



The attentional blink within and across the hemispheres: Evidence from a patient with a complete section of the corpus callosum

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ABSTRACT

The attentional blink (AB) refers to an impairment in the report of a second target (T2) if it closely follows the presentation of a first target (T1) in a rapid serial visual presentation (RSVP), when both targets must be reported. In the present study, a modified AB paradigm was used in which targets could appear in any of four simultaneous RSVP streams, one in each quadrant of the visual field. In half of the trials, T1 and T2 were displayed in the same visual hemifield (either left or right) and, in the other half, T1 and T2 were displayed in different visual hemifields. Using this paradigm with both neurologically intact individuals and a split-brain patient, we sought to investigate (1) possible hemispheric asymmetries in attentional processes, and (2) whether the AB would be reduced when targets are displayed in different visual hemifields. A comparable AB was found for both neurologically intact individuals and the split-brain patient, with no significant variations due to whether targets were displayed in the same or in different hemifields. A left hemisphere advantage in the processing of same and different hemifield targets was observed only in the split-brain patient.

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1. Introduction

Attention enables us to select relevant information to be processed at the cost of a decreased awareness of unattended stimuli. Of interest in this study are the issues of hemispheric specialization in the processing of sequential visual targets and the effects of separating the processing of sequential targets between cerebral hemispheres by using a modified version of the attentional blink (AB) paradigm. In the most common AB paradigm, two targets are embedded in a rapid serial visual presentation (RSVP) stream of distractors presented at fixation (e.g., Raymond et al., 1992). Accurate report of a second target (T2) is typically impaired when presented within a stimulus onset asynchrony (SOA) between 200 ms and 500 ms of a first target (T1). Although there is still an ongoing debate about the level of processing at which the AB occurs and the exact causes of the AB, most models suggest that the AB occurs either as a result of an overload of post-perceptual mechanisms that consolidate targets

in visual short-term memory, for problems in target selection at a post-perceptual processing level, or for distractor-induced suppression of trailing targets processing (Chun and Potter, 1995; Dell'Acqua et al., 2009; Di Lollo et al., 2005; Jolicœur, 1998, 1999; Jolicœur and Dell'Acqua, 1998; Nieuwenstein, 2006; Olivers and Meeter, 2008).

AB paradigms have been used with both neurologically intact individuals and patients to investigate whether well-known functional inter-hemispheric differences (e.g., spatial, configural, stimulus category processing) could also extend to a different ability of the two hemispheres to process sequential targets. The picture emerging from these studies is somewhat mixed. Several studies provided evidence suggesting a selective advantage of the right hemisphere over the left hemisphere in processing sequential stimuli (Holländer et al., 2005; Kessler et al., 2005). However, using a lateralized version of the AB paradigm similar to the one used in Holländer et al. (2005), in which T1 and T2 were displayed left or right of fixation, Giesbrecht and Kingstone (2004) found that the AB in a split-brain patient was more pronounced when T2 was displayed to the right hemisphere relative to when T2 was displayed to the left hemisphere, suggesting a selective advantage of the left hemisphere over the right hemisphere in processing sequential stimuli. Given that this is the only study reporting a left hemisphere superiority, one interesting question is that pertaining to the validity of those findings. Would a different split-brain patient, tested under similar conditions, behave like that described

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by Giesbrecht and Kingstone (2004), thereby replicating some form of selective disadvantage of the right hemisphere (or, viceversa, a left hemisphere advantage) in the processing of sequential targets? To answer this question, we examined a different split-brain patient using an AB paradigm with targets displayed in either the same or opposite hemifields.

In split-brain patients, the callosal fibers connecting the hemispheres are surgically sectioned to relieve intractable epilepsy, in essence eliminating virtually all cortical transfer of information from one hemisphere to the other. Earlier studies suggested that even in the absence of a corpus callosum, attentional resources were shared between hemispheres (i.e., the harder a hemisphere works on a task, the worse the other hemisphere will do on a task of constant complexity; Holtzman and Gazzaniga, 1982). However, there is still some controversy pertaining to this issue as more recent work has found that visual-spatial attention systems are in fact divided, and there is no inter-hemispheric interference in the absence of the corpus callosum in divided-attention tasks (e.g., Arguin et al., 1999). Thus, if in fact the corpus callosum plays a role in mediating attentional processing of the hemispheres, bilateral presentation of targets should abolish the AB in the split-brain patient, but not in healthy participants. Moreover, any hemispheric asymmetries in the processing of rapid temporal information should be more pronounced in the split-brain, because no attentional resources could be recruited from a specialized hemisphere to aid task performance in the opposing hemisphere via callosal connections.

