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C. Mark Borgstrom
University of Nebraska at Omaha

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Cerebral Lateralization and Cognitive Function

A Thesis

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In Partial Fulfillment

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by

Mark C. Borgstrom

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THESIS ACCEPTANCE

Accepted for the faculty of the Graduate College, University of Nebraska, in partial fulfillment of the requirements for the degree Master of Arts, University of Nebraska at Omaha.

THESIS COMMITTEE

Name	Department
Lee A Kallstrom	Special Education
Barbara Manning	Psychology
Evan Brown	"
Elton S. Carter	Communication

Kenneth A. Deffenbacher
Chairman

Date July 20, 1978

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Abstract

Eighty-seven undergraduate students were given the Edinburgh Handedness Inventory, two dichotic listening tasks, and a paired-associate task to assess the relationship between visuo-spatial/verbal abilities and cerebral lateralization. It was hypothesized that well lateralized subjects, as measured by the handedness inventory and dichotic listening tasks, would score higher in the visual imagery condition of the paired-associate task than less well lateralized subjects, and would score about the same as the less well lateralized subjects on the verbal mediation condition. According to the Levy-Sperry hypothesis the less well lateralized subjects should have experienced difficulty using visual imagery mneumonics on the paired-associate task due to the interference from language processes in the left hemisphere. The results failed to support the Levy-Sperry hypothesis in that there were no significant differences between handedness or cerebral dominance groups. The differences between the hypotheses and results were attributed to defects in experimental procedure and several possible improvements in procedure were discussed.

Cerebral Lateralization and Cognitive Function

Researchers in the area of cerebral asymmetry and hemispheric function have come to several broad conclusions about cognitive function. For example, the left, generally dominant hemisphere processes in a verbal, serial, analytic manner while the right hemisphere is more often associated with visuo-spatial, parallel, and wholistic processing (Bradshaw, Gates, & Patterson, 1976). This asymmetry in hemispheric function is usually termed "cerebral dominance". Cerebral dominance refers to the tendency of one of the hemispheres, generally the left hemisphere, to "lead", or respond more quickly to stimuli presented to the brain.

One of the more popular indicators of cerebral dominance is performance on a dichotic listening task (DLT). In a dichotic listening situation, subjects are generally presented simultaneously with two different stimuli one to each ear. Under these conditions the majority of normal adults identify the stimuli presented to the right ear more accurately than those delivered to the left ear (Broadbent, 1954; Kimura, 1961a; Studdert-Kennedy & Shankweiler, 1970; Zurif & Bryden, 1969). Kimura (1961a) has interpreted this right ear superiority as a manifestation of left-hemisphere speech dominance since most auditory fibers cross over to the contralateral side of the brain before reaching the cortex.

Dichotic listening stimuli take many forms. The first DLTs employed series of digits to assess cerebral dominance (Broadbent, 1954; Kimura, 1961a). There are two major difficulties associated with this type of task, both of which occurred in most of the earlier studies.

The first of these problems is a tendency for the subjects to recall all of the stimuli in one or both ears over all the trials. This ceiling effect tends to push laterality scores toward zero since laterality is measured by the difference in numbers of digits recalled in each ear across trials. That difference may be artificially limited when a subject obtains a perfect score in one ear. Ceiling effects occur quite often when only three pairs of digits are presented to the subject per trial. This problem can usually be remedied by using four pairs of digits per trial instead of three; however, there is then more of a tendency for subjects to adopt recall strategies than there is in a three digit-pair DLT.

Recall strategies are the second major group of difficulties in a digits DLT in both the three- and four-digit pair per trial task. For example, the subject may report the stimuli from one ear first for various reasons, tending to bias his laterality score in favor of that ear, since he will tend to forget the digits heard through the other ear while reporting scores from the first ear. This can be avoided by instructing the subject to report one ear or the other first when recalling the digits. In order to determine the relationship between free and ordered recall, Zurif and Bryden (1969) compared both styles and found that free recall and ordered recall were correlated .49 which was significant at the .05 level. This suggests that the ordered recall DLT does not measure exactly the same thing as the free recall DLT since the correlation only accounts for 23% of the variance. The question as to which technique is most appropriate is still unresolved.

