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OBJECT RECOGNITION AND LATERALITY: NULL EFFECTS

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Abstract—In two experiments, normal subjects named briefly presented pictures of objects that were shown either to the left or to the right of fixation. The net effects attributable to hemifield were negligible: naming RTs were 12 msec lower for pictures shown in the left visual field but error rates were slightly lower, by 0.8%, for pictures shown in the right visual field. In both experiments, a second block of trials was run to assess whether hemifield effects would be revealed in object priming. Naming RTs to same name–different shaped exemplar pictures were significantly longer than RTs for identical pictures, thus establishing that a component of the priming was visual, rather than only verbal or conceptual, but hemifield effects on priming were absent. Allowing for the (unlikely) possibility that variables with large differential left–right hemifield effects may be balancing and cancelling each other out, we conclude that there are no differential hemifield effects in either object recognition or object priming.

INTRODUCTION

IT HAS often been speculated that aspects of object recognition might be more effective in one hemisphere than the other (see [7] for a recent survey and a theory). As part of an investigation of translational invariance in visual priming [2], we employed a design that allowed an evaluation of laterality effects on visual object recognition. The design included an assessment not only of whether there were hemifield effects on the speed and accuracy of object naming on the first presentation of an object, but also whether there were hemifield priming effects on a second presentation of that object. As far as we can determine, this was the most extensive investigation of the effects of laterality on visual object recognition ever undertaken.

Previous research

A number of experiments have attempted to assess whether hemispheric differences would be revealed in the identification of pictures of objects. LEVINE and BANICH [9] provide an extensive and critical review of this research. A right visual-field (RVF) advantage for the naming of line drawings was reported by YOUNG *et al.* [16], MCKEEVER and JACKSON [10], BRYDEN and RAINEY [4] and WYKE and ETTLINGER [15]. None of these studies controlled for the mirror image orientation of the stimuli or used pattern masks to control for effective stimulus duration. In some experiments there were too few pictures. A number of additional

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methodological problems were apparent with the individual experiments. These will be detailed in this section.

The WYKE and ETTLINGER [15] experiment lacked positional uncertainty: exposures of an object picture (one of 24) at the same position were repeated (with lengthened exposure durations after every five trials) until the subjects ($N=18$) could accurately identify the picture. If the tendency to drift off central fixation was greater for exposures on the right side, then a RVF advantage would be expected.

BRYDEN and RAINEY [4] used only eight pictures with 32 subjects, 16 for each of two fixation instruction conditions. That failure to maintain fixation might have been a problem was evidenced by larger hemifield differences when strong instructions emphasizing the importance of maintaining fixation were given than when they were not. Considering only the strong instruction condition, with simultaneous presentation of a picture pair, one in each hemifield, an enormous 16.8% LVF superiority in naming accuracy was found, which Bryden and Rainey attributed to an order of report effect. With successive presentation of a picture pair to the same hemifield, the effects were reversed, with a 21.3% advantage for RVF presentations.

Neither WYKE and ETTLINGER [15] nor BRYDEN and RAINEY [4] obtained reaction time (RT) measures. MCKEEVER and JACKSON [10] ran 20 subjects and did obtain a RVF advantage for naming RTs, but they used only five stimuli in repeated presentations.

The 20 subjects in the YOUNG *et al.* [16] experiment each viewed 20 pictures. Two pictures were presented at a time, one in each hemifield. A cue, a red line, determined whether the left or the right picture was to be reported first. No effect of hemifield was found for the picture reported first, but an RVF advantage was found for the stimuli reported second [produced by a decline from first to second report for the left visual field (LVF) stimuli only]. No effect was found for a duration manipulation: 30 msec presentations led to a performance that was identical to 150 msec presentations.

These reports of an RVF advantage have to be evaluated against a number of failures to find any field differences. Indeed, if we accept the data from the first reported stimulus in the Young *et al.* [16] experiment as the condition least likely to be affected by memory, then these investigators did not find a hemifield effect. Another failure to obtain an RVF superiority with object pictures was reported by KIMURA and DURNFORD [6], who did control for mirror image orientation, although details were not presented. Perhaps more telling was SCHMULLER and GOODMAN'S [12] report, with 32 subjects and 64 pictures. Pairs of pictures were presented for 64 msec with an arrow at the central fixation area cueing which picture was to be reported. They found that right-handers (half the subjects) made fewer errors with LVF reports, in contrast to the RVF advantage obtained in some of the earlier reports.

