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THE STABILITY OF TACHISTOSCOPIC MEASURES OF HEMISPHERIC SPECIALIZATION

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Abstract—Two-week test–retest reliabilities were determined for two tachistoscopic tasks, consonant–vowel–consonant trigrams and dot location, in 48 right-handed university students. Both visual field and laterality scores were examined. Analysis of variance showed no significant main effects or interactions of session for either task, indicating stability of *mean* performance and laterality scores. Likewise, grouping subjects as "high" or "low" by median laterality scores showed concordance across sessions for both tasks. Test–retest correlations were moderately high for all verbal task measures and for visual field scores for the dot location test. However, laterality indices for dot location showed low stability despite comparable within-session reliabilities of laterality scores for the two tasks. These findings suggest stability of group means and subgroups for verbal and dot location tachistoscopic measures. However, the degree to which individual scores are predictable from one session to the next differs between the two tasks.

Key Words: tachistoscopic measures; laterality; hemispheric specialization.

INTRODUCTION

The use of tachistoscopic measures of hemispheric specialization for subgroup classification or to examine associations with other variables assumes that these measures are stable. This is particularly true when a tachistoscopic measure is related to a measure obtained at a different time point. The stability of tachistoscopic assessments over time can only be examined by test–retest paradigms, but there are few such studies in the literature [10].

Test–retest reliabilities have been reported for tachistoscopic studies using letter pairs [4, 5, 7], four- and five-letter words [2, 6] and chimeric faces [12]. In 16 right-handed subjects [4] and 20 left-handed subjects [5], visual half-field scores for letters were examined over four sessions at 1-week intervals. Although visual field scores showed moderate stability among the latter three sessions (Pearson product moment correlations 0.55 to 0.91), correlations between the first and remaining sessions reached significance only in left-handers, and primarily for right visual half-field scores. Test–retest reliabilities for right–left difference scores averaged 0.29 for right-handers and 0.10 for left-handers.

Variability in the stability of laterality indices has also been reported for four- [2, 6] and five- [2] letter word recognition tasks. Grant [6] found a 2-day test–retest correlation of 0.46 in 39 11-year-old children, with greater stability for good as compared with poor readers and

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boys compared with girls. Brysbaert and D'Ydewalle [2] reported moderate test–retest reliabilities for a variety of laterality indices over five replications within 1 week in 14 subjects (7 right-handed and 7 left-handed). Stability again improved after the first task administration. The only study to examine test–retest reliability of a nonverbal tachistoscopic task suggested a moderate degree of stability for left visual field (LVF) bias in children's perception of chimeric faces [12]. Sixty-seven percent of the 348 children showed a consistent bias across two test sessions, 1 month apart.

To examine the test–retest stability of non-verbal as well as verbal tachistoscopic tasks, we administered two tachistoscopic measures to a sample of 48 university students. The tasks included the consonant–vowel–consonant (CVC) trigram and dot location tasks employed by Levy and Reid [9], which were reported to show visual field effects in relation to hemispheric specialization. Stability was examined by addressing the following questions: 1. Do average visual field and laterality scores vary systematically with repeated administrations? 2. What is the stability over time of subgrouping subjects by laterality score? 3. What are the test–retest correlations? In addition, correlations across tasks were examined to assess the extent to which laterality scores measure common versus unique dimensions of hemispheric specialization.

METHODS

Subjects

Subjects were 48 University of Pennsylvania students (25 males and 23 females) recruited through advertisements in the student newspaper. Subjects who passed a telephone screening to rule out histories of psychiatric and neurologic problems were invited for a semi-structured in person interview for further assessment. Handedness was determined by a standard set of items [11], and only right-handers were included in the study. Subjects whose visual acuity was poorer than 20/40 in either eye (Titmus Vision Tester) were excluded. Mean ages were 20.6 ± 2.8 years for males and 20.7 ± 2.7 years for females.

