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# Interhemispheric cooperation for familiar but not unfamiliar face processing

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**Abstract**

Evidence for interhemispheric cooperation during language processing has been demonstrated for words, but not for meaningless pseudowords. Specifically, responses were found to be faster and more accurate when identical copies of a word were presented bilaterally to both hemispheres, relative to unilateral single presentations. This bilateral advantage for words seems to be a robust effect in normals. The present study addressed the question of whether the bilateral advantage is restricted to lexical material or whether it is a more global phenomenon occurring for meaningful material in general. Thirty healthy participants performed a familiarity decision in which one copy of familiar and unfamiliar faces was presented tachistoscopically to the right visual hemifield (RVF), the left visual hemifield (LVF) or simultaneously to both visual hemifields (bilateral condition, BVF). We obtained a highly significant familiarity by visual field interaction ($P < 0.006$) showing that only for familiar faces, a bilateral advantage was obtained. Unfamiliar face processing did not yield a bilateral advantage. We conclude that interhemispheric cooperation only occurs for meaningful material for which cortical representations can be assumed. 

*Keywords:* Bilateral advantage; Hemispheres; Interhemispheric interaction; Face perception

## 1. Introduction

Relative specialization of the left and right cerebral hemisphere in humans for diverse perceptual and cognitive tasks has been demonstrated by a large number of studies. Insights into lateralized brain functions have come from brain damaged patients with unilateral lesions, from split-brain patients and from healthy persons undergoing particular experimental testing (e.g. lateralized tachistoscopic techniques or dichotic listening). In addition, modern brain imaging techniques, such as measurement of cerebral blood flow or high-resolution electroencephalogram (EEG) and magnetoencephalogram (MEG) have provided greater insight into the brain sites, areas and the temporal aspects involved in cognition and perception. Research has shown that certain cognitive processes, or some aspects of these processes, are lateralized to the left hemisphere (LH) or right hemisphere (RH) [10]. For many tasks including language or face processing, however, it seems more appropriate to speak of relative instead of absolute functional lateralization [30,36]. This leads to the question of interhemispheric interaction: to what extent, how and for what kind of material do the two cerebral hemispheres coordinate their respective processing abilities in order to operate most effectively?

One way to test hemispheric interaction with behavioral measures is to present stimuli tachistoscopically to the left visual hemifield (LVF) or right visual hemifield (RVF) (unilateral conditions) and simultaneously to both visual hemifields (bilateral condition, BVF)—a paradigm first used by Dimond and Beaumont in the early 1970s [5]. In the bilateral condition, both hemispheres are stimulated at the same time, whereas, in the unilateral conditions, only one hemisphere is stimulated initially (before information crosses the corpus callosum). By comparing performance in unilateral conditions with performance in bilateral conditions, it is possible to obtain a measure of hemispheric interaction. To this end, many studies on interhemispheric interaction have been conducted and there are many different models trying to incorporate multiple aspects of the findings obtained so far [2,10,24,29,44]. None of these models, however, is capable of explaining all of the existing data available and taking into account possible neurophysiological

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mechanisms underlying interhemispheric communication. One reason for this may be the fact that the experimental designs used in the study of interhemispheric interaction vary between studies. In particular, the bilateral stimulation condition differs most. Bilateral stimulation with two stimuli often leads to a so-called bilateral advantage, meaning better behavioral performance resulting from bilateral stimulation compared to unilateral stimulation. The definition and meaning of the term bilateral advantage is dependent on the particular question addressed and the experimental paradigm used to investigate hemispheric interaction. To give some examples, we would like to contrast three different approaches and paradigms: One approach addresses the question: (i) whether hemispheric asymmetries can be enhanced by bilateral stimulus presentation. This question has been investigated in a number of studies using bilateral displays contrasted with unilateral ones. In the bilateral display, two different, though similar, stimuli are always presented simultaneously to both visual fields. Boles [3] presented two different words and non-words, or bar graphs in a task in which the target stimulus had to be named. He showed that hemispheric asymmetries were significantly larger when two different stimuli were simultaneously presented in the two visual hemifields. This enhancement of hemispheric asymmetries by bilateral displays compared to unilateral displays has been called bilateral advantage [3] and has also been demonstrated in a go–no go task where study participants had to respond only to words [27].

