PERCEPTION OF LINGUISTIC STRESS BY MUSICALLY-TRAINED SPEAKERS OF FINNISH: A LATERALIZATION EXPERIMENT

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Introduction

The present paper aims to study the effects of production lateralization (handedness) and what is traditionally called perceptual asymmetry (monaural half-field reception) on stress identification performed by musically-trained Finnish teenagers. The results will later be compared with the responses given by American English and Finnish non-musical adults, Finnish children of different ages, as well as with the behaviour of Finnish linguists in the same test. The main theme will be the influence of stimulus experience on the perception of linguistic stress. The paradigm used in the studies, monaural listening, can show perceptual field asymmetries (ie. either left or right ear advantage, LEA or REA) as reported, eg., by Bakker 1969, Catlin et al. 1976, Fry 1974, Harriman and Buxton 1979, and Morais and Darwin 1974. From this evidence it can be deduced that notions of stimulus competition and occlusion of the ipsilateral pathways as derived from dichotic studies are not prerequisites for the ear advantage.

At this juncture, a short review of language perception and, in part, production in relation to cerebral organization will be presented. Extensive discussions on the auditory half-field experimental designs are to be found, eg., in Zaidel 1978 and Berlin and McNeil 1976. In the discussion below only lateralization will be considered, since perceptual half-field experiments only tap hemispheric asymmetries. All the divisions of labour between the hemispheres given below should be regarded as end-points on continua of functional specialization. The conclusions are to be considered ones drawn from a population called "normal right-handed adults". This subject category is an idealization of a speech community with varying speech lateralization and handedness interrelations. The statements and theories will be presented in the rough order of the development of our knowledge of language lateralization. Thus the borderlines between different schools of thought will be somewhat blurred during the ensuing presentation.

To start with, the hemispheres can be claimed to differ on the dimension linguistic (left hemisphere, LH) vs. auditory (RH) processing (Oscar-Berman et al. 1975). This view states that man has a separate LH linguistic processor, "a linguistic device" in generative terms. (Cf. the related anonyms: verbal (LH) - nonverbal (RH), Kimura 1962; encoded - non-encoded (stops vs. vowels), Shankweiler 1971; phonetic - acoustic, Berlin et al. 1973.) That the left hemisphere can process the order of even nonlinguistic stimuli (Gordon 1978) or that the right hemisphere can have rudimentary capacities for speech and language (Van Lancker 1975, Day 1977) cannot be explained in this framework.

A higher-order cognitive mode theory that describes the inter-hemispheric differences not on the basis of what is processed in each hemisphere but how the input is processed in the central nervous system can account for much of the data that the previous type of reasoning left unanswered. The hemispheres have been found to differ, eg., in the following modes of information processing:

Left Hemisphere Mode	Right Hemisphere Mode	Source
Temporal	Spatial	Levy 1974
Sequential	Holistic	Mills and Rollman 1979
	Template Match	Zaidel 1978
Analytic	Synthetic	Levy 1974
Familiar stimulus properties	New stimulus properties	Milner 1971
Similar units focally on the cortex	Different units diffusely on the cortex	Semmes 1968
Functional	Formal (structural)	Levy and Trevarthen 1976
Objective	Subjective	Safer and Leventhal 1977
	Less specialized	Beaumont 1974
	Creative	Dimond and Beaumont 1974

Yet language does appear to have significance in the development of lateralization, since aphasia is equally probable after a left and a right hemisphere damage in the illiterate (Witelson 1977). Similarly, congenitally deaf non-signers have a bilateral representation for language, while sign-language users show asymmetries (Neville 1977).[1] Evidence on the association between speech production and perceptual lateralization as

[1] For further arguments, see Witelson 1977.

measured by the perceptual half-field paradigm is offered by Sussman and MacNeilage 1975. Their tongue tracking experiments suggest a link between speech production and perception as measured by dichotic studies. In fact, Freides 1977 emphasizes the output variables in speech perception experimentation of the half-field reception kind (see footnote 5 below).