Apparatus

A Harvard 3-field tachistoscope (Gerbrands Model 3B-T-1) was employed for stimulus presentation.

Measures

CVC trigram and dot location stimuli were those employed by Levy and Reid [9]. Stimuli and procedures for administration are detailed below. Each task included a fixation stimulus card, a masking stimulus, and the actual test stimuli. All test stimuli had a central fixation point with a number at fixation. Each task was administered in three phases: (1) threshold determination; (2) a practice set of 10 items; (3) the actual test items. Each item presentation was preceded by a fixation stimulus card and followed by a masking stimulus card.

CVC trigrams

The verbal task was composed of 72 test items of CVC nonsense trigrams, half in each visual field. Each stimulus card consisted of the three letters presented vertically, approximately 2 degrees to the right or left of the fixation number. The trigrams were white on black background and were 2.86 cm in length. Presentation time for test items was constant at threshold time plus 40 msec. The fixation stimulus was a card containing only the fixation point and was administered for 300 msec. The masking stimulus was a partial noise field, administered for 1000 msec. For a "correct" response, subjects were required to recall the fixation number, whether the trigram was to the left or right, and the correct trigram. For threshold determination, stimuli were single letters presented 2 degrees to the right or left of the fixation point. To obtain a correct response, subjects were required to report the correct fixation number, followed by the letter. Exposure time for threshold determination began at 60 msec and was modified in increments of 10 msec, until a criterion of 80% correct was obtained.

Dot location

The dot location task was composed of 80 test items of white dots (0.32 cm diameter) on black cards, located in 20 possible positions within a rectangular frame in either the right or left field. The fixation field was composed of two rectangular frames, 5.72 cm by 4.45 cm, with the medial borders located 0.48 cm from a central fixation point. Presentation time for test items was constant at threshold time plus 20 msec. The fixation stimulus was a card containing the fixation point and the rectangular frames, with exposure duration of 300 msec. The masking stimulus was composed of the rectangular frames, with noise within each frame, and was administered for 1000 msec. Subjects reported the fixation number and the position of the dot, using a reference card placed in front of them. Both were required for a correct response. For threshold determination, stimuli contained a dot 1 degree of visual angle from the fixation point. Subjects were required to report the correct fixation number and whether the dot was on the right or left. Exposure time for threshold determination began at 30 msec and was modified in increments of 5 msec, until a criterion of 80% was obtained.

Procedures

The tasks were administered in a counter-balanced order within the same test session. Tasks were repeated during a second test session 2 weeks later, again counter-balanced for order. Thresholds were determined separately for each test session.

Statistical analysis

Total number of correct reponses for each visual field was calculated for each task. Two measures of hemispheric laterality were also examined: Laterality Difference (LATDIFF) = Right Visual Field (RVF) − Left Visual Field (LVF), and Laterality Index (LATINDEX) = [(RVF − LVF)/(RVF + LVF)] × 100.

Statistical analysis was performed using the SAS package [13]. The first question concerning stability of visual field and laterality scores was examined by a 2 × 2 × 2 repeated measures analysis of variance (ANOVA), with sex as the grouping factor and session (Session 1, Session 2) and visual field (RVF, LVF) as repeated measures factors. ANOVA's were performed separately for verbal and dot location visual field scores. Using a similar design, effects of gender and session were examined with threshold values and laterality indices as dependent measures. In addition, overall ANOVA's across the two tasks (CVC Trigrams, Dot Location) were performed to examine the effects of task on visual field scores, laterality indices, and threshold values, and the differential stability of these measures across tasks. To control for the different number of trials for the verbal and dot location tasks, the proportion of correct responses was employed as the dependent measure in the overall ANOVA.

To address the second question, laterality scores were used to dichotomize subjects into those above and below the medians for sessions 1 and 2, separately. Median values were: Session 1—verbal LATDIFF = 4, LATINDEX = 30; dot location LATDIFF = −2, LATINDEX = −3.5; Session 2—verbal LATDIFF = 5, LATINDEX = 30; dot location LATDIFF = −1, LATINDEX = −2. Chi-square analyses were performed to evaluate the frequencies with which subjects fell into the same groups for both sessions.