A second type of DLT which does not have recall strategy problems and ceiling effects is the Consonant-Vowel (CV) DLT first introduced by Shankweiler and Studdert-Kennedy (1966). In this task the subject is presented with a CV in each ear and is asked to recall what he heard, laterality being determined by the number of CVs he recalls correctly in each ear. As with the digits task there is a tendency for subjects to recall more CVs presented to the ear contralateral to the dominant hemisphere than the ear ipsilateral to the dominant hemisphere.

Direction and degree of lateralization as measured by a DLT is determined by summing the number of stimuli recalled correctly in each ear across trial and either comparing them directly or applying a formula to them to determine a laterality quotient (LQ). The earlier studies compared the scores for each ear directly. Later, Studdert-Kennedy and Shankweiler (1970) applied the index $(R - L)/(R + L) \times 100$, where R = the number of correct right-ear responses and L = the number of correct left-ear responses yielding a LQ which ranges from -100 to +100. Kuhn (1973) criticized this formula because the maximum value of the index decreases rapidly as overall performance rises above 50%, assuming the task is to identify both stimuli on each dichotic presentation. Studdert-Kennedy and Shankweiler had suggested that only trials on which one stimulus is correctly reported should be included in the computation of the ear advantage. Kuhn rejected this technique on the grounds that subjects who obtain the same LQ may be qualitatively different from each other in terms of cerebral dominance due to the ratio between the number of correct responses and the total possible number of correct responses for each subject. He suggests an alternate formula based on the correlation statistic, phi. In relation to dichotic listening,

$$\text{phi} = \frac{R - L}{\sqrt{(R + L)[2T - (R + L)]}}$$

where R = the number of correct right-ear responses, L = the number of correct left-ear responses, and T = the total possible number of responses for each ear. Since phi is a correlation coefficient, it ranges from -1.00 to +1.00. "Computed in this way, the index can be thought of as yielding a value of correlation between correct performance and 'right earedness': a negative value indicates a left-ear advantage" (Kuhn, 1973, p. 454).

A variable commonly associated with cerebral dominance is handedness. Zurif and Bryden (1969), for example, showed handedness to be related to cerebral dominance using the digits DLT mentioned above. Specifically, right-handed subjects had greater differences between the number of digits recalled from each hemisphere than did left-handed subjects, suggesting right-handed subjects were more lateralized than left-handed subjects. This is in agreement with White's (1969) suggestion that right-handers have more consistent lateral differences than left-handers. White estimates that 90% of right-handed people are left-hemisphere dominant, based on Milner, Branch and Rasmussen's (1964) study which utilized the intracarotid amytal technique to test for cerebral dominance. This technique involves the intracarotid injection of sodium amytal on either the right or left side to interfere with hemispheric function. It is then possible to compare the involvement of each hemisphere in the processing of verbal materials. Annett (1970a), in contrast to White, proposed that if true right-handers are left-hemisphere dominant, then true left-handers will be right-hemisphere dominant while mixed-handers may be either left- or right-hemisphere dominant for speech. Perhaps not surprisingly, Beaumont (1974) suggests the relationship between handedness and cerebral dominance is probably dependent on the type of handedness measure employed.

Handedness can be measured in several different ways, the most popular measure for adults being a handedness questionnaire. Several handedness questionnaires are currently available, probably the two most popular being Annett's (1970b) handedness questionnaire and Oldfield's (1971) Edinburgh Handedness Inventory. Both questionnaires use similar items to which the subject responds by writing "left", "right", or "either" in the case of the Annett questionnaire or by responding "++", "+", in either the left or right column or a "+" in each column in the case of the Edinburgh Handedness Inventory.

Oldfield has quantified his scale by using the same Fechnerian formula as Studdert-Kennedy and Shankweiler (1970) where R = the number of pluses in the right column and L = the number of pluses in the left column. Because of this quantification and the validity and reliability research on the Edinburgh Handedness Inventory, it is probably preferable to the Annett questionnaire.

