Bulletin of the Psychonomic Society
1976, Vol. 7 (5), 452-454

Laterality in the perception of successive tactile pulses

EUGENE C. LECHELT and GORDON TANNE
University of Alberta, Edmonton, Alberta, Canada T6G 2E9

Effect of laterality on absolute judgments of the number of successive tactile pulses was investigated by presenting 5 to 13 mechanical pulses to the preferred and nonpreferred hands of right- and left-handed subjects. While nonpreferred hand stimulation consistently yielded significantly higher reports of signal number for both right- and left-handed subjects, there was a shift in laterality in terms of response accuracy. Preferred hand reports for both right- and left-handed subjects were more accurate with trains of seven or fewer pulses but less accurate when trains contained more than seven pulses.

The association between sensory-perceptual discrimination and cerebral dominance or laterality of cerebral function has been traditionally investigated within a clinical perspective, e.g., the documentation of sensory loss or impairment directly related to unilateral brain lesions has been most extensive (Zangwill, 1963). More recently, however, reliable psychophysical techniques have been employed using normal populations to specify the relationship between specific perceptual discriminatory abilities and differential hemisphere specialization (White, 1969).

Although the majority of left-right cerebral asymmetries for verbal and nonverbal stimulation have been reported primarily for visual and auditory modalities (Crowell, Jones, Kapunial, & Nakagawa, 1973; Kimura, 1973), functional lateralization of basic spatial and intensive discrimination has also been demonstrated for the tactile sense (Weinstein, 1968). The somatosensory system is particularly interesting in terms of lateralization of function since it is anatomically unlike vision and audition and is believed to be almost entirely crossed, e.g., the right side of the body has cortical representations at the left postcentral gyrus (Gazzaniga, Bogen, & Sperry, 1963; Sinclair, 1967). While tactile spatial pattern discrimination has been clearly shown to be a right hemisphere function for intact (Hermelin & O'Connor, 1971) and commissurotimized patients (Milner & Taylor, 1972), tactile temporal order and simultaneity discrimination appears to be a left or dominant hemisphere function (Efron, 1963). Dominance or lateralization of temporal pattern perception, although extensively investigated for audition (Robinson & Solomon, 1974), has not been clearly specified for the tactile sense.

The present study is an attempt to explicate possible lateralization of a specific form of tactile temporal pattern discrimination, tactile temporal numerosity discrimination (i.e., the ability to assess the number of successive signals in a fixed period of time). Such discrimination has been shown previously to be a function of spatial patterning and stimulus intensity (Lechelt, 1974a, b).

This research was supported by Grant A8621 from the National Research Council of Canada to E. C. Lechelt. Requests for reprints should be sent to E. C. Lechelt, Department of Psychology, University of Alberta, Edmonton, Alberta, Canada T6G 2E9.

PROCEDURE

One and one-half second trains of either 5, 6, 7, 9, 11, or 13 2-msec 15-dB SL square-wave mechanical pulses were presented to right and left middle fingers of three right-handed and three left-handed male subjects. Signals were delivered to the ball of each finger via a ¼-in.- (.63-cm) diam Lucite contactor projecting through a cover plate with appropriate finger cutouts. Contactors were affixed to, and driven by, a Clevite Co. bimorph transducer.

Subjects served in two experimental sessions. In session one, thresholds for tactile pulses were first determined for each finger, followed by a sample of 20 trains. After a 5-min rest period, 15 replications of each of the six pulse number trains were randomly presented to the preferred and then the nonpreferred hand. In the second session, hand order was simply reversed. Thirty reports were thus obtained from each subject for each treatment. Subjects initiated the onset of each train by depressing a foot switch and were specifically instructed to report only the number of pulses counted in each train.

RESULTS AND DISCUSSION

As right- and left-handed subjects provided statistically homogeneous numerosity reports in terms of preferred and nonpreferred hand stimulation, data were combined across subjects and analyzed from two perspectives: (1) actual numerosity report (i.e., the number of signals counted by subjects); and (2) veridicality of report. From Figure 1, it can be seen that the number of pulses counted was consistently higher for the nonpreferred hand for both right- and left-handed subjects. A Wilcoxon matched-pair signed ranks test showed laterality, in terms of preferred vs. nonpreferred hand, exerted a significant effect on perceived numerosity [$T = 0$, $p < .01$ (two-tailed)]; nonpreferred hand numerosity reports being significantly higher than preferred hand

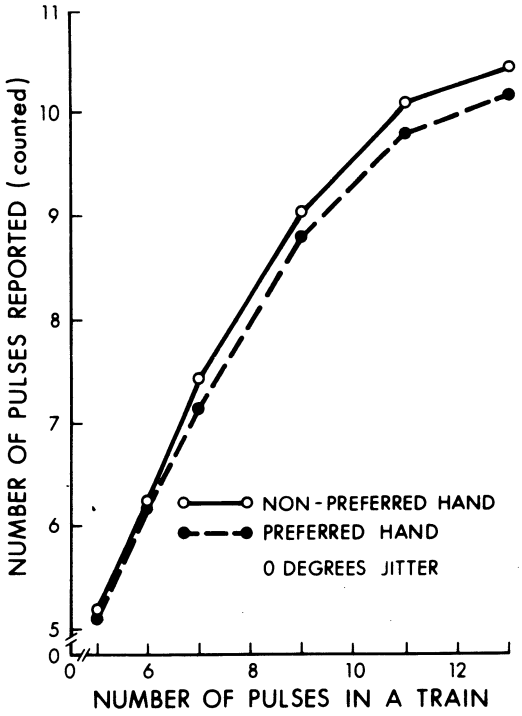

Figure 1. Mean reported (counted) number of pulses for preferred and nonpreferred hand conditions combined for right- and left-handed subjects shown as a function of the number of pulses in a train.