To address the last two questions, Pearson product moment correlations were computed between visual field and laterality scores for the two test sessions and for laterality scores across tasks. In addition, within-session reliabilities were estimated using the Kuder–Richardson 21 formula [3].

RESULTS

Stability of means across sessions

Means and standard deviations for thresholds, visual field scores, and laterality indices are presented in Table 1.

For the verbal task, the 2(Male, Female) × 2(RVF, LVF) × 2(Session 1, Session 2) ANOVA showed the predicted effect of visual field, right greater than left [F (1, 46) = 66.08, P = 0.0001]. There were no main effects of session or interactions, indicating similar findings across the repeated testings. For dot location, the analogous ANOVA using the dependent measure of total correct for each visual field yielded no significant main effects or interactions. The overall ANOVA across both tasks was performed using a 2(Male, Female) × 2(CVC Trigrams, Dot Location) × 2(RVF, LVF) × 2(Session 1, Session 2) repeated measures design. This analysis showed a main effect of task [F (1, 46) = 48.87, P = 0.0001], reflecting the higher proportion of correct responses for the dot location compared with the verbal task. There was also a main effect of visual field, right greater than left [F (1, 46) = 31.07, P = 0.0001], which was due to the magnitude of the right visual field advantage for the verbal task. As expected, the task × visual field interaction was highly significant [F (1, 46) = 45.05, P = 0.0001], due to the pronounced right visual field advantage for the verbal task and the relative symmetry of visual field scores for the dot location task.

Table 1. Mean thresholds, visual field scores and laterality scores for Session 1 and Session 2

	Males $N=25$	Females $N=23$	Combined $N=48$
Verbal			
Threshold*			
Session 1	113.6 (25.5)	120.9 (22.1)	117.1 (24.0)
Session 2	107.6 (28.3)	104.8 (33.0)	106.2 (30.4)
RVF			
Session 1	13.2 (8.6)	13.1 (5.8)	13.1 (7.3)
Session 2	12.4 (6.3)	13.7 (7.3)	13.0 (6.7)
LVF			
Session 1	7.6 (5.3)	7.9 (5.4)	7.7 (5.3)
Session 2	6.6 (4.6)	7.9 (6.0)	7.2 (5.3)
LATDIFF			
Session 1	5.6 (5.6)	5.2 (4.5)	5.4 (5.1)
Session 2	5.8 (4.5)	5.7 (7.0)	5.8 (5.8)
LATINDEX			
Session 1	28.3 (23.5)	32.7 (27.9)	30.4 (25.5)
Session 2	34.0 (26.2)	32.3 (34.9)	33.2 (30.3)
Dot location			
Threshold*			
Session 1	59.8 (19.1)	65.9 (27.1)	62.7 (23.2)
Session 2	48.8 (16.3)	43.5 (9.0)	46.2 (13.4)
RVF			
Session 1	16.5 (6.6)	17.1 (6.3)	16.8 (6.4)
Session 2	18.2 (7.2)	18.0 (5.3)	18.1 (6.3)
LVF			
Session 1	16.8 (5.7)	17.7 (6.9)	17.2 (6.2)
Session 2	17.4 (7.5)	19.2 (5.8)	18.2 (6.7)
LATDIFF			
Session 1	−0.3 (6.4)	−0.7 (6.3)	−0.5 (6.3)
Session 2	0.8 (5.8)	−1.2 (5.3)	−0.1 (5.6)
LATINDEX			
Session 1	−3.5 (22.2)	−1.8 (19.4)	−2.7 (20.7)
Session 2	2.6 (16.5)	−3.2 (14.8)	−0.2 (15.8)

Note: *msec; Abbreviations—RVF right visual field; LVF left visual field; LATDIFF laterality difference = RVF − LVF; LATINDEX laterality index = [(RVF − LVF)/(RVF + LVF)] × 100. Numbers in parentheses are S.D.