Since visuo-spatial and verbal processing are associated with cerebral dominance it would be reasonable to assume that handedness would also be related to verbal and visuo-spatial processing. Several theories have been suggested to explain this relationship, two of which are presented here. The Levy-Sperry hypothesis suggests that, unlike right-handed persons, language abilities are present to some degree in both hemispheres in left-handed persons (Levy, 1969; Levy & Sperry, 1968; Marshall, 1973). This degree of language ability in the right hemisphere might then interfere with visuo-spatial processing in the right hemisphere, causing a decrease in visuo-spatial processing ability for left-handers. Annett's hypothesis (1970a) of handedness differs from the Levy-Sperry hypothesis in that she divides handedness into three groups: right-, mixed-, and left-handedness. Right- and left-handers are postulated to have fairly complete lateralization of verbal processing. Mixed-handers, on the other hand, have less lateralization of verbal processes and would therefore differ from left- and right-handers in terms of visuo-spatial processing due to the verbal interference.

Recently Sherman, Kulhavy, and Burns (1976) used a serial learning task to determine the differences in visuo-spatial and verbal processing between right- and left-handers. The "left-handed" group included both pure left-handers and mixed-handers. Right-handers recalled significantly more nouns than left-handers in the learning condition where all nouns memorized were abstract. In the learning condition where all nouns were concrete, right- and left-handers performed similarly. The authors discussed these results in terms of supporting the Levy-Sperry hypothesis, suggesting that the concrete items were encoded by both the imaginal and verbal systems leading to superior recall. The superior recall of the right-handers was attributed to their ability to use this imaginal system in addition to their verbal system while left-handers could only encode information using the verbal system. In the imagery condition subjects were asked to visualize the object represented by the noun and in the rote condition were asked to simply repeat the nouns over and over. There were no significant differences between handedness groups in the imagery condition contrary to the authors' predictions.

It was the purpose of the present study to use a technique similar to Sherman, et al. (1976) to test assumptions of Annett's model of handedness. This study differed from the above study in several ways. The most important difference was the use of three handedness groups instead of two, to test the assumption that left-and mixed-handers are functionally different. A second difference was the use of a paired-associate task instead of a serial learning task. A paired-associate task was used because of the large body of research using this particular paradigm and because most visual imagery and verbal mediation studies have used the paired-associate learning paradigm. Verbal mediation instead of rote learning was used because verbal mediation is a more complex task and because it is probably more analogous to the visual imagery task than the serial learning task. The last major difference was the inclusion of a third variable, cerebral dominance in place of the concrete vs. abstract variable. This variable was included to determine whether cerebral dominance accounts for the relationship between handedness and visuo-spatial/verbal processing ability.

It was hypothesized that right-handers would not perform significantly different from left-handers on the paired-associate task in either the verbal or visuo-spatial condition and that mixed-handers would score significantly lower than either right- or left-handers in the visuo-spatial condition and would not differ significantly from right- and left-handers on the verbal task. It was also hypothesized that right-hemisphere dominant subjects and left-hemisphere dominant subjects would score higher than less lateralized (mixed-dominant) subjects on the visuo-spatial task and all three groups would perform similarly on the verbal task.

Method

Pilot Study

A pilot study was conducted to determine whether the handedness inventory and DLTs were correlated to the extent that it would be redundant to include all three measures. Thirty-nine subjects (20 right-handed, 19 left-handed) were tested using a CV and a digits DLT and the Edinburgh Handedness Inventory. Phi scores were calculated for the DLTs and LQ scores for the handedness inventory according to the same formulas Kuhn (1973) and Oldfield (1971) used, respectively. The scores were then correlated yielding three coefficients, .265, .195, and .198 corresponding to the correlations between the CV DLT and handedness, the digits DLT and handedness, and the CV DLT and digits DLT, respectively. The correlation between handedness and the CV DLT was significant at the .05 level, one-tailed. Because the correlations among the three laterality measures were rather low, all three measures were included in the main experiment.

Subjects and Design

Two variables, handedness and instructions, were varied to form six experimental groups. Thus the design was a 3 Handedness (right vs. mixed vs. left) X 2 Instructions (visual imagery vs. verbal mediation) factorial design, employing unequal *ns* analysis. Eighty-seven undergraduate students at the University of Nebraska at Omaha, who were given extra class credit for their psychology courses, participated in the experiment. They were later divided into six groups on the basis of handedness and instructions.