LEVINE and BANICH [9] also controlled for mirror image orientation. These investigators presented 40 line drawings, two at a time, for an average of 23 msec (the duration was adjusted for individual sensitivities). Subjects ($N=32$) had to name a central digit for the trial to be scored, with the objects named in any order. No overall effect of hemifield of presentation was found for pictures.

We concur with SERGENT'S [13] conclusion that the previous evidence for hemifield effects on picture identification is weak and inconsistent. For two of the experiments showing an RVF advantage, WYKE and ETTLINGER [15] and BRYDEN and RAINEY [4], the effects were so large, approximately a 40% RVF advantage in the former and 21.3% in the latter (with successive presentation), that one's suspicions that artifacts might have been at play are raised. (Indeed, Bryden, personal communication, January 1991, no longer maintains confidence in the RVF advantage reported in [4].) Barring the possibility that the

WYKE and ETTLINGER [15] and BRYDEN and RAINEY [4] experiments just happened to hit the correct conditions that would maximize hemifield effects, it is safe to conclude that if there are hemifield effects in object perception, they are likely to be quite modest. We typically do not experience any noticeable difficulty in identifying objects in our left visual field compared to that of our right.

When more general aspects of picture naming are considered, prior research could be interpreted as suggesting that for our tasks, in which subjects named briefly presented single line drawings of common objects, there would be an RVF advantage for three reasons: (a) The line drawing stimuli required a discrimination of high spatial frequencies; (b) the basic level classification can be performed using categorical contrasts [1]; and (c) subjects responded with the name of the object. An advantage (a) of the RVF for high spatial frequencies has been demonstrated by SERGENT [13]. BIEDERMAN [1] has argued that basic level object recognition can be accomplished through simple categorical contrasts in image edges, and KOSSLYN [7], KOSSLYN *et al.* [8] and HELLIGE and MICHIMATA [5] have shown RVF advantages for such processing. That the LH has an advantage in naming is a widely accepted result among students of laterality.

Priming

By varying whether an object appeared in the same or different hemifield on its second presentation, the design also allowed an assessment of a differential hemispheric contribution to priming. Possibly, the uncontrolled conditions of previous natural viewing obscured the detection of a laterality effect on the first presentation of an object. Given substantial object-specific facilitation on naming RTs and error rates between the first and second presentation of an object, we can inquire as to whether primed or priming hemifield affects the magnitude of the priming.

Object specific effects

An additional feature of the design was that it also allowed control of a variable that might have obscured some previous attempts at assessing laterality effects in object identification: the left–right (mirror image) orientation of the object. There are at least two reasons why orientation need be controlled. If the image has more distinguishing features on, say, the left side, its presentation in the left visual field will place those features at a more eccentric position than when it is presented in the right visual field.

It is also possible that individual objects are better depicted in one orientation than another [14]. Tzeng speculated that some objects that we typically interact with motorically, say a cup, might be better depicted with the handle to the right. Other objects, animals, for example, might be better depicted facing left, so that the animal's face would project to the right hemisphere in central viewing. We know of no evidence establishing that objects have a preferred left–right orientation, though recognition is certainly favored in some front to back or top to bottom views over others, as established by PALMER *et al.* [11]. However, there are cultural practices which tend to favor some left–right biases. For example, in cinematography, smooth, easier action is generally portrayed as flowing from left to right. Difficult movement, as when someone is attempting to make their way against the high winds of a blizzard, is often portrayed right to left. Standard practice in newspaper and magazine layout is to print a face so that it is oriented toward the center of the page, rather than towards the margins (where it would appear to be staring out in empty space). This latter effect would not be revealed as a left–right advantage, but rather as an advantage for nasal orientation. To the extent that faces were better processed in the right hemisphere, then a left visual-field advantage might be expected. However, to repeat, we know of no evidence that such individual object–position or object–orientation effects are real in the sense of producing an effect on perceptual recognition performance, but our design did allow their assessment.

EXPERIMENT 1

Method

Subjects. The subjects were 32 native English speakers, 19 males and 13 females; 28 were right-handed and four were left-handed, with normal or corrected-to-normal vision. They participated for payment ($5/hr) or for research experience points for the Introductory Psychology course.