There were no other main effects or interactions. A similar pattern of results was obtained using laterality score as the dependent measure. There were highly significant effects of task for both laterality indices, but no significant effects of gender, session or interactions.

In contrast to the task performance data, analyses of the threshold values showed significant decreases in threshold from Session 1 to Session 2. The results of a 2(CVC Trigrams, Dot Location) × 2(Male, Female) × 2(Session 1, Session 2) ANOVA yielded significant main effects of session, [$F(1,46)=29.33$, $P=0.0001$] and task [$F(1,46)=323.99$, $P<0.0001$], with higher thresholds for the verbal than spatial task. In addition, there was a significant interaction between session and gender [$F(1,46)=4.40$, $P<0.05$], with females showing greater decreases in threshold from Session 1 to Session 2. The separate ANOVA for each task indicated decreased thresholds in Session 2 for both the verbal [$F(1,46)=7.3$, $P<0.01$] and dot location tasks [$F(1,46)=24.0$, $P<0.001$], but no significant interactions.

Table 2. Subgroup concordance for laterality measures

	Session 1 High Session 2		Session 1 Low Session 2	
	High	Low	High	Low
Verbal				
LATDIFF*	37.5%	10.4%	12.5%	39.6%
	(18)	(5)	(6)	(19)
LATINDEX†	35.4%	16.7%	14.6%	33.3%
	(17)	(8)	(7)	(16)
Doc location				
LATDIFF‡	31.2%	16.7%	16.7%	35.4%
	(15)	(8)	(8)	(17)
LATINDEX§	31.2%	16.7%	18.8%	33.3%
	(15)	(8)	(9)	(16)

* χ^2 (1 d.f.) = 14.1, $P<0.001$.
† χ^2 (1 d.f.) = 6.8, $P<0.01$.
‡ χ^2 (1 d.f.) = 5.3, $P<0.05$.
§ χ^2 (1 d.f.) = 4.1, $P<0.05$.

Table 3. Test–retest correlations for visual field and laterality scores

	Males $N=25$	Females $N=23$	Combined $N=48$
Verbal			
RVF	0.75***	0.52**	0.63***
LVF	0.73***	0.73***	0.72***
LATDIFF	0.52**	0.54**	0.51***
LATINDEX	0.45*	0.70***	0.59***
Dot location			
RVF	0.51**	0.36	0.44**
LVF	0.78***	0.68***	0.72***
LATDIFF	0.15	0.28	0.21
LATINDEX	0.04	0.24	0.11

Abbreviations as in Table 1.
*$P \leq 0.05$, **$P \leq 0.01$, ***$P \leq 0.001$.

Stability of subgroup classification

As shown in Table 2, subjects classified by median laterality scores on the first session verbal or dot location tasks were likely to fall into the same grouping on the second testing. Subgrouping by the laterality difference measure, 37 of the 48 subjects (77%) fell into the same group on repeated testing for the verbal task ($\chi^2=14.1$, $P<0.001$), and 32/48 (67%) showed subgroup concordance for the dot location task ($\chi^2=5.3$, $P<0.05$). Using the laterality index measure, similar results were obtained.

Stability of individual scores

Two-week test–retest correlations for the total sample and by gender are presented in Table 3 and Fig. 1. Visual field scores were moderately stable for both the verbal and dot location tasks ($r=0.36$ to $r=0.78$), with the lowest stability for the RVF dot location score. While the laterality indices for the verbal task were also moderately stable ($r=0.45$–0.70), the laterality indices for the dot location task showed low stability ($r=0.04$–0.28).