Apparatus and Materials

The learning materials consisted of five lists of eight concrete word-pairs each, with Thorndike and Lorge (1944) frequencies of "AA" or "A" and imagery and meaningfulness values both above 6.00 (Paivio, Yuille, & Madigan, 1968). The word-pairs were presented visually via a Kodak 550 carousel projector onto a 20.32cm Hudson translucent rear-projection screen. The dichotic listening stimuli were presented via a Viking 433 tape recorder, a Maico MA-24 dual channel audiometer, two McIntosh MC 50 solid state power amplifiers, and Auraldomes calibrated audiometric headset noise barriers.

Procedure

Handedness Assessment. Upon entering the experimental room, which was acoustically attenuated about 40 dB, subjects were seated and given instructions as to the nature of the experiment. Each subject was run individually. The subject was first assessed for handedness using the modified Edinburgh Handedness Inventory (Oldfield, 1971) presented in Appendix A.

Cerebral Dominance Assessment. After being assessed for handedness, the subjects were taken to the second room, which was also acoustically attenuated by approximately 40 dB, and fitted with headphones where he remained for the rest of the experiment. The experimenter returned to the other room and determined the subject's speech reception threshold by having the subject repeat two syllable words spoken to him over the headphones, decreasing the sound intensity five decibels after each word until the subject could no longer hear them. The lowest level at which the subject could repeat three words was considered his speech reception threshold for that ear. The same procedure was repeated for the other ear. The intensity level was then increased 50 decibels above the speech reception threshold for each ear. The subject was then given the instructions for the first DLT.

> You will now hear short sounds such as /pa/, /ga/, or /da/. You may hear one and you may hear two. Repeat any sound or sounds that you hear. I'll tell you where the sounds will start - You will hear one more tone and the sounds will begin.

The subject was then presented with the stimuli.

The CV DLT consisted of thirty trials with one pair of CVs presented on each trial.[1] The CVs were constructed by pairing the vowel /a/ with the six English stop consonants, /p/, /b/, /t/, /d/, /k/, and /g/. The CVs were presented at a rate of about one per five seconds, giving the subject time to respond verbally. After the CV DLT the subjects took about a two-minute break while the experimenter changed tapes. The subjects were then given the instructions for the second DLT.

> You will now hear a series of numbers in each ear. For example you may hear 3-6-1 in your right ear while at the same time you may hear 7-4-2 in the left ear. You are to repeat all of the numbers that you hear, even though you may be unsure.

The subject was then presented with the digits stimuli.

The digits DLT consisted of 20 trials with three pairs of digits being presented one pair at a time.[2] The digits were presented with an interitem period of .5 seconds and a recall period of about ten seconds between trials. At the end of the digits DLT the subject was asked to remain seated while the experimenter came into the room to remove the headphones.

Paired-associate Learning. After the digits DLT the subject was given written instructions for the appropriate condition (visual imagery vs. verbal mediation) in the paired-associate task. The condition assigned was partially dependent on the subjects handedness score in order to fill all cells of the design. The instructions for each condition appear in Appendix B.

As suggested by the instructions the paired-associate task consisted of six trials with eight word-pairs on each trial. Each word-pair appeared on the screen for 3.9 seconds with an interitem slide change time of .9 to 1.1 seconds. Timing on the recall sequence started as soon as the subject turned the page in the answer booklet, which had the eight "stimulus" words for each trial on separate pages. At the end of the one minute recall session the slide projector was started again. At the end of the paired-associate task the subject was questioned with regard to what recall and encoding strategy or strategies he had used during the paired-associate task. The subject was then debriefed.

Results

Each of the dependent and independent measures were scored in a different manner with the exception of the two DLTs. The responses in the paired-associate task were scored in the following manner. Two points were given for each correct response, one point for each word recalled with the incorrect stimulus word and zero points for no response, or incorrect response (Bugelski, Kidd, & Segmen, 1968). The DLTs were scored by summing across trials for each ear yielding the number of correct responses for each ear. The Kuhn (1973) phi formula was then applied to these scores so that each subject had a phi coefficient representing his performance on the CV DLT and one representing his performance on the digits DLT. The Edinburgh Handedness Inventory was scored in the manner suggested by Oldfield (1971), discussed previously.

