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DICHOTIC LATERAL ASYMMETRY: THE EFFECTS OF GRAMMATICAL STRUCTURE AND TELEPHONE USAGE*

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Abstract - No confirmation could be obtained that the magnitude of the dichotic REA for speech is affected by whether the stimuli are syntactically structured, Recall-order was controlled in Experiment I by cueing one ear immediately after a dichotic stimulus; in Experiment 2 by cueing before a stimulus, The subject's reported ear preference for telephone usage was correlated with his ear difference in the first experiment but not in the second. Perhaps telephone usage causes an attentional bias (for speech) to one or other ear, more often to the right; which is over-ridden by the precued instruction to attend to a particular ear.

INTRODUCTION

THE AIM of this paper is to investigate the influence on lateral asymmetry of a linguistic organizational variable - syntactic structure.

Such organizational variables have been shown to be relevant to comparisons of unilaterally brain-damaged patients, that is, left hemisphere patients are selectively impaired for language tasks demanding more complicated skills than the purely phonological/perceptual But there is no consensually accepted influence of organization on the magnitude of right ear advantage (REA) in normals to correspond with this, in the way that would be expected if the evidence were a reflection of left hemisphere specialization for linguistic organization. This mismatch inconveniently and enigmatically constrains the level of utility of the ear-difference technique.

The important varieties of *monaural* situation in which a REA has been shown before or was likely to be shown have previously been tried [1, 2]. It would be possible endlessly to attempt to improve the sensitivity of monaural experiments (for example by running more subjects) but it seems an appropriate initiative to put aside the arguments advanced in favour of this method of presentation and to move to a dichotic experiment.

ZURIF and SAlT [3] compared identification of meaningless sequences in two dichotic conditions, termed structured and unstructured. In the structured condition these sequences were grammatically ordered, in the sense that if the nonsense stems were replaced by English stems a grammatical sentence would result, and they were recorded in the natural intonation of this sentence. Such sequences were re-arranged randomly to form the unstructured sequences, which were recorded in a monotone like a laundry list. In both conditions

*These experiments are taken from a D.Phil. dissertation ([1] Experiments 7 and 8) which gives a great deal more detail, background and discussion. The experiments were carried out at the Laboratory of Experimental Psychology, University of Sussex, the provision of whose facilities is gratefully acknowledged.

recognition accuracy was superior for right-ear stimuli but this superiority was significant only in the structured condition. However as evidence for an influence of syntactic structure on lateral asymmetry these statistics are not really appropriate-what should be reported is the significance of the interaction between Syntax Condition* and Ear. ZURIF and MENDELSOHN [4] repeated the structured condition of this experiment, again finding a significant REA, but used for contrast a semi-structured condition which preserved the syntactic form of the structured condition but was recorded in a monotone like the unstructured condition. In this semi-structured condition there was no significant difference between right and left ears, which implies intonation rather than syntax is the crucial influence on dichotic REA.

Apart from the desirability of confirming these findings, with regard to an aim of reconciling the clinical with the experimental-normal evidence there are certain disturbing features of the experiments which indicate that further investigation might be valuable. In the first place there seems to be no good reason why an examination of the role of syntax in dichotic listening should not employ, for stimuli, words and sentences rather than unnatural nonsense-syllable constructions. Secondly, the use of a recognition procedure in which distractors are described simply as being "similar" to the stimuli leaves it very unclear exactly what information the subject is required to retain in the two conditions. Thirdly, the results of these experiments do not attain a satisfactory pattern: one would expect a significant REA, albeit reduced, in both the unstructured condition of ZURIF and SAlT [3] and the semi-structured condition of ZURIF and MENDELSOHN [4], just as is normally obtained with dichotic speech stimuli. Finally, inspection of the data of ZURIF and MENDELSOHN [4] reveals the highly paradoxical fact that the inclusion of intonation-cues in its structured condition actually *reduces* average performance as compared with its semistructured condition.

ZURIF [5] also reports unpublished data which did involve dichotic presentation of ordinary sentences. The control condition was asyntactic strings of words. According to ZURIF [5], for first ear reports only, a significant REA emerged for the asyntactic material but not for the sentences. In contrast when accuracy for the delayed channel was assessed, the reverse pattern obtained: there was a noticeable REA in the syntactic condition, but not in the asyntactic condition. Zurif's *interpretation* of the three-way interaction between Ear, Syntax and Channel (first or second) has some intrinsic plausibility but it would be preferable to have greater detail for this unpublished data.