Procedures

The stimuli of the test were generated on the KLATT synthesizer of the Speech Perception Laboratory in the Department of Psychology at Indiana University-Bloomington.[2] A basic stimulus /sasa/ was created within which the following parameters were systematically varied: Duration (DR) of the second syllable vowel altered in five millisecond steps from 105 to 175 msec. The amplitude (AV) contours on the vowels had the patterns: 60, 60 dB; 60, 54 dB; 60, 48 dB; 48, 60 dB; or 54, 60 dB. The melody contour (fundamental frequency, FØ) had a fixed first syllable value, 90 Hz, while the second syllable varied between 70 and 90 Hz in five-Hertz steps. The number of these stimuli was 400, since each stimulus type was taped twice. The order of the sasa's was randomized by the computer.[3] The inter-stimulus interval was three seconds with a longer pause after every fiftieth stimulus.

The musically-trained subjects used in this test were chosen from among the students at the Community School of Music in Joensuu. A sort of "top twenty" list of the most musically advanced left- and right-handed students was devised by the staff of the School for this purpose. The six subjects were the first ones available to take the test. Handedness was checked only through a question in the response booklet, where the alternatives were left-handed, right-handed or ambidextrous. Each subject participated in two sessions during which he or she heard the stimulus

[2] Thanks are extended to Professor Davis Pisoni for his permission to use the laboratory. Diane Kewley-Port and Tom Carrell taught me how to run the apparatus. And Arto Nykänen at the Joensuu University Computer Center was patient enough to run and re-run the response data to attain the final results. The help from them all is also gratefully acknowledged.

[3] Another set of stimuli was embedded in the material. The variables of this set were the quality (reduction) and the temporal onset of the FØ decline of the final vowel. The responses to these 88 stimuli are ignored in the present exposition.

tape monaurally through high-quality headsets in the Phonetics Laboratory of the University of Joensuu. The subjects were asked to decide which of the two syllables of /sasa/ was stressed and to mark the corresponding alternative on the answer sheets. The age ranges of the subjects in both groups were 15 to 18 years. There was one girl in each group.

Results and Discussion

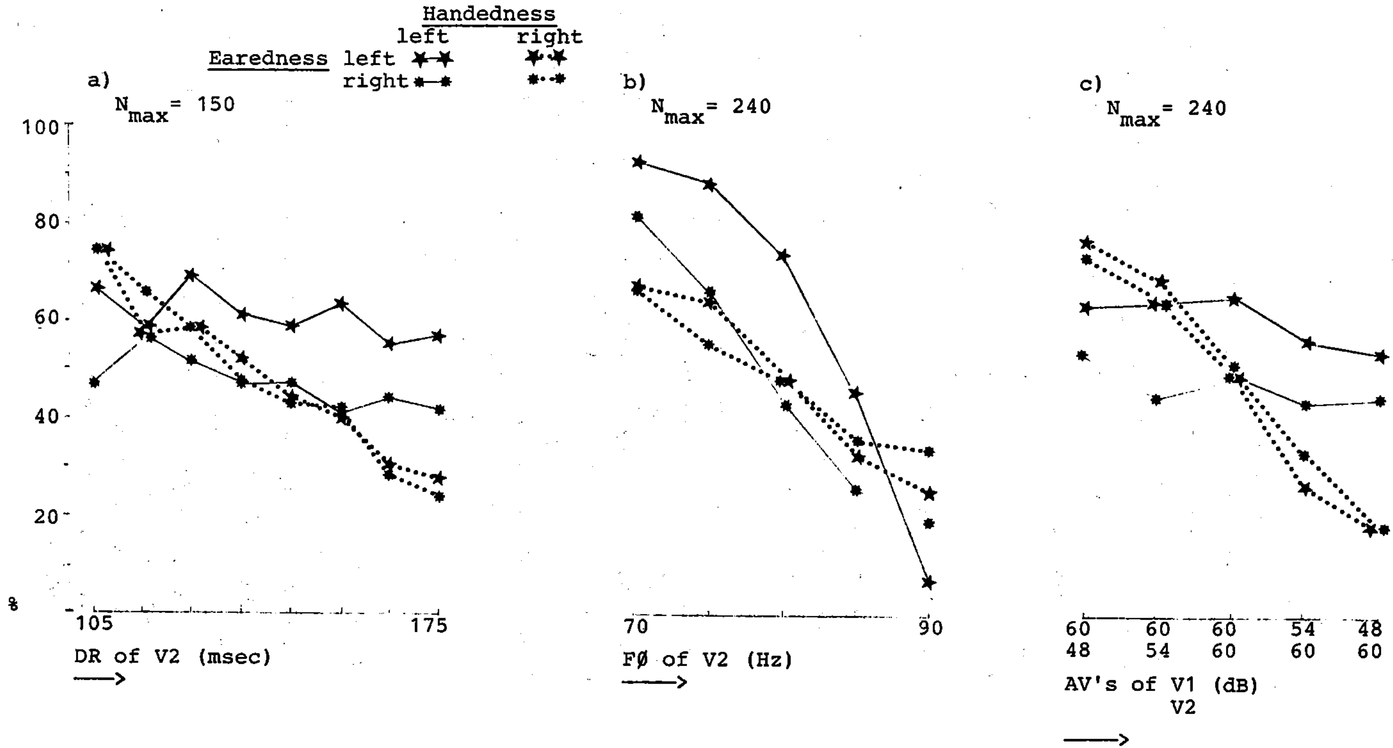
The results of the listening tests are plotted on Figure 1a-c. The left-handed subjects seem to rely totally on the fundamental frequency when assigning stress on the /sasa/, while the right-handers use all the three parameters, duration, frequency and amplitude simultaneously in this function. There thus seems to exist interdependency between manual preference in writing and the perception of linguistic prominence.