The scores for the two DLTs and handedness were correlated over all 87 subjects. The correlation between handedness and the CV DLT and handedness and the digits DLT were .231 and .295, respectively, both of which are significant at the .05 level, two-tailed. The correlation between the CV DLT and the digits DLT was .442, which is significant at the .001 level, two-tailed.

The scores on the paired-associate task were split with regard to instruction condition (visual imagery vs. verbal mediation) and also correlated with handedness, and the two DLTs. The correlations between the scores on the verbal mediation condition on the paired-associate task and handedness, the CV DLT, and the digits DLT, were

.164, .062, and -.080, respectively, none of which are significant at the .05 level. The correlations between the scores on the visual imagery condition on the paired-associate task and handedness, the CV DLT, and the digits DLT, were .115, -.200, and -.119, also not significant at the .05 level.

To test the hypothesis that direction of lateralization is not as important as degree of lateralization, the negative signs on the phi coefficients for the CV DLT and digits DLT were dropped and then correlated with the paired-associate conditions. The correlations between verbal mediation condition scores and the modified CV and digits DLT scores were .312 and .168, respectively, the former correlation being significant at the .05 level, two-tailed. The correlations between visual imagery condition scores and the modified CV and digits DLT scores were both nonsignificant (-.072 and .091, respectively.

To test the hypothesis that mixed-handers differ from left- and right-handers in terms of performance in the visual imagery condition and not the verbal mediation condition a 3 Handedness X 2 Instructions unequal ns analysis of variance was calculated using the paired-associate scores as the dependent measure. The handedness variable was divided into three groups by classifying all subjects scoring above .500 as right-handers, those scoring between and including .500 and -.500 as mixed-handers, and those scoring below -.500 as left-handers. The ±.500 level was chosen because it is the midpoint of the scale on either side of zero. The two levels of instructions are verbal mediation and visual imagery. The means for each group appear in Table 1. The analysis of variance yielded no significant effects for handedness, F(2,81) = .5809, instruction, F(1,81) = .0823, or the interaction, F(2,81) = .0416.

A post hoc analysis of variance was calculated using two levels of handedness instead of three, dividing handedness at the zero point, with type of instruction as the second independent variable. This analysis also yielded no significant results for handedness, F(1,83) = 2.212; instructions, F(1,83) = .071; or the interaction, F(1,83) = .019.

An analysis of variance was calculated to determine the relationship between cerebral dominance and paired-associate learning. This analysis had three levels of cerebral dominance as measured by the CV DLT and two types of instruction (visual imagery vs. verbal mediation). Cerebral dominance groups were determined by classifying all subjects scoring in the positive range and above the .20 level on Kuhn's (1973) probability table as being left hemisphere dominant, those below the .20 level as mixed dominant, and those above the .20 level and in the negative range as right hemisphere dominant. The .20 level was chosen to obtain adequate cell sizes. The means for each group are also in Table 1. The unequal ns analysis yielded no significant results for cerebral dominance, F(2,81) = .364; instructions, F(1,81) = .459; or the interaction, F(2,81) = .474.

Table 1

Mean Percent Correct Responses by Each Handedness and Cerebral Dominance Group for Each Instruction Condition

	Instruction Condition	
Group	Verbal Mediation	Visual Imagery
Handedness Groups		
Left-handed	78.7%	77.2%
Mixed-handed	81.6%	82.0%
Right-handed	81.7%	80.2%
Cerebral Dominance (CV DLT)		
Right Hemispheric Dominance	81.9%	82.3%
Mixed Hemispheric Dominance	78.7%	79.9%
Left Hemispheric Dominance	85.2%	78.3%
Cerebral Dominance (digits DLT)		
Right Hemispheric Dominance	82.7%	90.3%
Mixed Hemispheric Dominance	80.3%	78.5%
Left Hemispheric Dominance	81.3%	83.3%

A 2 X 2 post hoc analysis of variance was calculated using a median split division on the CV DLT measure, the median being .0349, and instructions being the second variable, yielding no significance at the .05 level (cerebral dominance, $F(1,83) = .067$; instructions, $F(1,83) = .147$; and interaction, $F(1,83) = 3.519$). The interaction was, however, significant at the .10 level. This analysis suggests that subjects classified as right hemisphere dominant have a mean performance score on the visual imagery task (79.050) higher than the visual imagery performance scores of the left hemisphere dominant subjects (74.391). The advantage is reversed in the verbal mediation task with the right hemisphere dominant group having a lower mean (74.750) than the left hemisphere dominant group (80.900). This is not in agreement with the hypothesis which would predict the reverse in terms of the visual imagery task and no differences between groups in the verbal condition.

