NOTE

A NOTE ON LOCATION OF THE DECISIONAL STAGES OF CHOICE REACTIONS IN THE LEFT HEMISPHERE

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Bisiach, Mini, Sterzi and Vallar (1982) reported two experiments concerned with the question of whether a hemispheric specialization for decision in reaction times exists. This is an important investigation, since in divided visual field studies of cerebral lateralization dealing with hemispheric differences of cognitive functions these are confounded with the possible lateralization of the decisional stage related to the binary choice reaction, which impairs the interpretation of the data. Bisiach et al. (1982) propose a model according to which the decisional stage is localized in the left hemisphere and claim that this model predicts their experimental results. We show that this is not the case and argue for a somewhat different model which is able to predict the obtained field differences.

In the first experiment with simple reaction times to lateralized black dots Bisiach et al. (1982) obtained a right field superiority for right hand reactions and a left field superiority for left hand reactions and no main effect for field or hand. This result is consistent with the literature (e.g., Jeeves, 1969; Anzola, Bertoloni, Buchtel and Rizzolatti, 1977; Berlucchi, Crea, Di Stefano and Tassinari, 1977) as the authors mention. They explain the result in "terms of differences between crossed and uncrossed RTs related to the length of the anatomical pathways involved and in terms of degree of spatial compatibility" (Bisiach et al., 1982, p. 195 seq.). But as nothing is said in the article about the answer position (presumably lateral) it remains unclear whether the result depends on the anatomical connections or the stimulus response compatibility, or possibly both together. Since the field difference is similar and in opposite direction for right and left hands this at least indicates no aymmetry for the "decisional stage" in simple reaction times.

In the second experiment the subjects had to press a switch with their index fingers of the right hand or left hand when a dot was presented in the right visual field or in the left visual field, but to refrain from pressing when two dots were shown simultaneously. The results were a significant field effect (9 msecs faster reaction with right field presentations), no hand effect (although right hand reactions were 9 msecs faster than left hand reactions) and a significant field × hand interaction, indicating that right hand reactions were 16 msecs faster to right field presentations than to left field presentations.

To interpret the data the authors assume (with reference to Nickerson, 1971) that a binary task consists of four stages: stimulus encoding, comparison, binary decision, and response initiation. The result of their first experiment indicates that there seem to be no hemispheric differences for stimulus encoding or response initiation with simple reaction times. The results of the second experiment with a go/no-go-paradigm are interpreted as indicating that the decision is taken by the left hemisphere.

The authors take the data of their second experiment to be consistent with their model, since they assume this model to predict just their results, viz. "faster ipsilateral right hand responses and meager ipsi-contralateral differences for the left hand" (Bisiach et al., 1982, p. 196).

Their argument for the first point (faster ipsilateral right hand responses) seems to be the following: A right field stimulus arrives directly at the side where comparison and decision takes place, whereas a left field stimulus first has to pass from the right side to the comparator on the left side, i.e., a callosal step is needed. But this is not correct: Even in the case of a right field stimulus, comparison and decision cannot start before the comparator has registered that there is no left field stimulus. Since the comparator does not know in advance whether there is a left field stimulus, he must "wait" until a signal from the left field is expected to arrive in order to compare the right field stimulus with the absence of a left field stimulus. So it does not make any difference whether one compares different stimuli from both fields or a stimulus with a non-stimulus. In both cases the time of one callosal step is needed: in the case of a left field stimulus the time of the actual transmission of the stimulus from the right hemisphere to the comparator on the left, in the case of a right field stimulus the time a left field stimulus would have needed to be transmitted if there had been such a left field stimulus. Therefore, if we denote by s the stimulus input time, by e the encoding time and by e^x the interhemispheric crossing time for the encoding-result, the pre-comparison-time p, i.e., the time before comparison may start, is $p = s + e + e^x$, and this is independent of whether the stimulus is presented in the right or left visual field. That means, no field difference can be predicted from a model where both comparison and decision are localized in the left hemisphere.

As to Bisiach et al. 's second point (meager ipsi-contralateral differences for the left hand), one can of course explain by their model that the reaction times for left hand responses are generally slower than for right hand responses, since for left hand responses motoric initiation takes place in the right hemisphere and so a further callosal step between comparison/decision and motoric initiation is needed. But this model gives no reason for the assumption that (even if it predicted a field difference, what is not the case) the field difference is weaker in left hand responses.