With German subjects and locutions HEESCHEN and JERGENS [6] describe an Ear x Syntax interaction with greater REA for syntactically structured (but non-sentential) word stimuli. However, (1) their report procedure was free recall (uncontrolled order) and (2) the proportion of complete sequences among the correctly identified words was much greater (a) for the right than for the left ear and (b) for structured than for unstructured stimuli with the right but not the left ear. These points indicate that in addition to the normal tendency towards prior report of the right ear [7, 8] there is some tendency towards what is now known as the Ear Order of Report [9, 10 (p. 212), 11 (pp. 153-161)] which will naturally be increased by the provision of syntactic structure on each ear (for the importance of syntactic structure for report order cf. GRAY and WEDDERBURN [12]). This, rather than any parallel with clinical evidence due to left hemisphere specialization for linguistic

*Capitalization indicates a variable.

organization, is sufficient to explain the Ear x Syntax interaction in HEESCHEN and JERGENS [6] and would be so sufficient in any study with uncontrolled report order.

EXPERIMENT I: POST-CUED REPORT ORDER

Method

The design of this experiment incorporated two main conditions, one including normal sentences and the other asyntactic strings of words. The predicted shape for such an interaction is an REA in both conditions but greater in one than in the other. There is a problem, already discussed elsewhere [1 (pp. 23, 40)], that such an interaction might be an artefactual consequence of differential floor or ceiling effects for conditions at different levels of difficulty. In other words, when measuring per cent correct, a manipulation of performance will be constrained by the relative proximity of the 0% and 100% limits, so that a 10% population value of REA would be accurately sampled if right ear performance were 50% for (easy) sentences but not if it were 5% for (difficult) asyntactic strings. This artefact is more malignantly pervasive than might at first appear, so precautions were taken to cover the possibility. Firstly, since differential proximity to a floor or ceiling is expected to cause heterogeneity of variance, the plan was made to transform the data by means of an arcsine formula [13 (p. 221)] designed to stabilize variances of proportional data. Secondly, it was thought best to create the option of obtaining some idea of the effect of difficulty on the pattern of data without confounding level of difficulty with Syntax. So within each condition the length of the sequences was varied continuously from three to eight words. This feature of the design also leaves open the possibility of forestalling another possible objection to a successfully demonstrated interaction. Supposing it were found that the provision of syntactic structure improved right-ear performance more than it improved left-ear performance: the desire would be to ascribe this to favoured access of the right ear to a left-hemisphere syntactic processor. However it might be objected that more information is retained from the right ear even before syntactic processing and that this processing acts to increase retained information by some constant multiple, so that the finding is inevitable regardless of the locus of syntactic processing. Assuming no exercise of the discretion to use a logarithmic scale of measurement, this would yield a significant but valueless interaction. This possibility could be checked by estimating whether syntactic processing improves performance at shorter message-lengths, where proportionately more information is retained, more than it improves performance at longer message-lengths.

In constructing sentences, some psycholinguistic research excludes pronouns, proper names, negatives, highly qualified nouns and low frequency nouns, on the grounds that these complicate processing, but such a purification was not carried out in this experiment, since it was felt that complicating syntactic and semantic processing would tend only to produce a desirable accentuation of differences between the two main conditions. On the same reasoning a variety of syntactic moods and forms was included, mixed haphazardly between trials. However all the sentences were *semantically* structured, in the sense of HEESCHEN and JERGENS [6] and WILLIAMS [1] (Experiment 5). The asyntactic strings of words were jumbled sentences (a point which was mentioned in the instructions). Pursuing comparability in two further respects to ZURIF and SAIT [3] and ZURIF and MENDELSOHN [4] rather than to WILLIAMS [1] (Experiment 5), the jumbling did not follow any regular pattern but was random from trial to trial (again, to make the two conditions as dissimilar as possible with respect to organizational constraint) and also the jumbled sentences did retain function-words. Each subject served in both conditions and the trials in each condition were blocked.