A second motivation underlying the present study is related to a methodological issue that arises in the presentation of lateralized stimuli in the AB paradigm. In the Holländer et al. (2005) study, only one RSVP stream was presented on each side of fixation. Consequently, T1 and T2 were always presented in the same RSVP stream in intra-hemispheric trials, whereas, T1 and T2 were always presented in different RSVP streams in inter-hemispheric trials. This complicates the comparison between intra- and inter-hemispheric processing of T1 and T2 because visual-spatial attention need not be shifted from one RSVP stream to the other RSVP stream in intra-hemispheric trials, whereas this is likely to occur in inter-hemispheric trials. In the Giesbrecht and Kingstone (2004) study, the confound between same-stream/different-stream presentation and within-hemisphere/between-hemisphere presentation compromises the interpretation of results in terms of hemispheric differences, particularly because of documented differences in the AB when T1 and T2 are presented in the same stream versus in different streams (see Dell'Acqua et al., 2003). To overcome these methodological problems, we used four simultaneous RSVP streams, one in each quadrant of the visual field. Targets were displayed in any of the streams with equal probability. In this way, two targets could appear either in the same visual field (intra-hemispheric condition, in the same or in different streams) or in opposite visual fields (inter-hemispheric condition, necessarily in different streams). This experimental design enabled us to compare within-hemisphere and between-hemisphere AB effects under equivalent T1–T2 between-stream presentation conditions.

2. Experiment

2.1. Method

2.1.1. Neurologically intact participants

Twenty-two participants (14 women; 13 right handed), aged from 19 to 39 years (mean of 22 years), participated in the experiment for financial compensation. Given that two previous studies have reported no correlation between general intelligence and the magnitude of the AB (Colzato et al., 2007; Martens and

Johnson, 2009), we did not match the neurologically intact group to the split-brain patient in terms of IQ.

2.1.2. Split-brain participant (M.L.)

M.L. is a 28 years old, left-handed man who underwent complete callosotomy for alleviation of intractable epilepsy at the age of 22. At the time of surgery, he had on average one generalized seizure and numerous absences per week. His seizures were characterized by a sudden fall followed by post-ictal confusion. At present, he has one or two absences per week. M.L. has retained complete independence of the responses signaled by his left and right hands. On standard cognitive assessments, M.L. has always functioned in the borderline range without a discernible discrepancy between his verbal and nonverbal skills. On the Wechsler Adult Intelligence Scale-Revised (WAIS-R), M.L. obtains a global IQ of 76. Presently, he lives with his father and is unemployed. His medication includes Dilantin, Lamictal, and Epival. A more detailed case history for M.L. can be found in Keenan et al. (2003).

2.1.3. Stimuli

Stimuli comprised four simultaneous RSVP streams of 14 randomly generated uppercase letter distractors (excluding B, I, and O) in which two digit targets were embedded. The RSVP streams were 2.2° (center to center) from fixation and equidistant from each other, one in each quadrant, as shown in Fig. 1. All characters were white on a black background and subtended an angle of 2° × 2°. Stimuli were presented using a 15-in. cathode-ray tube driven by a Pentium IV computer running MEL 2.0 software.

2.1.4. Design

Given that T1 and T2 could be presented unpredictably in any of the four RSVP streams, T1 and T2 sometimes appeared in the same RSVP stream (1/4 of the trials), and sometimes appeared in different RSVP streams (3/4 of the trials). When targets were presented in different streams, they could be presented in the same left–right visual hemifield (intra-hemispheric presentation) or in different hemifields (inter-hemispheric presentation). We anticipated that results from the same-stream trials would be different from the remainder of the trials because of previous work showing that these trials sometimes produce no AB effect, or even a reversed AB effect (Dell'Acqua et al., 2003). For present purposes, we focused mainly on two subconditions: (a) an intra-hemispheric condition in which T1 and T2 appeared in different streams, and (b) an inter-hemispheric condition in which T1 and T2 appeared in different hemifields.

A robust AB effect is observed whether subjects are required to count or identify the targets embedded in a central RSVP stream (Dell'Acqua et al., 2007). Therefore, to accommodate both M.L.'s limited manual dexterity with either hand (rendering typing responses on a numeric keypad difficult) and the fact that verbal responses could only be given for stimuli presented in the right visual field, we asked M.L., and control participants, to report how many digits they had seen (zero, one, or two digits) instead of the identity of the digits presented.

M.L. responded by lifting zero, one, or two fingers with the hand ipsilateral to the hemifield in which target(s) were seen (for example, M.L. would lift zero right hand fingers and one left hand finger to report having seen zero digits in the right hemifield and one digit in the left hemifield), and the experimenter recorded M.L.'s responses into the computer at the end of each trial. Control participants reported how many digits they saw on the left side of the visual display by pressing the “Z,” “X,” or “C” keys with fingers of the left hand for 0, 1, or 2 digits, respectively, and how many digits they saw on the right side of the visual display by pressing the “N,” “M,” or “,” keys with fingers of the right hand for 0, 1, or 2 digits, respectively.

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