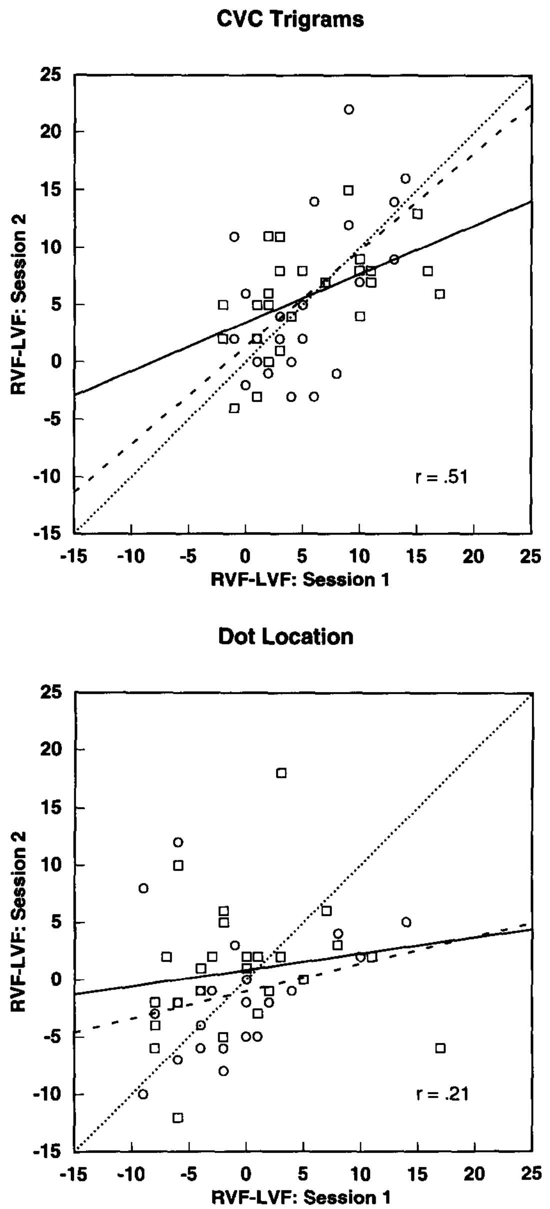

Fig. 1. Test–retest scatterplots for CVC Trigrams (a) and Dot Location (b) Laterality Difference scores. RVF and LVF are right and left visual field scores, respectively. Solid and dashed lines are regression lines for males (squares) and females (circles), respectively. The dotted line is the identity line.

In contrast to the low test–retest stability of the dot location laterality indices, within-session estimates of the reliabilities of visual field and asymmetry scores indicated moderate to high reliability for all measures (Table 4). The within-session reliabilities for the visual field scores were estimated from the Kuder–Richardson 21 formula [3]. This approach

Table 4. Within-session reliability estimates for visual field and right–left difference scores

	Males $N=25$	Females $N=23$	Combined $N=48$
Verbal			
RVF			
Session 1	0.91	0.77	0.87
Session 2	0.82	0.86	0.84
Average	0.86	0.82	0.85
LVF			
Session 1	0.81	0.81	0.80
Session 2	0.77	0.85	0.82
Average	0.79	0.83	0.81
RVF–LVF			
Session 1	0.38	0.35	0.41
Session 2	0.32	0.74	0.61
Average	0.35	0.51	0.50
Dot location			
RVF			
Session 1	0.79	0.77	0.78
Session 2	0.83	0.67	0.77
Average	0.81	0.72	0.78
LVF			
Session 1	0.71	0.81	0.76
Session 2	0.84	0.72	0.80
Average	0.78	0.76	0.78
RVF–LVF			
Session 1	0.54	0.54	0.54
Session 2	0.48	0.31	0.41
Average	0.51	0.41	0.47

Abbreviations as in Table 1. RVF–LVF is the difference score for right–left visual fields, with reliabilities estimated as described in the text. Average refers to the estimated overall within-session reliability across both sessions, calculated as the square root of the product of Session 1 and Session 2 reliabilities.

assumes equal item difficulties for all trials and will underestimate the true reliability when this assumption is violated. These reliabilities thus represent lower bound estimates of the true within-session reliabilities.

