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Note

Individual differences in interhemispheric transfer time (IHTT) as measured by event related potentials

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Abstract

The present study examined possible gender differences in interhemisperic transfer time (IHTT), as measured by event related potentials (ERPs). Using visual half-field presentations of letter pairs in a match/no-match paradigm, N1 latency was measured for each visual half-field and hemisphere. IHTTs were determined by subtracting the "direct" (i.e., contralateral or non-callosal) pathway N1 latency from the "indirect" (i.e., callosal) pathway N1 latency. Based on studies showing gender differences in corpus callosum size and function, we hypothesized that females would show more symmetric and faster overall transfer times than males. Results showed faster right-to-left IHTT across all participants, but females had more symmetric IHTT and shorter overall IHTT—primarily due to significantly shorter left-to-right times compared to males. Little support was found for the influence of hemisphere (i.e., "direct" pathway) response, or potential lateralization of function, on the length of IHTT in either direction.

Keywords: Interhemispheric transfer; IHTT; Gender; ERPs; Hemisphere specialization; Corpus callosum

The present study explored possible gender differences in the timing of information transfer between the cerebral hemispheres. Previous studies (Barnett & Corballis, 2005; Brown, Larson, & Jeeves, 1994; Rugg & Beaumont, 1978) have demonstrated that visual Event Related Potentials (ERPs) can be used to gauge interhemispheric transfer time (IHTT). For example, Brown et al. found that briefly presented letter pairs in the left visual field (LVF) or right visual field (RVF) generated faster latencies for "direct" pathway ERPs (e.g., LVF-Right hemisphere) than for "indirect" pathway ERPs (e.g., LVF-Left hemisphere). The difference between direct and indirect pathway latencies for the N1 portion of the ERP waveform, as measured from parietal leads, was presumed to constitute the IHTT. Brown et al. also found an asymmetry of IHTT, with right-to-left hemisphere transfer time being shorter than left-to-right. This asymmetry of transfer time was consistent with earlier ERP/IHTT studies (see meta-analysis by Brown et al., 1994) and studies using reaction time measures of IHTT (see meta-analysis by Marzi, Bisiacchi, & Nicoletti, 1991).

The current study sought to explore the relationship of IHTT to characteristics of the corpus callosum by comparing the IHTTs of males and females. While studies comparing male and female corpus callosum size have shown mixed results, several studies have reported greater average corpus callosum thickness for females—primarily in the isthmus or posterior regions (see Hoptman and Davidson (1994) for a review). The possible effect of this size difference on transfer times has been explored using a Poffenberger (1912), crossed-uncrossed difference (CUD) reaction time paradigm with mixed results (Bellis & Wilber, 2001; Dufresne, Lapierre, Chouinard, Daigneault, & Braun, 1993; Jeeves & Moes, 1996).

ERP measures of IHTT may provide a clearer picture of possible gender differences by eliminating variability related to motor responses and their potential to obscure an already complicated picture of transfer dynamics. Using ERP measures in response to laterally presented three-letter words, Nowicka and Fersten (2001) found that females had significantly faster IHTT than males for the left-to-right direction, but not for the right-to-left

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direction. In other words, females did not show the commonly found asymmetry of transfer times.

Based on the weight of evidence we predicted the following: (1) Shorter right-to-left than left-to-right transfer times across all participants. (2) Shorter *overall* transfer times for right-handed females compared to right-handed males. (3) Females would have more symmetric transfer times (i.e., left-to-right similar to right-to-left).

1. Methods

1.1. Participants

All procedures were approved by the institutional review board and the participants provided informed consent prior to the study. Average age of the 19 male and 19 female right-handed participants was $M = 19.3$ years (range 18–23). Handedness was confirmed with Annett's inventory (Annett, 1967) and all participants were free of significant neurological dysfunction and had normal or corrected-to-normal vision.

1.2. Materials and apparatus

1.2.1. Letter matching task

The visual matching task used was identical to that used by Brown et al. (1994). For each trial, two letters were presented (60 ms exposure) on a standard computer CRT. The letter pairs, drawn from a set of four letter characters (A, a, B, b), were presented as either the same or different case. Participants were instructed to make a match/no-match decision using a "name" match (e.g., "A," "a") rather than a physical identity match. The letter pairs were presented in two of four possible locations forming the corners of an imaginary rectangle surrounding the always-present central fixation character. These arrangements created four possible trial types: left visual field (LVF), right visual field (RVF)—with letters presented vertically, bilateral-horizontal (above or below fixation), or bilateral-diagonal (one above and one below fixation). Each level of the independent variable (e.g., field, case, position, etc.) was presented with equal frequency, in random order, during each block of trials—with the constraint of no more than three examples of that condition in sequence. At the viewing distance of 60 cm, each letter height was 27′ of visual angle and the central fixation (":") was 25′ by 40′. Letter locations were 2°19′ left/right of fixation, and 1°56′ above/below fixation. The letters and central fixation were white with a black background. An ever-present dark blue rectangular frame surrounded the stimulus display (3°49′ above and below fixation, and 5°9′ left and right of fixation).