Two dichotic tapes were recorded, one comprising a block of sentences followed by a block of jumbled sentences, the other in the reverse order. Each block of jumbled sentences was derived from the block of sentences on the other tape. Thus for the experiment as a whole the same words appeared equally often in either Syntax condition, an important precaution omitted (with a small stimulus-set) by HEESCHEN and JERGENS [6]. But it is worth noting that the variable Syntax Order (sentences before jumbled sentences vs jumbled sentences before sentences) is confounded with word differences in the present experiment. For obvious reasons no word occurs in both sequences of a dichotic pair. In order to facilitate synchronization the dichotically paired sequences for a particular trial have not only the same number of words but also the same number of syllables within each word-pair (though they do not have the same stress patterns). To retain this balance it was necessary for the jumbling of a sentence-pair to be parallel for either sentence. Each sentence-pair also exhibits constancy of grammatical mood. The balancing was achieved by constructing a template sentence and matching the other onto it; as it seems possible the templates may be more natural sentences they were assigned equally often to Channel 1 or Channel 2 of the dichotic tapes. The jumbled sentences were pre-recorded in a monotone at 3 words per sec; the sentences were spoken at a similar rate (though as their intonation was natural their rhythm was unpaced and irregular). Jumbled sentences were aligned at both onset and offset but, because of this varied rhythm of natural speech, sentences were imperfectly aligned at offset, the asynchrony varying to a maximum of about two words. The procedure of controlled report-order was preferred to free recall from either ear, to circumvent problems discussed in the Introduction and by WILLIAMS [1] of interpretation of REA. On each trial the subject was cued with the name of one or other ear. In this experiment the cue was given immediately *after* the subject heard a dichotic pair of sequences (to which he had been instructed to try to pay equal attention). Pilot study suggested that subjects found it confusing to be required to follow report from

the cued ear with additional report from the other ear, so on each trial words were reported from one ear only. Headphones were reversed on an ABBA sequence with two groups of subjects defined by whether headphones began normal or reversed. All subjects were right-handers by self-classification but were also given a handedness questionnaire, in this experiment the one used by ANNETT [14] (Questionnaire 2), with some extra questions regarding telephone usage. Laterality quotients were computed according to the same procedure as that of OLDFIELD [15] and all subjects had a positive quotient. *N* was 16, the same as in ZURIF and SAIT [3] but less than in ZURIF and MENDELSOHN [4] *(N* = 48). Only one dependent variable was analysed - words correct. In scoring the data credit was given only for morphemically accurate words, reversing the decision in WILLIAMS [1] (Experiment 5), since on reflection it was believed that syntactic processing is more likely to result in improvement of morphemic accuracy than in recovery of otherwise inaccessible words in a morphemically inaccurate form.

Results

The factors included in the main analysis of variance (on arcsine-transformed scores) were Ear, Syntax, Message Length, Syntax Order and Headphones. Separate ANOVAs for the sentence data and for the jumbled-sentence data were also computed (not including Message Length). The F-ratio for the critical term, the Ear x Syntax interaction, was less than 1.0. There was a significant REA ($p<0.02$) found in all three ANOVAs. It can be seen from Table 1 that the REA (as a difference of means) is greater for sentences than for jumbled sentences. It might be objected that the REA for sentences could have turned out greater, perhaps great enough to yield a significant Ear x Syntax interaction, if sentences had been synchronized as accurately as jumbled sentences, since there is evidence that highly accurate synchronization increases the REA for single dichotic pairs of nonsense-syllables [16 (p. 205)]. However when 14 of the worst-aligned sentences were selected and the REA calculated for these trials only, it proved to be actually greater than for the complete set of sentences (30% as opposed to 18 %). Syntax and Message Length were significant ($p<0.001$) but not any of the interactions (except Syntax x Ear x Message Length x Headphones, $p<0.05$ but >0.1 after Greenhouse-Geisser correction). It seems then that there is strong cause for doubt about the existence of an influence of syntactic structure on dichotic lateral asymmetry.

Table 1. Mean % words recalled on either ear

	Left ear	Right ear
Sentences	63	81
Jumbled sentences	37	47

On the basis of his answers to the questions about telephone usage each subject was given a score from zero (representing a strong preference for putting the receiver to the left ear both when making and when taking calls) through intermediate scores to eight (representing a similar bias to the right). (Moving the receiver from right to left ear when it was necessary to write a message was taken as evidence that the rightwards bias was weak.) The correlation coefficient was calculated between this measure of ear preference for telephone usage and the subjects' individual ear-difference scores, first for the whole experiment ($r=0.60$, $p<0.05$) then separately for sentences ($r=0.49$, n.s.) and jumbled sentences ($r=0.50$, n.s.). (A scattergram showed the Pearson requirement of linearity is fulfilled.) So in this experiment a remarkably high proportion of the variance of Ear can be explained in terms of variation in

telephone usage. * The distribution of scores for ear preference in telephone usage was skewed towards the right, though much less so than the distribution of handedness quotients or ear difference scores.

