Hemispheric asymmetry in stimulus size evaluation

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Abstract. In the present study a possible hemispheric asymmetry in size evaluation was tested. Subjects were presented with geometrical Vanderplas type figures of various sizes and shapes. The stimuli were exposed in pairs, for 100 ms, one after another. The subject's task was to decide (by pressing one of three buttons) whether the second stimulus was the same as, smaller or bigger than the first one. The first stimulus in each pair was exposed unilaterally (randomly in the left or right visual field), and the second one in the centre of the screen. Three different interstimulus intervals (ISI) were used: 50 ms, 500 ms, and 2,000 ms. The results showed shorter reaction times for left visual field presentation than for right visual field presentation at the 50 ms and 500 ms interstimulus interval. No laterality effect occurred at the 2,000 ms ISI. The results indicate a right hemisphere predominance in stimulus size evaluation. Moreover, they suggest that hemispheric asymmetry is not a stable feature of the brain but is a dynamic process that may change in the course of information processing.

Key words: hemispheric asymmetry, size perception, interstimulus interval
Many important questions are still to be answered as to the nature of hemispheric asymmetries revealed by laterality studies. One such question concerns the perceptual stage at which asymmetries emerge. According to visual information-processing theory, the form or code in which a stimulus is represented undergoes successive transformations over time as it proceeds from one stage of analysis to the next (Sperling 1963, Turvey 1973). In the initial stages, the stimulus is represented in terms of low-level, precategorical properties such as brightness, contrast or contour (Turvey 1973, Coltheart 1975). Selective, categorical encoding mechanisms then operate and the information so encoded is maintained as a relatively stable memory trace. Unless the information available in the initial precategorical stages receives the benefit of further encoding, it is lost within several hundred of milliseconds after the physical stimulus disappears.

The two hemispheres may differ at all stages of visual information processing or, alternatively, at only some of them. One possible approach to this problem is to study the effect of interstimulus interval (ISI) on hemispheric asymmetry. Such an approach is based on the assumption that at different ISIs the second stimulus is compared to different representations (memory traces) of the first one. Moscovitch (1976) measured reaction times for correct responses in a face comparison task at interstimulus intervals of 5 ms, 50 ms, 100 ms, and 1,000 ms. The sample face was presented at fixation and then the test face appeared either in the right or in the left visual field to probe the subject’s memory of the sample. Only at ISIs of 100 ms and 1,000 ms did clear visual field differences emerge. Moscovitch concluded that perceptual asymmetries emerge as stimulus information is lost from the decaying, precategorical, short-lived memory trace and appear in the more stable memory representation that characterizes the later processing stages. In keeping with this finding, there is much evidence that the cognitive strategy adopted in a perceptual task, rather than the stimulus material per se, is the crucial factor which determines the presence and direction of hemispheric differences (Bradshaw and Nettelton 1981, 1983, Hellige 1990). Many authors, therefore, believe that the hemispheres are functionally symmetrical at the earlier (sensory) stages of information processing and that hemispheric asymmetries emerge at later (cognitive) stages (Moscovitch 1979, Sergent 1983a,b).

Another approach to the problem of the stage of information analysis at which the hemispheric asymmetry emerges is represented by those authors who are seeking hemispheric asymmetries in functions which are supposed to result from the activity of sensory areas of the cortex. An example of this approach is to measure the contrast sensitivity function (CSF) in the two visual fields or in left and right brain damage patients (Greenlee 1990). Although there is one report that the left and right visual fields differ in their CSFs (Rao et al. 1981), most investigators report no differences (Beaton and Blakemore 1981, Fiorentini and Berardi 1984, Peterzell et al. 1989). Judgements of such fundamental visual attributes as brightness (Davidoff 1975), colour (Davidoff 1976, Pennal 1977) and orientation (Fontenot and Benton 1972, Kimura and Durnford 1974), for dot detection (Gardner and Branski 1976, Davidoff 1977) and for stereoscopic vision (Carmon and Bechtoldt 1969, Durnford and Kimura 1971, Grabowska 1983) were also examined for hemispheric asymmetries. Most of the studies showed a left visual field/right hemisphere superiority, although there are also reports which contradict those findings (Filbey and Gazzaniga 1969, Dimond and Beaumont 1972, Dyer 1973, Bryden 1976, Birkett 1977). Moreover, a laterality effect has been found in the McCollough orientation-contingent colour aftereffect (Meyer 1976), and in the tilt after-effect (Grabowska 1987), both of which are believed to reflect functions of the visual cortex. In both studies stronger effects were observed in the right hemisphere. These findings would suggest then, that the two hemispheres may differ not only in cognitive processing strategies but also in the initial handling of sensory information.
In the present study we tested possible hemispheric asymmetry in size evaluation. Stimulus size is another fundamental visual feature, and to our knowledge no investigation has been performed to study lateralization of this type of judgement. We used three interstimulus intervals: 50 ms, 500 ms and 2,000 ms. The former two represents the stage of sensory processing and the later one a more stable short-term memory trace.