That the sinistrals in this test use solely FØ may be better understood when the results of Deutsch 1978 are taken into consideration. Her moderately left-handed subjects performed better in a musical memory task than did the other three groups, the strongly left-handed and the moderately and strongly right-handed. The signals were sine waves that differed in their frequency. Davis and Wada 1978 go as far as to associate frequency processing with the other "spatial" right-hemisphere functions when discussing the relationship between handedness, sex[4] and the hemispheric modes of processing information. However, contrary to these studies there exist data on the bilateral representation of frequency in the central nervous system. Curry 1968 and Doehring 1972 suggest a possibility for subcortical processing of pitch.[5]

4 No sex differences were found in the present experiment.

5 In music perception, too, experience with the signal and code systems has been found to have influence on auditory lateralization, see Gates and Bradshaw 1977. Their musically naive subjects had an LEA which was interpreted as holistic perception. The musically-trained listeners showed REA and thus perhaps analyzed the input into its components.
See the EEG data in Hirschowitz et al. 1978. Bever and Chiarello 1974 give monaural, Johnson 1977, Shankweiler 1966 and Kimura (1967) dichotic data on music. The latter two studies also contain results on neurological patients.
The perceptual asymmetries, as we have called them, may be influenced by output factors and outward orientation like handedness; a claim that is supported by the present experiment. (Cf. Freides 1977 and Kinsbourne and Hiscock 1977.)

Figure 1. Stress identification by Finnish musically-trained Ss. y-axis denotes the percentage of the words perceived as having stress on the first syllable.



As regards the ear-effect in the sinistrals of the present study, the FØ curves in Figure 1b can be interpreted to indicate categorical perception of pitch by the left ear. Siegel and Siegel 1977a,b confirm the existence of categorical perception of tonal intervals by musicians.

Even if the six informants of our study conformed very well to their respective group behaviour, the role of chance cannot totally be ruled out due to the small number of subjects. This need for replicating the experiment with larger populations concerns especially the fine-grain ear-effect results of the sinistrals. Furthermore, that only one handedness group exhibited an advantage while the other did not appears to increase the need for additional testing. The handedness results find, however, corrobobating evidence at least in Deutsch 1978 and, besides, they are large scale differences appearing consistently in the same manner during the two earedness sessions.

We may conclude that motor orientation (handedness in writing) enhances the "auditory" processing mode capacities of the more manual hemisphere. The dextrals use duration and amplitude that must be employed when a sequential analysis of auditory events is being performed, and this type of analysis is claimed to be a left-hemisphere phenomenon. That the right-handers also use FØ may be a sign of a bilateral representation of FØ. The sinistrals in the present study and in Deutsch 1978 perform in a manner that would suggest a more pronounced right-hemisphere processing of pitch (see also Davis and Wada 1978, Bever and Chiarello 1974, Kimura 1967 and Shankweiler 1966). The use of the three parameters can be explained within a framework that postulates a link between manual preference and the auditory modes during the perception of linguistic prominence.

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