EXPERIMENT 2: PRE-CUED REPORT ORDER

It was decided to run more subjects in this paradigm to probe whether the failure of the Ear x Syntax interaction to achieve significance could have been due to lack of power. This would also permit further exploration of the role of telephone usage.

Method

The procedure was similar in most respects to that of Experiment 1 but there was one major change. It is possible to control not only report but also the direction of voluntary attention by cueing one ear *before* the stimulus is presented. It is true that this may slightly reduce the magnitude of REA [22, 23] but it is repeatedly found that REA is nonetheless significant. Some subjects in Experiment 1 did report difficulty in following the instruction to divide attention equally between the ears, so that pre-cueing might well reduce variance due to extraneous fluctuations of attention. Using the pre-cueing procedure it proved practicable to ask, subsequent to the cued sequence, for the unattended (i.e. uncued) one as well, thereby economically increasing the data-pool as well as providing comparability to ZURIF [5]. The randomization of pre-cued (report) ear across the trials was mirror-reversed for half the subjects. This variable, but not Headphones group, was factorially crossed with Syntax Order.

Results

Channel (pre-cued vs unattended) was included in the ANOVA and Report Randomization replaced Headphones. The data provided no evidence at all of an effect of Ear x Syntax though a strong REA was still manifest. The direction of the interaction is the same as in Experiment 1 (a greater REA for sentences than jumbled sentences: Table 2) but F is less than 1.0. It is worth noting that, in spite of the failure to reject the hypothesis of additivity of Syntax and Ear, syntactic structure improved mean performance by a remarkably constant *multiple* for both ears in both experiments, regardless of whether the raw or the transformed scores are used for computation. So on either type of model, additive or multiplicative, it is impossible to reject the null hypothesis of independence of Syntax and Ear. Again it could not have been the case that the REA for sentences was deflated by imperfect synchronization since the worst-aligned sentences showed an REA of 19% (as opposed to 16% for the complete set). Ear, Syntax, Message Length and Channel were significant ($p<0.001$ except Ear $p<0.01$) but not any of the interactions except Ear x Syntax x Report Randomization ($p<0.01$) and Channel x Message Length ($p<0.01$ but >0.05 after Greenhouse-Geisser correction). The present results, then, run contrary to

Table 2. Mean % words recalled on either ear**

	Pre-cued		Unattended	
	Left ear	Right ear	Left ear	Right ear
Sentences	70	80	49	65
Jumbled sentences	49	64	24	35

*This correlation compares reasonably with the test-retest reliability of dichotic listening as assessed by PIZZAMIGLlO, PASCULlO and VIGNATI [17] who find only 70% of their subjects biased towards the same ear on both tests and by others [18-21].

** Some figures updated from first publication following discovery of an error in data transcription. The changes do not affect the results upon statistical testing.

the findings of ZURIF and SAlT [3] and ZURIF and MENDELSOHN [4] as indeed do the results of ZURIF [5], since there it was found for first-channel reports (which is the appropriate comparison) that the REA was greater for asyntactic strings. With regard to all these findings the evidence of HEESCHEN and JERGENS [6] is neutral. Here different studies yield contradictions which seem only tortuously reconcilable, though it is worth reiterating that there are anomalies within ZURIF and SAlT [3] and ZURIF and MENDELSOHN [4]; all told the most sensible conclusion seems to be that no effect of syntactic structure on lateral asymmetry has been demonstrated.

The correlation between telephone usage and ear difference contrasted with the result of the previous experiment (r =-0.23, not significant; the scattergram gave no indication of a curvilinear relationship). The contrast can be explained by postulating that telephone usage causes an involuntary attentional bias to one or other ear which is eradicated in this experiment by the requirement to direct voluntary attention to a particular ear. In view of the significant REA in Experiment 2 it is clear that telephone usage is not a sufficient explanation of the dichotic REA, although the possibility remains open that in many experiments it has been one determinant of it.

DISCUSSION

The results give strong cause for doubt about the existence of an influence of syntactic structure on dichotic lateral asymmetry, of the kind reported by ZURIF and SAlT [3]; the magnitude of the REA is similar for sentences and for jumbled sentences: various points of detail make the discrepancy of their report unsurprising.