The within-session reliabilities of the right–left difference scores were calculated as:

$$r_{DD} = 0.5(r_{RR} + r_{LL} - 2r_{LR})/(1 - r_{RL}),$$

where r_{RR} and r_{LL} are the within-session reliabilities of the right and left visual field scores, respectively, and r_{LR} is the correlation between visual field scores [1]. The correlations between RVF and LVF scores were significant and comparable for both tasks and sessions: Verbal: 0.72 and 0.56 for Sessions 1 and 2, respectively; Dot Location: 0.51 and 0.63 for Sessions 1 and 2, respectively.

To investigate possible contributors to the differential stability of the verbal and dot location laterality indices, changes in threshold were examined in relation to changes in laterality scores and changes in performance. Change in spatial threshold (Session 1 Threshold − Session 2 Threshold) was positively correlated with change in laterality on the dot location task [(Session 1 RVF − Session 1 LVF) − (Session 2 RVF − Session 2 LVF)]; correlations were 0.32 ($P<0.05$) and 0.37 ($P=0.01$) for the LATDIFF and LATINDEX

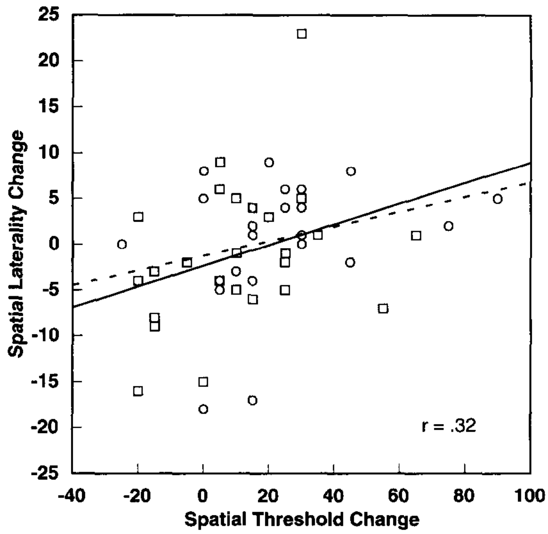

Fig. 2. Association between change in dot location threshold and change in laterality difference score from Session 1 to Session 2. Threshold change is defined as Session 1 threshold minus Session 2 threshold. Spatial laterality change is (Session 1 RVF − Session 1 LVF) − (Session 2 RVF − Session 2 LVF). The significant positive correlation reflects an association between decreases in threshold from Session 1 to 2 and relative increases in right hemispheric advantage in Session 2. Symbols and abbreviations as in Fig. 1.

measures, respectively. These relationships indicate that greater decreases in spatial threshold from Session 1 to Session 2 were associated with relative increases in right hemispheric advantage for Session 2 compared with Session 1 (Fig. 2). Consistently, there was a significant negative correlation between change in threshold for the spatial task and change in RVF performance (Session 2 RVF − Session 1 RVF), $r = -0.35$, $P < 0.05$, but no relationship for LVF performance, $r = 0.01$. The negative correlation with change in RVF performance reflects improved Session 2 scores in the subgroup of subjects whose thresholds increase or are unchanged and poorer performance in a subgroup of subjects with large decreases in threshold between sessions.

Change in threshold on the verbal task was unrelated to change in laterality scores across sessions. However, there was a significant negative correlation between change in verbal threshold and change in total performance, $r = -0.41$, $P < 0.01$ (Fig. 4). Greater decreases in threshold from Session 1 to Session 2 were associated with declines in performance for both the RVF ($r = -0.35$, $P = 0.01$) and LVF ($r = -0.35$, $P = 0.01$) scores.

