Differential specialization of the cerebral hemispheres for the perception of sameness and difference*

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Pairs of letters were presented 4 deg left or right of fixation, and Ss were asked to indicate as quickly as possible whether the letters in a pair were the same or different. Reaction times for "different" responses were faster when stimuli were in the left visual field than in the right, but reaction times for "same" responses were faster when stimuli were in the right visual field than in the left. These results may indicate that the right hemisphere is better specialized for difference detection, while the left hemisphere is better specialized for sameness detection.

Recent work suggests the possibility that judgments of sameness and difference may be mediated at least in part by independent perceptual mechanisms. For example, when Ss were required to indicate whether pairs of stimuli were the same or different, the latencies of "same" judgments were influenced by the familiarity of the stimuli, but the latencies of "different" judgments were not (Egeth & Blecker, 1971). In a related study, "same" latencies were affected by the symmetry of the elements to be compared, as well as by their familiarity, while "different" latencies were not affected by either variable (Hock, 1971). The results of these two studies, taken together, invite (but do not demand) the speculation that the mechanism underlying the perception of sameness is sensitive to wholistic, configurational properties of stimuli, while the mechanism underlying the perception of difference is analytic and sensitive to parts and features of stimuli (see also Bamber, 1969; Sekuler & Abrams, 1968).

Interestingly, a distinction between analytic and wholistic functioning has been made recently in connection with the modes of information processing characteristic of the two cerebral hemispheres. The well-known superiority of the left hemisphere for the processing of verbal information has been taken to reflect a specialization for analytic functioning, whereas the superiority of the right

hemisphere for the processing of spatial information has been taken to reflect specialization for wholistic Gestalt processing (Klatzky & Atkinson, 1971; Levy-Agresti & Sperry, 1968). If this description is accurate, and if the speculations based on the studies by Egeth and Blecker and by Hock are reasonable, then one might hypothesize that sameness would be more readily detected by the right hemisphere than the left and that difference would be more readily detected by the left hemisphere than the right. The purpose of the present experiment was to test this hypothesis.

METHOD Procedure

On each trial, two letters were presented, one directly above the other, for 150 msec, randomly either in the left visual field (LVF) or in right visual field (RVF). The S's task was to indicate whether the letters were the same or different. Two groups of Ss were used. One group was instructed to respond when the letters were the same by depressing a key with the index finger of their right hand but to refrain from responding when the letters were different. The other group of Ss was instructed to respond in the same way when the letters were different.

On each trial, reaction time was measured from the onset of the stimulus to the initiation of the keypress. There were 4 or 8 practice trials, depending on the S's comprehension of the task, followed by 72 test trials.

Stimuli

The letters used were nine Futura Demi capitals symmetric about a vertical axis: A, H, I, O, T, U, V, X, Y. On half of the trials, the letters were the same, and on half they were different. The nine letters were used

equally often. Most importantly, there was a perfect balance of the pairs used on the left and right. For example, if A appeared above X on a particular LVF presentation, then there was also a RVF presentation with A above X. The letter pairs were prepared on slides in random order and back-projected on a translucent screen by a slide projector fitted with a tachistoscopic shutter. The viewing distance was 197 cm. At that distance, the vertical center-to-center distance between letters was 4.8 deg and the letters subtended about .8 deg in height and .6 deg in width. The horizontal distance between the fixation point and the letters was 4 deg, an eccentricity great enough to insure that right-field stimuli are projected entirely to the left hemisphere, and vice versa. The fixation point was visible at all times.

Subjects

Pilot testing indicated that the task was fairly difficult, and so a 90% accuracy criterion was adopted (instead of the 95%-98% demanded in many reaction time experiments). For the purposes of statistical analysis, 10 "same" and 10 "different" Ss were desired. However, to get these 20 "good" Ss, a total of 32 had to be tested. All were right-handed male students at The Johns Hopkins University who volunteered to serve. They were each paid \$2.00.

RESULTS

The data for the 20 Ss who exceeded 90% accuracy are shown in the upper part of Table 1. Two important results are evident. First, there was a 21-msec LVF superiority for "different" judgments [$t(9) = 4.46, p < .01$]. Second, there was a 22-msec RVF superiority for "same" judgments [$t(9) = 2.71, p < .05$].

When the Ss with less than 90% accuracy were included in the analysis, the data for "different" judgments were equally clear with a LVF superiority of 20 msec [$t(17) = 4.09, p < .001$]. However, the 19-msec right-field superiority for "same" judgments was not significant [$t(13) = 1.66, p > .05$].

Inspection of the within-Ss difference scores ($RT_{LVF} - RT_{RVF}$) indicated that the LVF advantage of the "different" Ss was more consistent than the RVF advantage of the "same" Ss. In this connection, note especially the magnitudes of the three reversals in sign among the "same" Ss. The variances of the difference scores of the "same" vs the "different" Ss were compared by F test, for both the accurate Ss and the total set of Ss, and found to be significantly different

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Table 1
Mean Reaction Times and Errors for "Same" and "Different" Ss for Stimuli Appearing in Left and Right Fields