It can however be shown that by changing the model somewhat the difference between right and left field can be predicted. For that purpose we retain the framework concerning the four stages of stimulus processing in binary decision tasks and furthermore Bisiach et al.'s hypothesis that decision is performed in the left hemisphere. But contrary to Bisiach et al. we assume that comparison is made in the hemisphere where the stimulus directly arrives (so that comparison and decision may take place in different hemispheres). We do not consider the encoding to be problematic and different, so we take the pre-comparison-time p to be the same in all cases as argued above. Response initiation is as usual assumed to be localized in the hemisphere contralateral to the responding hand. Table I shows the localization [left (L) or right (R)] of comparison, decision and response initiation according to our model for the different cases of stimulus presentation and responding hand, and the expected reaction times, as additively composed of pre-comparison-time p, times for comparison c, for decision d, for answer initiation a and for motoric performance of answer m, and interhemi-

TABLE I

Additive Composition of Expected Reaction Times in Dependence on the Localization of Comparison (C), Decision (D) and Answer Initiation (A) in the Right (R) or Left (L) Hemisphere

		C	D	A		LF–RF	RH/LF–LH/RF
RH	RF	L	L	L	$p + c + d + a + m$	c^x	
RH	LF	R	L	L	$p + c + c^x + d + a + m$		$c^x - d^x$
LH	RF	L	L	R	$p + c + d + d^x + a + m$	c^x	
LH	LF	R	L	R	$p + c + c^x + d + d^x + a + m$		

RH: Answer with the right hand
LH: Answer with the left hand
RF: Stimulus in the right field, blank in the left field
LF: Stimulus in the left field, blank in the right field
p: Pre-comparison-time
c: Comparison-time
c^x: Callosal crossing-time for comparison result
d: Decision-time
d^x: Callosal crossing-time for decision result
a: Answer initiation-time
m: Time for motoric performance of answer

spheric crossing times for comparison-result c^x and decision-result d^x. If there is a change from R to L or L to R, a crossing time must always be added. Our model predicts a right field superiority for both hands to the amount of c^x and a difference between right hand responding to a left field stimulus and left hand responding to a right field stimulus of $c^x - d^x$ which is zero, if the crossing times of results of comparison and results of decision are assumed to be the same.

If we are interested only in the number of interhemispheric crossings between comparison and response initiation, we can represent our model by a matrix as given in Table IIa, where in the end-column the number of callosal crossings is mentioned. It can easily be seen that other assumptions about the localization of comparison and decision do not predict a field-asymmetry at all (e.g., comparison and decision throughout in the left field — Bisiach et al.'s assumption, cp. Table IIb — or throughout in the right field; comparison throughout in the left and

TABLE II

Matrices Showing Number of Interhemispheric Transmissions (T) for Different Models

		a) C	D	A	T	b) C	D	A	T	c) C	D	A	T	d) C	D	A	T
RH	RF	L	L	L	0	L	L	L	0	L	R	L	2	L	L	L	0
	LF	R	L	L	1	L	L	L	0	R	R	L	1	R	R	L	1
LH	RF	L	L	R	1	L	L	R	1	L	R	R	1	L	L	R	1
	LF	R	L	R	2	L	L	R	1	R	R	R	0	R	R	R	0

decision throughout in the right field or vice versa), or predict an inverse asymmetry (e.g., comparison in the hemisphere where the stimulus directly arrives and decision throughout in the right hemisphere — Table IIc; comparison in the hemisphere opposite to the one where the stimulus directly arrives and decision throughout in the left hemisphere) or even predict different asymmetry directions for both hands (e.g., comparison and decision in the hemisphere where the stimulus directly arrives — Table IId — or comparison in the hemisphere where the stimulus directly arrives and decision in the opposite hemisphere).

Our model is the only one which predicts a field superiority for the experimental results (faster reactions to right field presentations with right hand reactions and left hand reactions as well) and a main effect for hand (faster right hand reactions). In addition it predicts that the latencies of right hand reactions to left field stimuli and left hand reactions to right field stimuli are equal, and that fastest reactions are obtained with right hand respondings to right field stimuli and slowest with left hand reactions to left field stimuli. The field superiority for right and left hand reactions has the same direction and is of equal amount (cp. Table I).

These predictions are in general consistent with Bisiach et al.'s (1982) results where reactions were overall 9 msecs faster to right field presentations, right hand reactions were 9 msecs faster than left hand reactions and the field difference was for right hand reactions and for left hand reactions favouring the right visual field. The data show equal latencies for right hand reactions to left field stimuli and left hand reactions to right field stimuli as predicted by our model. That the hand effect was not significant while the field effect was, although the difference was of equal amount, might have something to do with the presumably larger variances of reaction times for the left hand responses. The same might be the reason for the fact that the difference of 16 msecs between reactions to right and left field presentations was significant for right hand reactions, but the difference of 16 msecs between right and left hand reactions to right field stimulation was not.

So the pattern of the experimental results is consistent with our model. Some results of the statistical analyses might be due to the problem of getting significant results for differences of a few msecs and with the authours' handling of the data (means instead of medians or transformed data; presumably larger variance for left hand reactions). Our model however is not able to predict that the field difference for right hand reactions is larger than for left hand reactions. This might only be predicted by making the additional assumption that the processing speed is increased in cases where all stages of processing take place in the same hemisphere; in terms of our matrices, if a row has only L's or only R's. This is, as Table IIa shows, in our model the case just for right hand reactions to right field stimuli.

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