Stimuli and procedure. Each subject named 48 briefly presented pictures of objects. Each picture was a simple line drawing of a common object with a readily available basic level name created with Cricket Draw and shown on a high resolution (1024 × 768) monitor (Mitsubishi model HL6605) controlled by a Macintosh II. The subject pressed a mouse button to start each trial. A fixation dot would then be presented for 500 msec, followed by a 150 msec presentation of the object picture, which was, in turn, followed by a 500 msec mask, a random appearing arrangement of lines.

The subject named with the basic level term, e.g. "piano," each picture as it was shown. They had been instructed to respond as quickly and as accurately as possible. Prior to the presentation of the experimental stimuli, subjects were prefamiliarized with the names of the objects by reading the names from their terminal. They were told (correctly) that these were the names of the objects that they were to see in the experiment. This aspect of the procedure was designed to: (a) reduce naming variability, so that subjects would say "car" and not "auto" or "automobile", and (b) increase the availability of lower frequency names. In three experiments in our laboratory, we have never found the name prefamiliarization to interact with any stimulus variable or even to reduce RTs. The naming RTs were recorded through a Lafayette voice key. Reaction time and accuracy feedback were displayed after each trial. Prior to the experimental trials, subjects were given 12 practice trials with images that were not presented on the experimental trials.

The 150 msec presentation duration of the pictures was too brief to make a second eye fixation. The images were centered 2.4° to the left or to the right of fixation, in random appearing fashion, so that the subject could not accurately anticipate the position of the image. The maximum extent of each image could be contained in a circle whose diameter subtended a visual angle of 4°. The subjects were instructed to maintain fixation which was undoubtedly facilitated by the natural tendency of visual capture by the presentation of the fixation point 500 msec prior to the presentation of the picture.

Design

The sequences of images were balanced across subjects so that the mean serial position of every object in every condition of position and orientation was equal, with all objects appearing equally often in the four conditions of position (left or right) and orientation (facing left or facing right). Two "buffer" trials, with images that were not part of the experimental set, were presented at the beginning and end of each block. These were not included in the data analysis.

The overall presentation conditions of the second trial block were identical to those of the first, with the pictures presented in a different random appearing order. The relation of the pictures on the second block with respect to the first block defined a 2 × 2 factorial design with half the pictures viewed by each subject either in the same or different field and half of each of these picture conditions either in the same or different orientation. The assignment of specific object pictures to conditions and sequences was balanced over subjects so that each picture was in each of the four priming conditions an equal number of times with the same mean serial position as all the other pictures. The priming conditions were also balanced across first block conditions (left vs right visual field, facing left vs facing right). Approximately 7 min intervened, on average, between the first and second presentation of an object picture.

An analysis of variance design (ANOVA) was constructed by defining three fixed factors, block (first or second), position (left or right) and orientation (facing left or right), and two random factors, groups and subjects nested within groups. The groups factor had two subjects nested within each of 16 groups. These two subjects saw exactly the same objects in the same conditions (one in forward order the other in reverse order). Variance between groups included variations in the difficulty of particular stimuli in particular conditions and thus served the goal of specifying stimuli as a random factor in the analysis.

Results and discussion

The mean correct reaction times (RTs) and error rates are shown in Figs 1 and 2, respectively. For RTs, the effect of block was highly significant, with RTs 84 msec lower on the second block than on the first [$F(1, 15) = 74.88$, $P < 0.001$] but neither a 4 msec advantage for stimuli in the left visual field nor a 2 msec advantage of stimuli facing left were significant [$F(1, 15) < 1.00$ for both variables]. None of the interactions were significant. For error rates, a 5.1% decline from block 1 to block 2 was highly significant [$F(1, 15) = 21.46$, $P < 0.001$]. For position, a 1.67% higher error rate for stimuli presented on the left side was also significant [$F(1,15) = 7.10$, $P < 0.05$] but a 1.51% higher error rate for stimuli facing right fell short of significance [$F(1, 15) = 3.22$, $0.05 < P < 0.10$].