A warning "blink" of the fixation character preceded stimulus onset by 500 ms. Intertrial intervals varied randomly between 1.5 and 2.0 s. Responses were recorded using the "M" (match) and "N" (no-match) letter keys. Two fingers of a single hand were used for responding, with participants switching hands between sessions of four blocks. The first hand used was counterbalanced across subjects. There were eight blocks for a total of 384 trials. Only LVF and RVF trials, followed by a correct response with an RT between 150 and 2000 ms, were included in the ERP averages. Analysis of reaction time included only correct trials for all conditions.

1.3. ERP recording

Sixteen EEG channels were recorded using an electrode cap (Electro-cap International Inc.) and the standard 10/20 placement system. All leads were referenced to linked earlobe electrodes and grounded at Cz. Two electrodes were placed above and at the outer canthus of the right eye to record eye movements. While recordings were made at all 16 leads, the parietal leads were the focus of analysis since parietal electrodes are very near the maxima of visual P1 and N1 component fields and, thus, best reflect callosal transfer of these components of visual ERPs (Rugg, Lines, & Milner, 1984). EEG signals were recorded using an EPA-6 Electro-Physiology amplifier (Sensorium Inc.), along with CogniScan data acquisition software (EJC Systems) and stored on an IBM-compatible PC. Signals were amplified 20,000 times and filtered at 0.5–50 Hz. Electrode impedance levels were always below 5 kΩ. The sampling rate was 1 kHz.

Using Vision Analyzer analysis software (Brain Products), EEG recording epochs starting 150 ms prior to stimulus onset and continuing 750 ms after stimulus presentation were captured from the continuous EEG, and then averaged to obtain the ERP wave. Before averaging these EEG segments, both computer artifact detection and visual inspection were used to eliminate any trials where eye movements or movement artifacts were present. A minimum of 30 acceptable correct epochs for each condition (e.g., LVF) at each lead was required for averaging. The average total number of epochs for LVF and RVF combined was $M = 120.1$; S.D. = 28.7, with each field showing approximately equal numbers. In addition, the averaged ERP wave had to produce unambiguous wave components from both the left and right hemispheres in order to be included in the analysis.

1.4. Data summary procedures

Average wave patterns were obtained for each condition (LVF, RVF, bilateral), but separate averages were not obtained for match or no-match conditions or for right- and left-hand responding since differences have not been noted in the ERPs to these sets of stimuli in previous research (Brown & Jeeves, 1993). ERPs to bilateral presentations are not included in this report, but their N1 latencies were intermediate between direct and direct pathways as shown by Brown et al.

The N1 component was chosen for the focus of analysis since it provides the most robust and least confounded estimate of IHTT. The N1 wave was designated as the most negative inflection between 120 and 210 ms—with the average latency occurring at approximately 170 ms. The computer captured both latency and amplitude measures for each component the waveform. IHTT for each direction of transfer was calculated by subtracting the N1 latency associated with the direct path response from the N1 latency for the indirect path response.

2. Results

2.1. ERP latency

Fig. 1 shows the ERP waves, averaged across all participants by field and hemisphere. As was demonstrated by Brown and Jeeves (1993), the N1 component of the ERP wave appeared to be an unconfounded indicator of IHTT. In other words, the IHTT calculated for each direction was not significantly correlated with the N1 latency of the corresponding direct pathway. For example, there was no significant correlation of left-to-right transfer times with RVF/Left hemisphere N1 latencies ($r = -0.18$; $p = 0.5$). Therefore, it appears that the transfer time from the one hemisphere to the other was independent of the response time for the initial "receiving" hemisphere.

Fig. 2 shows average N1 latencies by conditions. N1 Latencies were analyzed using SPSS (12.0) with a three-way ANOVA (see Table 1) for field (2-within) × hemisphere (2-within) × gender (2-between). Based on the predictions made, the interaction effects for N1 latencies were of greatest interest for the present study. The significant field × hemisphere interaction indicates that direct path latencies (e.g., LVF-RH) were consistently faster than indirect (cross-callosal) pathway latencies yielding the robust IHTT that has been found in several previous studies. The significant field × hemisphere × gender interaction resulted from females showing a smaller difference in N1 latencies between the two hemispheres for a given visual field; in other words, females had significantly shorter average IHTTs than males. As Fig. 2 makes clear, RVF