A 3 X 2 unequal *ns* analysis of variance was calculated with cerebral dominance as measured by the digits DLT as one independent variable and instructions as the second variable. Subjects above one standard deviation from the mean on the digits measure were classified as left hemisphere dominant, those less than one standard deviation were classified as mixed-dominant, and those below one standard deviation as right hemisphere dominant ($M = -.011$, $SD = .231$). Means for these groups appear in Table 1. All F scores were less than one.

Two additional post hoc analyses were calculated using cerebral dominance as measured by the digits DLT as one independent variable and instructions being the second variable. In the first analysis subjects were divided in terms of cerebral dominance into two groups, one group's scores being above the .05 level on Kuhn's (1973) significance index (both positive and negative), and the other group's scores being below the .05 level. The second analysis divided cerebral dominance into groups by using a median split on the digits DLT scores, the median being -.0268. All *F* scores in both analyses were less than one.

A post hoc analysis was calculated using the student *t* statistic to determine if right-handers differ from left-handers in terms of cerebral dominance. Using the CV DLT as the dependent measure, 46 right-handers had a mean of .077 and 41 left-handers a mean of -.023, which were significantly different at the .05 level, t(85) = 2.167. Using the digits DLT as the dependent measure, the mean for the right-handers was .063 and for the left-handers was -.073, which were also significantly different at the .05 level, *t*(85) = 2.620. Taking only degree of laterality with no regard to direction of laterality, the left-handers did not differ significantly from the right-handers for either the CV or digits measure, *t*(85) = .565, *t*(85) = .409, respectively.

Discussion

The results of this study for the most part are not in agreement with the primary hypotheses. The results would indicate that there are no differences among left-, mixed-, and right-handers in terms of visuo-spatial abilities. The results were supportive of the hypothsis in that there were no significant differences among handedness groups in terms of verbal processing abilities. The results of the cerebral dominance analyses were also nonsupportive of the hypothesis; that is, mixed, and left hemisphere dominant groups did not perform significantly different from each other in terms of visuo-spatial processing abilities. The same was true for verbal processing abilities in terms of no differences between cerebral dominance groups, however, this was supportive of the main hypothesis.

The present findings are also not in agreement with the Levy-Sperry hypothesis of Annett's hypothesis, since both theories would predict differences between handedness groups in terms of visuo-spatial abilities and no differences between groups in terms of verbal abilities. The present findings suggest that either the theories are inappropriate or characteristics of the experiment are responsible for the contradictory results.

Upon inspection of the reported subject strategies it was found that 68.2% of the verbal group used visual imagery techniques instead of or in conjunction with the verbal mediation technique. In the visual imagery condition, 69.8% used techniques other than visual imagery, and 30.2% used only visual imagery. This data suggests that subjects in both conditions were not complying with the instructions, and may provide an explanation for the contradictory results. If subjects in both instruction conditions were using at least in part the memory strategy of the other instruction condition, the differences between mean paired-associate scores for each condition would be much smaller than if the subjects had complied with the instructions because of the overlap of the distributions. This would be true across all handedness and cerebral dominance groups.

Due to the characteristics of the verbal learning task, a tendency for left hemispheric functioning regardless of instruction might be expected. The task was biased toward serial processing and might favor an analytic style of cognitive function. Since the right hemisphere has been associated with, parallel, and wholistic modes of processing, it would not be surprising for subjects to adopt left hemisphere cognitive styles to perform this task. Since cerebral lateralization, in theory, does not have an effect on verbal functioning, all subjects should perform about the same.

Paivio (1971) has suggested people encode information in two discrete codes, one being a visual code and the other verbal. This dual coding hypothesis would lend to support to the possibility that subjects were using both visual and verbal strategies to encode the paired-associate stimuli. This would tend to cancel any differences due to instructions and would mask the interaction between laterality effects and instructions.