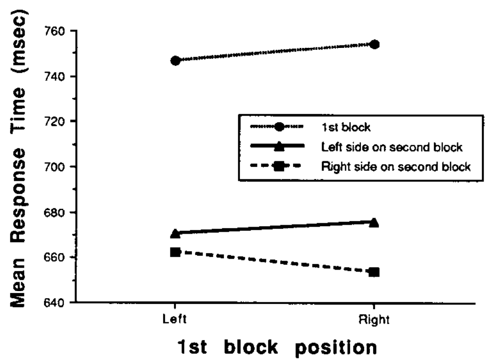

Fig. 1. Mean correct naming reaction time (RT) in Experiment 1 as a function of the hemifield on the first block (abscissa) and the block and hemifield of the second block (parameter).

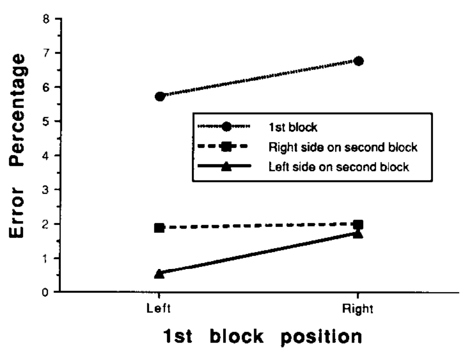

Fig. 2. Mean percentage error in Experiment 1 as a function of the hemifield of presentation on the first block (abscissa) and the block and hemifield of presentation of the second block (parameter).

The calculation of power for the ANOVA design is somewhat complicated but the power of a Least Significant Difference (LSD) test which would have less power than the ANOVA indicated that for RTs the design had sufficient power to detect as significant at alpha = 0.05, an effect of 36 msec for position and 28 msec for orientation on RTs. For error rates, the corresponding values were 2.55% for position and 3.45% for orientation. That the ANOVA had more power than the LSD test is revealed by the result that the 1.67% effect of position was significant, at alpha = 0.05, by the ANOVA but would not have been significant by the LSD test.

First block. There were only small and variable effects on RTs of position and orientation (left visual field: left facing = 744 msec, right facing = 764; right visual field: left facing = 743 msec, right facing = 749 msec). There was also no effect of whether the orientation was nasal vs temporal orientation. Mean RTs for these conditions were 754 and 746 msec, respectively.

Second trial (primed) block. The reduction in RTs from the first to the second block suggests that priming occurred. (The results from Experiment 2 and BIEDERMAN and COOPER [3] show that the second block gain can indeed be attributed to priming rather than to a general practice effect.)

The mean correct RTs and error rates on the second trial block as a function of the hemifield of presentation on the first and second trial blocks are shown as the solid and dashed lines in Figs 1 and 2. No effect of hemifield or orientation was apparent in these data, nor was there any effect of whether the image on the second block was in the same or different orientation than on the first block. Reaction time for pictures that appeared on the right side were 15 msec lower than those on the left side, but the error rates for pictures presented on the right side were 0.8% higher than those that were presented on the left. Neither of these effects approached significance [F (3, 93) = 1.24 for RTs and 1.04 for errors, ns]. For these analyses, the data were pooled over the orientation conditions leading to slight differences between these values and those reported for the previous analyses.

As noted in the Introduction, it is possible that individual objects enjoyed a particular visual field or orientation advantage. To assess the possibility of such an effect, subjects were divided into two groups of 16 subjects each, one from each of the 16 groups used as a factor in the analysis. Each of the subjects within the 16 groups saw the same objects in the same positions and orientations, but in reversed sequence. For each group of 16 subjects, the difference in average response time for each of the 48 objects when it was facing left and when it was facing right was calculated. The value of this correlation (r) between the two groups for the 48 difference scores was 0.334 [t (46) = 2.40, $P < 0.05$]. The magnitude of this positive correlation would be underestimated if there was some consistent change in performance within a block, because the subjects in the two groups viewed the objects in reversed sequence. However, performance was virtually flat for both RTs and errors over the 48 trials: the correlation between RTs and trial number was 0.118 (indicating slightly *longer* RTs at later trials); for errors it was -0.045, both rs(46) were nonsignificant.

A similar analysis was performed with the position data, with the difference scores defined as the difference between when the object was on the left and on the right. The correlation for this comparison was negative but short of significance [$r = -0.247$, $t(46) = -1.73$, $0.10 < P < 0.05$], indicating that there was a slight tendency for an object, that was more quickly identified when it was, say, on the left side for one of the groups, to be more quickly identified when it was on the right side for the other group.

