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Interhemispheric cooperation for face recognition but not for affective facial expressions

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Abstract

Interhemispheric cooperation can be indicated by enhanced performance when stimuli are presented to both visual fields relative to one visual field alone. This "bilateral gain" is seen for words but not pseudowords in lexical decision tasks, and has been attributed to the operation of interhemispheric cell assemblies that exist only for meaningful words with acquired cortical representations. Recently, a bilateral gain has been reported for famous but not unfamiliar faces in a face recognition task [Neuropsychologia 40 (2002) 1841]. In Experiment 1 of the present paper, participants performed familiarity decisions for faces that were presented to the left (LVF), the right (RVF), or to both visual fields (BVF). An advantage for BVF relative to both LVF and RVF stimuli was seen in reaction times (RTs) to famous faces, but this bilateral advantage was absent for unfamiliar faces. In Experiment 2, participants classified the expression (happy or neutral) of unfamiliar faces. No bilateral advantage was seen for expressions, although a right hemisphere superiority was seen in terms of higher accuracy for LVF and BVF trials relative to the RVF. Recognition of famous faces (but not of facial expressions) require access to *acquired* memory representations that may be instantiated via cortical cell assemblies, and it is suggested that interhemispheric cooperation depends on these acquired cortical representations.

Keywords: Hemispheres; Asymmetry; Face recognition; Emotion

1. Introduction

The cerebral hemispheres develop specialisations for a number of tasks [19,33]. For instance, language processing has been attributed to the left hemisphere (LH), whereas face processing has been related to right hemisphere (RH) function [40]. However, whereas traditional models tended to stress an absolute "dominance" of the LH or RH for a particular task, more recent work has emphasized that tasks should be considered as composed of separable task components [32], and that *relative* rather than absolute specialisation exists for a number of tasks [45]. This leads to the important question as to if and how the two hemispheres collaborate in cognitive processing [20].

One possibility to test hemispheric interaction is to present stimuli tachistoscopically either unilaterally to the left (LVF) or right visual fields (RVF), or to present the *same* stimuli simultaneously to both fields (BVF) [13]. The anatomy of primary visual pathways provides that LVF and RVF stimuli project directly to the RH and LH, respectively. Thus, unilateral stimuli initially project to only one hemisphere, but bilateral stimuli project to both hemispheres simultaneously. Many studies demonstrated better processing in the bilateral condition compared to the *best* unilateral condition. This effect (also called *bilateral advantage* or *bilateral gain*) has been found for words [16,27,28,30] and famous faces [25]. In contrast, it has never been seen for meaningless pseudowords [30] or unfamiliar faces [25]. A bilateral advantage has been first observed in lexical decision, where participants discriminate between words and pronounceable pseudowords in a series of letterstrings by speeded keypress responses. A consistent finding in this task is that words but not pseudowords lead to a robust bilateral advantage [27–30]. Moreover, in a split-brain patient with complete commisurotomy in whom any (cortically mediated) interaction between the hemi-

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spheres was unlikely, the bilateral advantage was absent [29].

These findings indicate four major theoretically important processing characteristics of the two hemispheres: First, redundant information facilitates processing, but only for previously learned stimuli (such as words or famous faces). Second, facilitation also occurs when information is divided across hemispheres, supporting the notion of hemispheric cooperation rather than independence. Third, hemispheric cooperation after bilateral presentation of a stimulus reflects cortical representation of that stimulus over both hemispheres. Fourth, the lack of a bilateral advantage in split-brain patients suggests that this bihemispheric representation includes excitatory connections via the corpus callosum [4,29,36].

Several models have been proposed to explain the bilateral advantage. First, a bilateral advantage might reflect a simple "horse race" between two independently operating hemispheres, in which the hemisphere specialised for a certain operation "wins the race" [49]. Accordingly, this would cause a pattern in which performance for bilateral trials is always superior to unilateral trials *for all kinds of stimuli* (for discussion [26]). Thus, a horse race model fails to account for a bilateral advantage seen for some stimuli but not for others.