In terms of the relationship between handedness and hemispheric dominance, right-handed people do seem to be more left hemisphere dominant than left-handed people. However, contrary to White's (1969) suggestion that right-handers have more consistent lateral differences than left-handers, there were no significant differences between right- and left-handers with respect to degree of lateralization. This relationship may be a function of the handedness measure, since several subjects who reported that they wrote predominantly with their left hand had overall handedness scores in the positive range.

In order to discern the true relationship between cerebral dominance and cognitive abilities as measured by the verbal learning task utilized in the present study, several adjustments in experimental procedure must be considered. A major problem in the present study was the noncompliance to instruction by the subjects. This problem could possibly be alleviated by stressing to the subjects the importance of compliance to the experimental instructions. Another possible remedy would be using practice trials before the experimental trials to allow the subject to become comfortable with the memory technique before entering the scored trials. A third strategy would be to explain several memory techniques to the subjects and ask that they consciously suppress the tendency to use memorization strategies other than the one instructed. The best procedure might be the use of all of the techniques mentioned above.

A second shortcoming of the present experiment was the digit DLT measure of cerebral dominance. A substantial number of subjects achieved perfect scores in one ear causing the ceiling effect discussed earlier which tends to push both ends of the distribution toward zero. A simple remedy would be to leave out the digit DLT and use only the CV DLT. However, the digits DLT and the CV DLT do not seem to be measuring the same thing since the two tasks were not correlated that highly accounting for only 19.5% of the variance. A better procedure would be the use of a four-digit pair task. This would probably for the most part eliminate ceiling effects.

Future research should be directed toward discovering exactly what each DLT is measuring and its relation to cerebral laterality. The use of a verbal learning task seems a reasonable procedure for the study of cognitive function assuming that appropriate refinements are made. In the final analysis, cerebral lateralization does seem to have some relation to cognitive function, although the relationship is not as clear cut as is sometimes suggested. The challenge now is to refine or create new measuring devices to discern that relationship and to improve the reliability and precision of the criterion task.

References

Annett, M. Handedness, cerebral dominance and the growth of I.Q. In D. Bakker & P. Satz (Eds.), Specific Reading Disability. Rotterdam: Rotterdam University Press, 1970a.

Annett, M. A classification of hand preference by association analysis. British Journal of Psychology, 1970b, 61, 303-321.

Beaumont, J. Handedness and hemisphere function. In S. J. Dimond & J. G. Beaumont (Eds.), Hemisphere Function in the Human Brain. New York: Halsted Press, 1974.

Bradshaw, J., Gates, A., & Patterson K. Hemispheric differences in processing visual patterns. Quarterly Journal of Experimental Psychology, 1976, 28, 667-681.

Broadbent, D. The role of auditory localization in attention and memory span. Journal of Experimental Psychology, 1954, 47, 191-196.

Bugelski, B ., Kidd, E., & Segmen, J. Image as a mediator in one-trial paired-associate learning. Journal of Experimental Psychology, 1968, 76, 69-73.

Kimura, D. Some effects of termporal lobe damage on auditory perception. Canadian Journal of Psychology, 1961a, 15, 156-165.

Kimura, D. Cerebral dominance and the perception of verbal stimuli. Canadian Journal of Psychology, 1961b, 15, 166-171.

Kuhn, G. The phi coefficiant as an index of ear differences in dichotic listening. Cortex, 1973, 9, 450-457.

Levy, J. Possible basis for the evolution of lateral specialization of the human brain. Nature, 1969, 224, 614-615.

Levy, J., & Sperry, R. Differential preceptual capacities in major and minor hemispheres. National Academy of Sciences Proceedings, 1968, 61, 1151.

Marshall, J. Some problems and paradoxes associated with recent accounts of hemispheric specialization. Neuropsychologia, 1973, 11, 463-470.

Milner, B., Branch, G., & Rasmussen, T. Observations on cerebral dominance. In A. V. S. de Rueck & M. O'Conner (Eds.), Ciba Foundations symposium on disorders of language. London: Churchhill, 1964.

Oldfield, R. The assessment and analysis of handedness: The Edinburgh Inventory. Neuropsychologia, 1971, 9, 97-113.