There thus appears to be a small effect, 6% of the RT variance, for individual objects to be more quickly identified in one mirror orientation than in another. This effect should be evaluated in additional studies. No such individual object effect was observed for position of presentation.

EXPERIMENT 2

A single experiment was run to provide a replication of the laterality manipulations of the first experiment and to determine the extent to which the item orderings in Experiment 1 could be attributable to nonvisual factors, such as name familiarity. To assess the nonvisual factors, the design included two exemplars for each basic level class. The exemplars differed in shape, such as a grand piano and an upright piano for the class PIANO. To the extent that the item orderings were based on nonvisual factors, the correlations across the exemplars should remain equivalent to the orderings within a given exemplar set.

Method

The method and procedure was the same as that of Experiment 1, except that there were 64 object pictures in the experiment, composed of 32 basic level classes. Each class had two exemplars. Fewer basic level classes were used in this experiment because each object had to be from a basic level class that had more than one exemplar. Included in this set were four animals, elephant, bird, dog and rabbit, where the different exemplars were generated by picturing different poses of the animal.

Subjects. The 32 subjects were composed of 13 males and 19 females. Twenty-four were right-handed and eight were left-handed.

Design. A given subject saw only one of the two exemplars on the first trial block (thus only 32 pictures). Orientation variations were not run in Experiment 2. An arbitrary exemplar variable (version 1 vs version 2) occupied the same status in the design as the orientation variable in Experiment 1. (Because the orientation main effect and orientation × position interaction in Experiment 1 were not significant, the orientation variable would not be expected to influence position effects in Experiment 2.) An ANOVA design was performed on the data from the second block with three fixed factors, exemplar (same or different), position of first block (priming) stimulus (left or right) and position of second block (primed) stimulus (left or right). Two random factors were groups and subjects nested within groups. As an Experiment 1, the error terms for the *F*-ratios were constructed by regarding pairs of subjects who had the same objects in the same conditions as a single group. These error terms reflected the interaction of conditions, subjects and specific objects, and thus served to account for variance due to viewing particular objects in particular conditions. Because the exemplar variable (same or different) could not be defined for the first block of trials, a separate factor for block could not be run but was evaluated separately by a *t*-test.

Results

First (priming) block. Figures 3 and 4 show the results for this experiment. As in Experiment 1, the effects of hemifield of presentation were not significant, although a modest 29 msec advantage for presentation in the left visual field approached significance [t (31) = 1.88, $0.10 > P > 0.05$]. The 1% difference for error rates was not significant [t (31) < 1.00]. This experiment could have detected as reliable at alpha = 0.05, a 32 msec RT effect and a 4.1% effect on error rates.

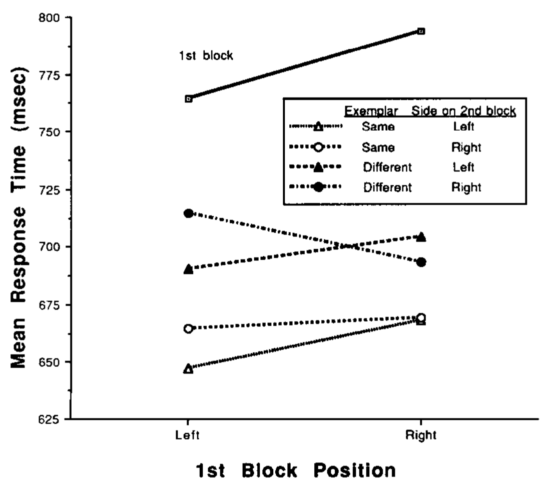

Fig. 3. Mean correct naming reaction time (RT) as a function of the hemifield on the first block (abscissa) and the block and hemifield of the second block (parameter), for same (unfilled symbols) and different (filled) exemplars in Experiment 2.

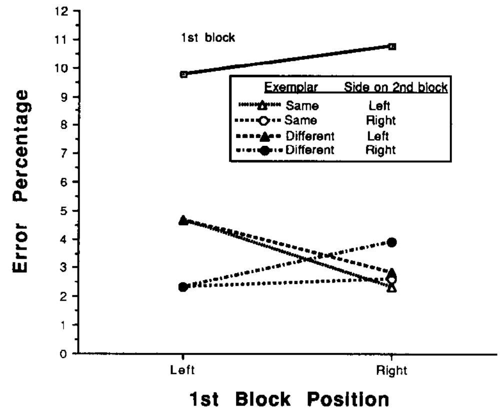

Fig. 4. Mean percentage error in Experiment 2 as a function of the hemifield of presentation on the first block (abscissa) and the block and hemifield of presentation of the second block (parameter), for same (unfilled symbols) and different (filled) exemplars.