A neurocognitive model can better account for this differential bilateral advantage. Based on Hebb's theory [18], it has been held that words are cortically represented by strongly connected cell assemblies (CAs). CAs may be distributed across both hemispheres [35], in line with findings of relative rather than absolute specialisation of the LH for language processing [45,53]. If a word is represented by a CA that is distributed across both hemispheres, there will be strong excitatory connections across the corpus callosum within this CA. If stimulated with only one copy via input through one hemisphere, the CA activation is relatively slow and less efficient than when stimulated with two copies via input through both hemispheres. This would explain a bilateral advantage for meaningful words. At the same time, no bilateral advantage should be seen for novel pseudowords which are relatively meaningless, and which are not thought to be represented by cortical CAs.

Although the bilateral gain has been mainly investigated in language studies, it should be possible to extend this account to the processing of other stimuli. Faces seem a good candidate stimulus, because although many aspects of face perception seem to be lateralized to the RH [40,42,44,48], both hemispheres contribute to it [10,11,46]. We have recently demonstrated a bilateral advantage in a face recognition task [25]. Participants performed familiarity judgements for famous and unfamiliar faces flashed to either the RVF, LVF, or BVF. A significant bilateral advantage was obtained for famous but not for unfamiliar faces. These results extend earlier findings beyond the verbal domain, and suggest that interhemispheric cooperation may depend on the recognition of stimuli for which a cortical representation has been acquired. Alternatively, interhemispheric cooperation might depend on the recognition of stimuli which are particularly meaningful or informative (e.g. "target" stimuli, such as words in lexical decision, or famous faces in face familiarity decision).

The aim of the present study was to extend our initial findings on interhemispheric cooperation in face processing, by comparing two different face processing tasks (face recognition versus recognition of facial expressions). In Experiment 1, participants performed familiarity judgements for famous and unfamiliar faces presented to either the RVF, LVF, or BVF. In Experiment 2, we presented unfamiliar faces with different expressions (either happy or neutral), and the task was to recognise the expression displayed.[1] The recognition of facial expressions, just like facial identification, is thought to rely more on the RH than the LH [48]. Also, happy expressions can be regarded as informative target stimuli in this task, just like famous faces can be regarded as informative target stimuli in a familiarity task. However, we reasoned that the recognition of expressions does not require the contact with a learned cortical representation in the same way as recognition of face identity does.

Identification of a face clearly requires the contact with an acquired memory representation, and one that is likely stored cortically, presumably in inferior temporal areas [12,47]. It is also more difficult to store and identify faces from other-race faces [50]. In contrast, the ability to recognise facial expression is thought to be innate and universal across cultural and racial borders [14]. Humans easily recognise expressions of someone they have never seen before, suggesting that recognition of expression does not require access to an acquired cortical representation. Instead, recognition of facial expression may be mediated by phylogenetically older limbic mechanisms, in particular the amygdala [1] or basal ganglia [9].

These considerations led us to propose the following hypotheses. If interhemispheric cooperation depends on whether recognition involves an acquired cortical representation, we would predict a bilateral gain for famous but not unfamiliar faces in the familiarity task. In addition, we would not expect a bilateral advantage for faces in an expression task. In contrast, if interhemispheric cooperation depends on whether or not the stimulus is an informative target stimulus for a particular task, one would expect a bilateral gain for affective but not for neutral expressions in an expression task.

[1] We used a neutral and an expressive condition, rather than two different expressions, in order to make the task more similar to the face familiarity decision in Experiment 1. Specifically, we reasoned that relative to neutral faces happy faces would operate as relatively informative "target" stimuli, just like familiar faces would operate as relatively informative "target" stimuli relative to unfamiliar faces. Reaction time in two-choice discrimination or recognition tasks depends on the criteria set by participants [37], and based on the above reasoning we predicted faster RTs for those stimuli that participants regard as targets (i.e. faster RTs for famous than unfamiliar faces in Experiment 1, and faster RTs for happy than neutral faces in Experiment 2).