Paivio, A., Yuille, J., & Madigan, S. Concreteness, imagery, and meaningfulness values for 925 nouns. Journal of Experimental Psychology Monograph, 1968, 76(1, Pt. 2).

Paivio, A. Imagery and verbal processes. New York: Holt, Rinehart & Winston, 1971.

Shankweiler, D., & Studdert-Kennedy, M. Lateral differences in perception of dichotically presented synthetic consonant-vowel syllables and steady-state vowels. Journal of the Acoustical Society of America, 1966, 39, 1256.

Sherman, J., Kulhavy, R., & Burns, K. Cerebral laterality and verbal processes. Journal of Experimental Psychology: Human Learning and Memory, 1976, 2, 720-727.

Studdert-Kennedy, M., & Shankweiler, D. Hemispheric specialization for speech perception. Journal of the Acoustical Society of America, 1970, 48, 579-594.

Thorndike, E., & Lorge, I. The teachers wordbook of 30,000 words. New York: Teachers College, Bureau of Publications, 1944.

White, M. Laterality differences in perception: A review. Psychological Bulletin, 1969, 72, 387-405.

Zurif, E., & Bryden, M. Familial handedness and left-right differences in auditory and visual perception. Neuropsychologia, 1969, 7, 179-187.

Footnotes

[1] This dichotic listening tape is commercially available, and was obtained from the Kresge Hearing Research Laboratory, Department of Otorhinolaryngology of Louisiana State University.

[2] The author would like to acknowledge Burchard M. Carr of Oklahoma State University, who was responsible for the construction of the digits dichotic listening tape.

Appendix A

Edinburgh Handedness Inventory

Please indicate your preferences in the use of hands in the following activities by putting + in the appropriate column. Where the preference is so strong that you would never try to use the other hand unless absolutely forced to, put ++. If in any case you are really indifferent put + in both columns.

Some of the activities require both hands. In these cases the part of the task, or object, for which hand preference is wanted is indicated in brackets.

Please try to answer all the questions, and only leave a blank if you have no experience at all with the object or task.

	Left	Right
1. Writing		
2. Drawing		
3. Throwing		
4. Scissors		
5. Comb		
6. Toothbrush		
7. Knife (without fork)		
8. Spoon		
9. Hammer		
10. Screwdriver		
11. Tennis Racket		
12. Knife (with fork)		
13. Baseball bat (hand closest to the largest end)*		
14. Golf Club (lower hand)		
15. Broom (upper hand)		
16. Rake (upper hand)		
17. Striking Match (match)		
18. Opening box (lid)		
19. Dealing cards (card being dealt)		
20. Threading needle (needle or thread according to which is moved)		

*In the original inventory this item was "Cricket bat (lower hand)", because the inventory was used with British subjects. "Baseball bat" was substituted because baseball bats are more commonplace to American subjects than cricket bats.

Appendix B

Read for both conditions:

The following is an experiment in verbal learning. In this task you will be learning word-pairs. You will have six trials. In each trial you will learn eight word-pairs, with different word-pairs in each trial. Each word-pairs will appear on the screen for five seconds. A green slide will signal the beginning of each trial and a red slide will signal the end. At the end of each trial you will have one minute to recall the second word in each word-pair and write it next to the matching word which is on the answer sheet. For example, if the word-pair is "BONE-DOG", you would write "DOG" next to "BONE" on the answer sheet.

Read for the visual imagery condition:

In order to memorize these word-pairs, you will use a simple memory device called visual imagery. Visual imagery is a technique where you form pictures in your mind of the relationship between the two words in the word-pair. For example, if the word-pair was the example I gave you before, that is "BONE-DOG", you might imagine a dog carrying a bone in his mouth. You would keep this picture in your mind until the next word-pair appeared on the screen.

Read for the verbal mediation condition:

In order to memorize these word-pairs, you will use a simple memory device called verbal mediation. Verbal mediation is a technique where you form a phrase or sentence using the two words in the word-pair. For example, if the word-pair was the example I gave you before, that is "BONE-DOG", you might form the sentence: "The dog was carrying the bone in his mouth." You would repeat this sentence over and over to yourself until the next word-pair appeared on the screen.