xiao et al. (2013) concluded that these two studies together show that motion enhances part-based processing and that "natural face processing may not be done primarily in a holistic manner" (p. 9). However, an alternative explanation may be that the composite effect requires stability or similarity of the presentation and viewing conditions from learning to test (Richler, Bukach, & Gauthier, 2009; Richler et al., 2008; Rossion, 2013). One way that study and test faces may differ is in their alignment (e.g., aligned or whole faces are studied and misaligned faces are tested). Explanations of results become complicated when alignment conditions differ at study and test since they cannot be argued to have arisen solely from part-based processing on misaligned trials (because the face is seen in the first instance as whole and unaltered). Another way that study and test faces may differ is in their motion (e.g., moving faces are studied and static faces are tested). When motion differs from study to test, results may be a product of mismatching cues. Regardless of whether static and moving faces are both processed holistically, it remains that case that there are different perceptual cues and processes (e.g., changes in shape and speed of elements over time) available in each format. It may be more difficult to complete the composite task based on holistic perception when certain information available at study is no longer available at test. To compensate for this dissimilarity participants may adopt a diagnostic feature-based strategy or attend to a smaller region of the face, thus reducing the size of the composite effect. When study and test faces are in the same format, all information remains and switching strategies is unnecessary.

The results of Xiao et al. (2012, 2013) relate to how faces seen in motion might be subsequently recognised in a photograph. While this is a research problem with potential implications for security (e.g., matching real faces to passport photographs), the question of whether faces in motion are processed holistically remains unanswered. Until now, the composite identity effect has not been tested with dynamic face stimuli. A fundamental issue is whether two moving, aligned halves will be perceived as a novel whole face. There is some evidence to support this idea. Chiller-Glaus et al. (2011) show composite effects for some dynamic facial expressions. Note, though, that expression composites comprise two halves of the *same* identity with different expressions. Steede and Hole (2006) showed that while half faces primed famous face recognition, neither static nor dynamic (artificially animated) composite faces did. This result suggests that both static and dynamic composites were processed holistically as new whole faces (making identification of the target half for priming more difficult). More generally, the composite illusion is quite robust to image distortions. It has been shown that it is the spatial contiguity of the face halves that is essential for forming a whole face percept (Rossion, 2013; de Heering, Wallis, & Maurer, 2012) so it is expected that the aligning of dynamic face halves from two different identities will induce the illusion of a "new" composite face.

There is also indirect evidence for the holistic processing of moving faces using the inversion task. Studies have shown equivalent sized inversion effects when identifying famous faces in dynamic compared to static images (Knight & Johnston, 1997; Lander, Christie, & Bruce, 1999), suggesting similar levels of holistic processing. More recently, Thornton, Mullins, and Banahan (2011) found larger inversion effects in a gender categorisation task for dynamic faces compared to static faces (and no inversion effects for bodies) suggesting potentially enhanced holistic processing in dynamic faces (since gender judgements require holistic processing; Zhao & Hayward, 2010).

In the current experiment, we used a naming composite task to measure recognition of face halves learned and tested as dynamic stimuli or learned and tested as static stimuli. That is, participants learned to name dynamic (elastic motion) face halves and, crucially, were tested on recognition of target halves in a dynamic composite. As such, the target face half information available at learning and at test is equivalent. We compared performance on dynamic faces at learning and test with static faces and included an inversion manipulation to control for any effects of the task procedure and low-level properties (e.g., contrast, motion signals). Note that using a naming version of the composite task (see Carey & Diamond, 1994; McKone, 2008) has the advantage of avoiding the "standard" vs "complete" design issue (see Rossion, 2013 and Richler & Gauthier, 2013).

We expect to replicate the robust composite effect for upright static face stimuli and find no evidence of alignment effects for inverted static faces. If faces in motion are also processed holistically then we should find the same pattern for dynamic face stimuli. If integration does not occur across two moving face halves, that is, dynamic faces are not processed holistically, then we should expect to find either: (i) no alignment differences for upright dynamic stimuli, or (ii) equivalent composite effects for both upright and inverted dynamic stimuli (suggesting that the motion signal alone is sufficient to complete the task).

## 2. Method

### 2.1. Participants

Thirty-two undergraduate students (nine male) from the University of Wollongong participated in the experiment. Sample size was comparable with that of similar studies. The age range of participants was 18–45 years ($M = 22.0$ years). All participants gave informed consent. Research was carried out in accordance with the Code of Ethics of the World Medical Association (Declaration of Helsinki) and research protocol approved by the University of Wollongong Human Research Ethics Committee (reference HE13/267).

### 2.2. Design

All manipulations were within subjects. That is, each person participated in 2 (motion: static and dynamic) × 2 (alignment: aligned and misaligned) × 2 (orientation: upright and inverted) conditions. The experiment comprised four blocks, one for each condition: upright static, upright dynamic, inverted static, and