reports. Figure 2 depicts report accuracy (veridicality) for both hands and each condition of pulse number. It is apparent that there is asymmetry in terms of response veridicality with preferred hand numerosity reports of both right- and left-handed subjects being more accurate for trains of five, six, or seven pulses, but nonpreferred hand reports being more accurate for trains of 9, 11, or 13 pulses. This response asymmetry resulted in laterality not exerting a significant effect on the veridicality of numerosity reports.

The numerosity report data (the number of pulses reported to have been counted) would appear to implicate "handedness," i.e., preferred vs. nonpreferred hand, in the perception of tactile temporal numerosity. All subjects, right-handed and left-handed, consistently gave greater numerosity judgments for nonpreferred hand stimulation. However, the asymmetry in the veridicality of reports between small and large number discrimination for both right- and left-handed subjects makes one hesitant to speculate as to actual hemisphere dominance for such discrimination.

Perhaps most interesting is the position of the reversal of functional laterality in terms of response veridicality. When stimulation was within the "span of immediate memory (Miller, 1956)," the preferred hand for both right- and left-handed subjects (and hence, supposedly, the dominant hemisphere) provided more accurate reports of pulse number. However, when stimulation exceeded the so-called "channel capacity (i.e., trains with 9, 11, or 13 pulses)," subjects were more accurate with nonpreferred hand stimulation.

Although the present findings can only be considered as preliminary, corroborative evidence of such laterality shifts have been reported recently for varied types of auditory stimulation. Bakker (1967) found a shift in the recognizability of Morse-code-like signals from right to left hemisphere as a function of age. Bever and Ciarello (1974) reported that with increasing practice there was a switch in the recognition of melodies from right to left hemisphere. Differential hemispheric specialization for the recognition of Morse code signals between trained and naive operators has also been reported by Papcun, Krashen, Terbeek, Remington, and Harshman, 1974. Furthermore, Papcun et al. found a hemispheric shift in naive operators as a function of the number of elements in an auditory sequence; when the sequence was restricted to seven or fewer elements, more subjects showed right-ear superiority but when presented with trains of greater numbers of elements showed a left-ear superiority indicating right hemisphere function.

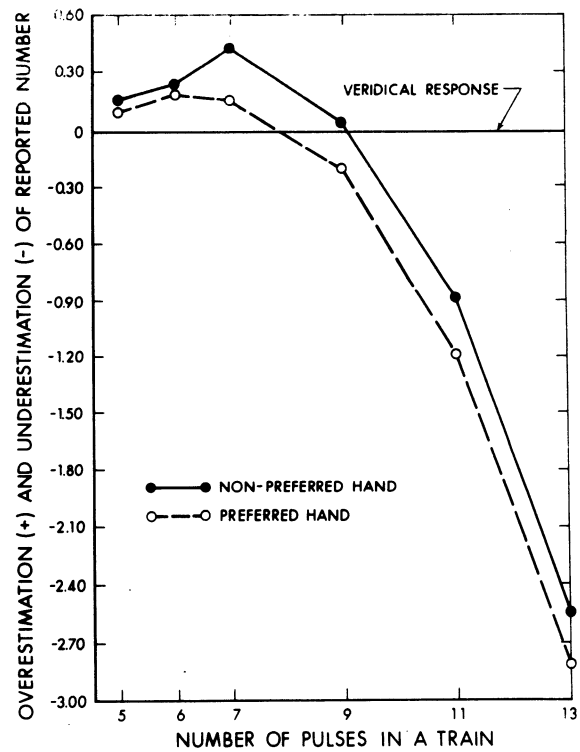

Figure 2. Response accuracy (veridicality) in terms of mean overestimation and underestimation of reported number for preferred and nonpreferred hand stimulation shown as a function of the number of pulses in a train. Data were combined for right- and left-handed subjects.

Although subjects in the present study were carefully instructed to report only the number of signals counted in each train, it is quite possible that differences in rhythm or temporal patterning resulting from having trains of fixed duration but variable numbers of pulses invoked differential analysis or strategies. Subjects did report that when pulse number was small (less than seven) they were able to discriminate each successive pulse and attend to (count) individual pattern elements, but when the number increased beyond seven they essentially based their impressions of numerosity on a poststimulation holistic analysis of the entire patterned sequence.

The specification of functional laterality and cerebral hemisphere specialization would appear to be dependent not only on physical stimulus characteristics, but, as well, the implications of the total stimulus complex in terms of the perceptual analysis or response strategy required of the observer. Specifically, increasing complexity of a stimulus pattern may indeed necessitate the switch from an elemental, feature analysis to a gestalt, global analysis. The veridicality analysis of the reported tactile temporal numerosity data appears to substantiate the suggestion of Papcun et al. (1974) that the hemispheres are differentially specialized for sensory-perceptual discrimination of stimulation within the "span of immediate memory" and for stimulation exceeding this limit and requiring some form of cognitive analysis.

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(Received for publication January 30, 1976.)