Same							Different						
Ss	Mean Reaction Time			Errors			Ss	Mean Reaction Time			Errors		
	LVF	RVF	Difference	LVF	RVF	Difference		LVF	RVF	Difference	LVF	RVF	Difference
High Accuracy							High Accuracy						
NM	413	376	37	2	0	2	LC	474	491	-17	2	2	0
AN	512	497	15	2	2	0	DM	459	458	1	5	1	4
HW	542	489	53	1	2	-1	RD	456	465	-9	4	1	3
CJ	544	513	31	4	3	1	AD	539	563	-24	5	1	4
TD	486	503	-17	4	2	2	MW	534	552	-18	4	2	2
CL	486	458	28	1	2	-1	JR	443	487	-44	2	0	2
KJ	428	451	-23	2	1	1	ML	428	445	-17	1	5	-4
LB	572	523	49	4	3	1	GB	551	557	-6	2	1	1
KW	516	505	11	1	1	0	TC	431	464	-33	5	2	3
MW	456	419	37	2	4	-2	RF	407	447	-40	3	0	3
Mean	496	473	22	2.3	2.0	0.3	Mean	472	493	-21	3.3	1.5	1.8
SD	52	47	26				SD	51	47	15			
Low Accuracy							Low Accuracy						
LS	586	498	88	6	6	0	LC	538	575	-37	5	4	1
JH	470	466	4	3	5	-2	IJ	524	515	9	8	8	0
RS	552	517	35	8	3	5	DC	471	526	-55	7	7	0
KC	609	697	-88	13	4	9	WE	459	466	-7	5	3	2
							WS	429	473	-44	6	5	1
							GG	444	467	-23	5	4	1
							CB	498	520	-22	10	3	7
							RS	530	503	17	4	8	-4
Overall Mean	512	494	19	3.8	2.7	1.1	Overall Mean	479	499	-20	4.6	3.2	1.4
SD	59	72	42				SD	46	42	19			

Note—Mean RTs based on correct responses only. Errors include omissions and commissions; to calculate proportions divide by 36. SDs are unbiased estimates. Overall mean includes high and low accuracy Ss.

($p < .01$) in the latter case but not in the former ($p > .05$).

Analysis of errors indicated that most "different" Ss made more errors on LVF than on RVF presentations. Thus, it may be that the LVF reaction time advantage for these Ss is in part the result of a speed-accuracy tradeoff. While this explanation of the results cannot be rejected on the basis of the present data, there are some reasons for thinking it less than convincing. First, note that among the "different" Ss, there does not appear to be any relation between the latency and error differences in the two fields. For example, S.D.M. made more errors on LVF presentations than on RVF presentations, but was obviously not faster on LVF trials. By contrast, S.M.L. made more errors on RVF trials, but was faster on LVF trials. Note also that the "same" Ss seemed to have attained their RVF superiority without any substantial difference in error rates between the two fields.¹

DISCUSSION

Since LVF pairs were projected to the right hemisphere (and vice versa), the data would seem to indicate that the left hemisphere is better specialized for perceiving sameness, whereas the right hemisphere is better specialized for perceiving difference. These results are, of course, precisely

the reverse of those hypothesized in the introduction.

If we accept the analysis of sameness and difference perception proposed in the introduction, we may conclude that the left hemisphere is more wholistic in its operation than is the right and that the right is more analytic in its operation than the left. Although the two major findings seem reasonably clear, at least for those Ss who performed at better than 90% accuracy, it is interesting to note that the effects were not equally consistent. The greater variability in difference RTs among the "same" Ss than among the "different" Ss (including three substantial reversals in sign) is a phenomenon that deserves consideration in its own right. Perhaps another of Hock's (1971) findings is pertinent here. He found large individual differences among the Ss making "same" judgments. Specifically, there was a positive correlation, over Ss, between the effects of symmetry and familiarity on the latency of "same" judgments, with some Ss being strongly affected by both variables and others quite unaffected. One might say that these latter Ss were making "same" judgments the way people ordinarily make "different" judgments, i.e., analytically. Perhaps, then, the greater variability of the difference scores for

the Ss in our "same" condition is due to the presence of Ss in that condition who were processing the stimuli in an analytic fashion and thus, presumably, with their right hemispheres.

Alternatively, since the data contradicted our initial hypothesis, it is possible that we have overemphasized the analytic-wholistic distinction as it pertains to "same"-"different" judgments of letter pairs. Indeed, the data may be telling us something quite different about such judgments. The right hemisphere has proved to be superior at several spatial tasks, e.g., dot counting, dot localization (Kimura, 1966, 1969), and face recognition (Rizzolatti, Umiltà, & Berlucchi, 1971). Perhaps, then, the right hemisphere superiority for difference perception in the present task means that Ss based "different" judgments on a physical, spatial match of stimulus letters. The superiority of the left hemisphere for verbal material is even more well established (e.g., Geschwind, 1970; Bryden, 1965, 1966). Thus, the left hemisphere superiority for sameness detection in the present task may mean that our "same" Ss were basing their decision on the names of the letters rather than on their physical characteristics. The use of a naming strategy may have been induced by the large vertical

separation between the elements of our stimulus pairs (cf. Hochberg, 1968), although it is possible that with alphabetic stimuli, implicit naming is virtually mandatory. Further research, using stimuli that differ considerably in their complexity and nameability and using name matching as well as physical matching tasks, may be useful in evaluating this and other alternative explanations of our data.

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NOTE

1. A previous study using similar methodology failed to yield any laterality differences (Egeth, 1971). In that study, pairs of geometric forms were presented only .85 deg left or right of fixation and thus may have been represented bilaterally. More recently, Cohen (1972) had Ss judge whether letter pairs were same or different; mean "same" RTs for physically identical stimuli were faster than mean "different" RTs in both the left and right visual fields. Two important observations need to be made about this study. First, Ss were instructed to respond on the basis of name identity (e.g., A and a are "same"), not physical identity. Second, Ss had to make a two-choice "same"-different response on each trial. In the present study, we used a go/no-go paradigm. Previous research in our laboratory (not yet published) has shown some interesting differences between these two response modes. We consider the go/no-go task to be a more direct indicant of perceptual processes than the two-response task.

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