Another question addressed is: (ii) whether it is advantageous (in terms of better behavioral performance) to divide cognitive processing between the hemispheres or whether it is more effective to restrict processing to one hemisphere only. Experimental designs to investigate this question include conditions in which the stimulus information is either restricted to one visual field/hemisphere or divided between the two hemifields. Thus, same and different stimuli are presented simultaneously. The task requires integration (matching or semantic categorization) of stimuli presented across or within hemispheres. It is important to note, that in the bilateral condition, the necessary information for doing the task properly, is presented partially to the LVF and partially to the RVF and is, therefore, divided between the hemispheres. This paradigm has been tested for letters, patterns, numbers, ASCII symbols and objects [4,13,15,42]. In many, though not all of these experiments, a bilateral advantage has been obtained. This means that bilateral presentation of stimuli, in which the relevant information has to be matched or categorized across hemispheres, leads to better performance compared to unilateral presentation of the necessary information [13,15]. This processing advantage seems to occur in complex, but less likely in simple matching tasks [1,42] and has been interpreted as hemispheric cooperation, dependent on the complexity of the task performed [42].

The third question is: (iii) whether the two hemispheres operate together or independently of each other or even inhibit each other when processing the same stimulus [20,44]. A way to test this, is to present redundant, identical stimuli either unilaterally or bilaterally in both visual fields (bilateral redundant trials). This design differs from former designs insofar as the same stimulus, redundant target, is always presented in the bilateral condition. In these studies, a bilateral advantage has been obtained. This means better processing of a certain stimulus when two copies of the same stimulus are simultaneously presented to both visual fields compared to the best unilateral condition in which only one copy of a stimulus is presented. This has been demonstrated by Miller [18] in a simple reaction time experiment. Similarly, Minuissi et al. [19] presented bars in the LVF, RVF and bilaterally while they recorded electrocortical responses with the EEG. Experimental participants reacted significantly faster to bilaterally presented stimuli than to unilateral ones. The physiological indicator of this bilateral advantage was a shorter latency of the P1 and N1 component of the event-related potential. The authors conclude that a bilateral advantage occurs at a relatively low perceptual level of processing. Bilateral presentation of consonant–vowel–consonant (CVC) syllables in most cases does not lead to a reliable bilateral advantage. Performance after bilateral stimulation instead resembles the performance in the RVF condition ([9], but see [16]). Meaningful words always lead to a robust bilateral advantage in healthy controls [6,16,20,22,23]. In contrast, processing of meaningless pseudowords does not result in better processing of bilaterally presented stimuli. To explain these data, it has been argued that the bilateral advantage could simply result from higher spatial uncertainty in the unilateral conditions compared to the bilateral one. Theeuwes [40] showed, however, that even under equal spatial-load conditions, a bilateral advantage was obtained for letters, ruling out the spatial uncertainty argument.

The bilateral advantage observed in these studies has been taken as evidence for interhemispheric cooperation and seems to be strongly dependent on the intactness of the corpus callosum [4,21]. This brain structure seems necessary for transferring complex information between the hemispheres, whereas, the transfer of simple information seems possible via extracallosal pathways [31].

All of the studies mentioned above (i)–(iii) address the question of how the two hemispheres interact when processing verbal and non-verbal stimuli simultaneously presented to each visual hemifield. As outlined above, the outcome of these studies differs, depending on whether same or different stimuli are presented. This is not surprising given that, in the case of different stimuli, two similar, though different cortical representations may be activated, whereas, the same cortical representation is likely to be activated when identical stimuli are being processed [30]. In the present study, we refer to the term bilateral advantage as a significantly better performance in the bilateral stimulation condition relative to the best unilateral condition during redundant stimulus processing.