METHODS

Subjects

Twenty four normal subjects (12 males and 12 females), aged between 20 and 30 years, participated in the experiment. All subjects were right-handed, as assessed by the Edinburgh Handedness Inventory (Oldfield 1971) and had normal or corrected to normal vision.

Stimuli

Subjects inspected four (Fig. 1 a, b, c, d) Vanderplas type figures (Vanderplas and Garvin 1959). Each of these shape was presented in four different sizes which varied in steps of 0.15 length of each side. Stimuli were generated on a computer screen.

Procedure

The stimuli were presented for 100 ms, in pairs, one after another. The two stimuli in each pair had the same shape and they differed only in their sizes. The second stimulus in each pair could be either the same as, smaller, or bigger than the first one. Each size relation occurred on one-third of the trials. The first stimulus was presented unilaterally with its midpoint shifted 4 from the fixation point, randomly in the left or right visual field. The second stimulus was exposed at the centre of the visual field. The subjects were to judge whether the second stimulus was the same as, smaller, or bigger than the first one by pressing one of three buttons on a computer keyboard. The subjects were instructed to respond as quickly and as accurately as possible. Reaction times were recorded and analysed by an IBM PC compatible computer.

Subjects attended three experimental sessions of testing. In each session a different interstimulus interval was used and subjects responded with the right and with the left hand in two separated blocks. The order of sessions and order of blocks was counterbalanced across subjects. Before each block the subjects were given 24 practice trials.

A total of 192 trials were used for each block; There were 96 exposures in each visual field: 4 shapes x 6 combinations of sizes (the first stimulus had one of the two middle sizes and the second one could be either larger or smaller) x 4 repetition of each trial type.

RESULTS

Reaction times (RTs) for correct responses were analyzed using SPSS/PC software. Three-way analyses of variance (repeated measures MANOVA) were performed for each ISI with hand (left vs right) and visual field (LVF vs RVF) as within-subject
variables and sex (male vs female) as a between-subject variable. As the analyses indicated no effect of subjects’ gender, the results presented here are collapsed across men and women.

50 ms ISI

The analysis revealed that the main effect of visual field was highly significant - $F(1,30)=15.37, P<0.0005$. RTs for correct responses were shorter when the first stimulus was presented in the left visual field than when it was presented in the right visual field (the mean RTs were 636 ms for LVF presentation and 670 ms for RVF presentation). Neither the main effect of hand nor the interaction were statistically significant.

500 ms ISI

In this condition similar results were obtained. The main effect of visual field was statistically significant - $F(1,22)=7.46, P<0.012$; the mean RTs for LVF presentation were 688 ms, for RVF presentation 717 ms. The main effect of hand and the interaction were not significant.

2,000 ms ISI

In this condition only the main effect of hand was statistically significant - $F(1,30)=5.65, P<0.024$; the right hand was faster than the left one (mean RTs for the right hand was 691 ms, for the left hand 750 ms).

The mean reaction times for correct responses for each visual field across three different ISIs are presented in Fig. 2.

DISCUSSION

The major purpose of the present investigation was twofold. First, it was aimed at testing whether the two hemispheres differ in their capacity to evaluate stimulus size. The second purpose was to investigate the role of interstimulus interval in the emergence of hemispheric asymmetry.

The results show right hemisphere predominance in stimulus size evaluation at best for the two shorter ISIs: the RTs to the stimuli presented in the LVF were shorter than those to the stimuli presented in the RVF for the 50 ms and 500 ms ISIs. Although direct data on possible hemispheric asymmetry in size evaluation are lacking, a number of studies provide evidence that stimulus size can be an important factor influencing the pattern of hemispheric asymmetry in various visual tasks. The most common observation is that increases in size impairs left hemisphere performance relative to the right and decreases in size benefits left hemisphere performance relative to the right (Sergent 1983, Christman 1987, 1989). The present study shows that in estimation of stimulus size the right hemisphere seems to be more efficient, or at least faster in making decision about size.

Another finding of the present study was that the observed LVF-RH advantage appeared to depend on the ISI duration. The highly significant asymmetry between the hemispheres was observed only at 50 and 500 ms ISI and it disappeared with the...
longer (2,000 ms) ISI. This finding confirms the prediction that hemispheric asymmetry may occur at the early stages of information processing. Our results are not consistent with Moscovitch’s studies showing that hemispheric asymmetry is associated only with the late stages of information processing. This disagreement may result from different types of tasks and stimuli used in the two experiments. In Moscowitch’s study the task consisted of comparisons of complex stimuli such as faces. In our study subjects compared a basic visual feature, size. It can be supposed therefore that depending on the character of the stimuli and task, hemispheric asymmetry can emerge either in earlier or in later stages of processing.

In summary, our results show the existence of hemispheric differences in stimulus size evaluation. Moreover they suggest that hemispheric asymmetry is not a stable feature of the brain but is a dynamic process that may change in the course of information processing.

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