Since the magnitude of the REA in the two conditions is similar, it is not necessary to present an analogue of ZURIF and MENDELSOHN's [4] semistructured condition. Nor is it necessary to estimate whether syntactic processing improves performance at shorter message-lengths, where proportionately more information is retained, more than it improves performance at longer message-lengths. For according to significance testing syntactic processing does not differentially improve right-ear performance, although the latter is better than left-ear performance: syntactic processing can already be said to act additively and therefore independently, rather than multiplicatively and therefore independently in a slightly more sophisticated sense. So the possible presence of a multiplicative relationship with message brevity is immaterial.

There is evidence of a very high correlation between ear advantage in Experiment 1 and ear preference in telephone usage. The latter was appraised by questions concerning side and strength of ear preferences both when making and when receiving a telephone call and with or without a necessity to write a message while holding the receiver (the spatial environment of telephone apparatus was not considered). Dichotic lateral asymmetry and right-ear preference for telephone usage might both be epiphenomena of hemispheric asymmetry but the strangely neglected possibility is raised that the experimental asymmetry should be explained in terms of telephone usage *rather than* in terms of hemispheric asymmetry. There is further discussion presently of the ramifications of this possibility.

Experiment 2 gave, firstly, even stronger cause for doubt about the existence of an influence of syntactic structure on dichotic lateral asymmetry. Secondly, controlling attention by instructing the subject in advance of the dichotic stimulus to report one ear before the other had one effect: the abolition of any correlation between ear advantage and telephone usage. So it seems that telephone usage causes an attentional bias for speech to

one or other ear, more often the right, which is over-ridden by the pre-cued instruction to attend to a particular ear: the bias is effective only when the subject is trying to maintain a balance of attention between the two ears. Telephone usage may be one determinant of the dichotic REA but since we find here a significant REA unconnected to such usage it is not the only factor. The data suggest there is a general tendency to pick up the receiver with the preferred hand and put it to the ipsilateral ear. It would be perfectly natural then, without invoking neurology, to expect ear advantage to follow hand preference. Such an interpretation of the REA for speech harmonizes well with the evidence of BEVER and his collaborators (e.g. [24]) that various psycholinguistic effects are found with right- but not with left-ear presentation (cf. also PERL [25]). Any point of view such as this one makes definite predictions about the development of asymmetry. A group of reports which are particularly difficult to explain in telephone-ear terms are GEFFNER and HOCHBERG [26], INGRAM [27], KIMURA [28] and NAGAFUCHI [29] finding REA as young as 3-4 yr (though it is noteworthy that GEFFNER and HOCHBERG [26] find onset of REA delayed until 7 yr of age in children from a low socio-economic level).

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RESUME

Au terme de deux expériences, on n'a pu confirmer si la supériorité dichotique de l' orel11e droite varie en fonction de la structure syntactique des stimulus. La capacité de rappel a été contrôlée dans la première expérience en désignant une oreille immédiatement après la stimulation dichotique; dans la deuxième expérience en désignant l' oreille avant la stimulation. La préférence marquée par un sujet pour une oreille dans l' emploi du téléphone s' est trouvée en corrélation avec la différence entre les oreilles dans la deuxième expérience. L'emp1oi du téléphone aurait pour resu1tat une tendance de la part du sujet à prêter attention a une oreille plutôt qu'à 1 'autre (en ce qui concerne la parole) le plus souvent à l'oreil1e droite. L' instruction de prêter attention à une oreil1e donnée avant l' administration du stimulus 1 'emporte sur cette tendance.

Zusammenfassung

Es konnte keine Bestätigung dafür gefunden werden, daß das Ausmaß der dichotischen Überlegenheit des rechten Ohres davon beeinflußt wird, ob die Stimuli syntaktisch strukturiert sind. Die Erinnerung wurde im ersten Experiment überprüft, indem das jeweilige Ohr nach dem dichotischen Stinlulus bezeichnet wurde, im zweiten Experiment vor dem Stimulus. Die von der Versuchsperson angegebene Bevorzugung für ein bestimmtes Ohr beim Benutzen des Telefons korrelierte im ersten Experiment mit ihrer Ohrdifferenz, aber nicht im zweiten. Es erscheint möglich, daß Benutzen des Telefons.eine erhöhte Aufmerksamkeit für eines der beiden Ohren hervorruft, häufiger für das rechte. Diese wird durch die vorangehende Anweisung, auf ein bestimmtes Ohr zu achten, aufgehoben.