Correlations among measures of hemispheric specialization

Correlations between verbal and dot location laterality measures were not significant for either Session 1 or Session 2, indicating that each task assesses a unique dimension of hemispheric specialization. Correlations were 0.05 and 0.07 for the Session 1 laterality difference and index scores, respectively, and 0.10 and 0.08 for the Session 2 laterality difference and index scores, respectively.

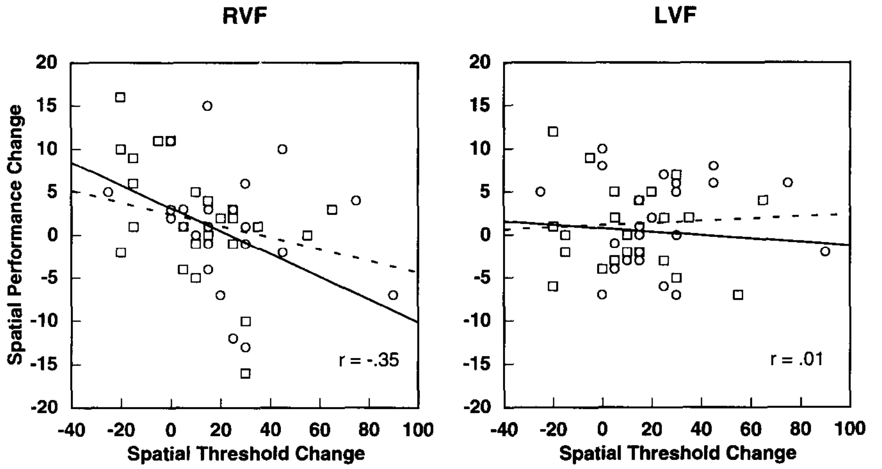

Fig. 3. Scatterplots of the association between changes in dot location threshold and changes in performance for right and left visual field scores. Threshold change is defined as Session 1 threshold minus Session 2 threshold, and performance change is Session 2 minus Session 1. Changes in RVF but not LVF performance are significantly negatively associated with change in threshold. Symbols and abbrevations as in Fig. 1. Note that there are overlapping points: RVF—2 males at ($x=5$, $y=-4$); LVF—1 male at each of the following points ($-15, -2$), (10,0), ($25, -3$).

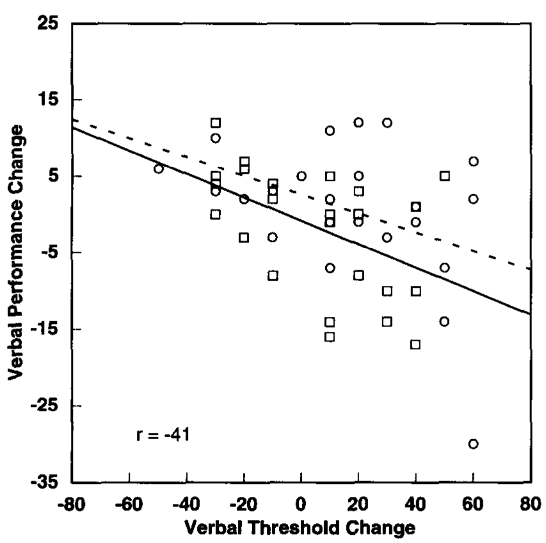

Fig. 4. Association between change in verbal threshold and change in total verbal performance. Threshold change is defined as Session 1 threshold minus Session 2 threshold, and performance change is Session 2 minus Session 1. Decreases in threshold are significantly associated with poorer Session 2 performance for total score and both visual fields, separately (see text). Symbols and abbreviations as in Fig. 1.

DISCUSSION

These results are consistent with a moderate degree of stability of tachistoscopic measures, greater for the verbal than dot location task employed in this study.

The absence of significant effects of repeated testing and significant interactions with session in the ANOVA for both tasks indicates stability of group means across test sessions. It is notable that the visual field and laterality scores remained similar despite significant decreases in thresholds from Session 1 to Session 2. Thus, when thresholds are independently determined for each test session, tachistoscopic measures can provide stable assessments of performance and laterality scores for groups of subjects.