Second (primed) block. There was considerable priming in that RTs and error rates were lower on the second trial block, as shown in Figs 3 and 4. Overall, mean second trial RTs (and error rates) were 89 msec (6.9%) lower than those on the first block [t (31) = 9.15 and 5.09 for RTs and errors, both $P < 0.001$]. That the priming had a visual component was revealed by a highly significant 39 msec RT advantage (shown in Fig. 3) for the same compared to the same name–different shaped exemplars [F (1, 15) = 17.12, $P < 0.001$ for RTs]. The error rates for the same exemplars were only 0.5% lower than those for the different exemplars [F (1, 15) < 1.00, ns].

There was a negligible effect of position. The mean RTs for pictures that appeared on the left side were 8 msec lower than those on the right, but had a 0.9% higher error rate. The Fs (1, 15) for both these effects were less than 1.00. There was also no effect of whether the priming picture was on the left or right side in block one: pictures that appeared on the left side in block one led to block two RTs that were 4 msec shorter than those that had appeared on the right side but had a 0.6% higher error rate. The Fs for these effects were less than 1.00. An LSD test for the position effect would have detected an effect as significant at alpha = 0.05 of 43 msec or 3.4% in error rates. As in Experiment 1, the LSD test had less power than the ANOVA actually run. No differential priming effect attributable to the combinations of first and second block hemifield was evident in these data: Fs (1, 15) were approximately equal to 1.00 for both RTs and error rates.

None of the two interactions between the exemplar variable and first and second block hemifield, or the three way interaction were close to being significant as all the F-ratios were below or approximately equal to 1.00 for both RTs and errors.

DISCUSSION AND CONCLUSIONS

To our knowledge, this is the most extensive investigation of laterality effects on visual object recognition done to date. Although a 1.7% difference in error rates favoring the RVF was obtained in Experiment 1, the net effects attributable to hemifield were negligible: the mean RTs (and error rates) over both blocks of both experiments were 714 msec (6.7%) to stimuli presented in LVF and 725 (5.9%) to stimuli presented in the RVF. The data do not change substantially when they are analyzed separately according to the handedness of the subjects. Combining over blocks and experiments, for the 52 right-handed subjects, RTs (and error rates) to stimuli presented to the left and right visual fields were 714 msec (5.2%) and 718 msec (5.0%), respectively. For the 12 left-handed subjects, the corresponding values were 718 msec (4.0%) for the left hemifield and 738 (7.9%) for the right hemifield. It is difficult to know whether this suggestion of a left visual-field advantage for left-handed subjects is a real effect or represents either sampling variability or incomplete balancing such that easier stimuli might have been presented on the left side for the left-handed subjects. The larger number of right-handed subjects reduces the likelihood that variability or incomplete balancing affected their results.

Hemifield effects on the magnitude of priming were absent. In addition, no overall effect of orientation or any evidence that specific items might enjoy an advantage in a given visual field was obtained in Experiment 1. In Experiment 1, there is a suggestion that there might be item-specific effects for the orientation of an object.

Most of the important results of this investigation do constitute acceptances of the null hypotheses, but the designs were sensitive enough to detect differences between identical and same name–different shaped exemplars on a second block of trials and priming effects in both experiments, as well as a 1.7% effect on error rates in Experiment 1. We conclude that differential hemispheric effects on object recognition, if they exist, are of relatively small magnitude.

What about variables that reveal differential hemispheric effects? For example, KOSSLYN *et al.* [8] recently reported that categorical judgements of visual configurations (whether a dot was on/off, left/right or above/below a shape) enjoyed a right visual-field advantage, but judgements of distance were performed best with left visual-field presentation. These results have been replicated by HELLIGE and MICHIMATA [5]. The extent to which either type of processing would be involved in object recognition is an open question but it would seem implausible for the two effects to be so well-balanced in the task of object recognition that no net field advantage is apparent. More plausible, perhaps, is the possibility that the processing tapped by such direct judgement tasks may play only a modest role in object recognition.

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