Subgrouping subjects by median laterality scores indicated that group membership can be predicted across sessions with greater reliability than individual scores. This subgrouping yielded significant subgroup concordance across sessions for both the verbal and dot location tasks.

On the other hand, the test–retest correlations indicate that the ability to predict a particular subject's performance from time 1 to time 2 is more limited and depends on the specific task. For the verbal task, both visual field scores and laterality measures showed moderately high correlations from Session 1 to Session 2. For the dot location task, moderately high stability was indicated for the individual visual field scores, but test–retest correlations for laterality indices were low. The differential stability of the laterality indices across tasks cannot be explained by lower internal consistency reliability of the dot location task. Within-session reliability estimates for the right–left difference scores, as well as the visual field scores, were comparable for the verbal and nonverbal tasks.

Despite comparable within-session reliabilities, there was low between-session stability of the dot location laterality indices. The observed associations between changes in threshold values and changes in laterality and performance offer a possible explanation of these findings. For the dot location task, decreased threshold from Session 1 to Session 2 was associated with a relatively greater right hemispheric advantage for Session 2 compared with Session 1. Examination of the relationships with changes in the visual field scores showed that the threshold changes from Session 1 to Session 2 were associated with changes in right visual field or left hemisphere scores. In contrast, left visual field or right hemispheric performance was unrelated to change in spatial threshold. The relationship for change in RVF performance reflected higher Session 2 scores in subjects with increasing or unchanged thresholds and poorer performance in a subgroup of subjects whose thresholds decreased. These findings suggest that left hemispheric processing of the spatial information is influenced by change in exposure duration while right hemispheric processing is unaffected. The association between RVF or left hemisphere performance and threshold change may thus contribute to the relatively lower stability of the RVF scores and low stabilty of the laterality indices for the spatial stimuli.

Associations between changes in threshold and changes in performance were also observed for the verbal task. However, decreases in verbal threshold from Session 1 to Session 2 were associated with declines in performance for *both* the RVF and LVF scores on the CVC trigram task. Changes in verbal threshold were unrelated to laterality change because both hemispheres were similarly affected.

Two alternative explanations for the lower stability of the dot location laterality scores merit consideration. It is possible that tasks which emphasize right hemispheric spatial functions are characterized by lower test–retest stability of laterality measures. Novelty effects may have greater impact on these relatively unfamiliar tasks. Perhaps, there is a greater change in the balance of hemispheric processing when a task is initially unfamiliar. Another potential explanation, although less likely, is that the low test–retest stabilities of the dot location task resulted from a sampling fluctuation, since our student population is a high ability sample. It is notable that the expected right hemispheric advantage for the dot location task did not reach significance in this sample, although the trend was in the predicted direction.

A limitation of our evaluation of test–retest reliabilities is that only one repeated session was conducted. As suggested by the results of Fennell *et al.* [4, 5] and Brysbaert and D'Ydewalle [2], it is possible that greater stability would be demonstrated between second testing and additional trials. However, in most experimental settings tachistoscopic measures are obtained only on a single occasion. Our findings can help gauge the degree of confidence warranted by investigators in generalizing from single session tachistoscopic data. This includes examination of correlations with other types of data and use of tachistoscopic data for classification of subjects into groups with particular laterality patterns. Our data would suggest that correlations with laterality scores based on the verbal CVC trigram task would be meaningful, but correlations with dot location laterality scores may be more difficult to interpret. However, subject groupings based on these verbal and nonverbal laterality indices are reliable.

Our findings indicate that the differential stability of various laterality measures cannot be inferred from within-session reliability estimates and must be evaluated for individual tasks. In addition, the very low correlations between laterality measures for the two tasks employed in this investigation indicate that each task assesses a unique aspect of hemispheric specialization. The low intercorrelations obtained under unilateral input conditions are consistent with meta-analytic results [8], which indicate lower intercorrelations for laterality indices measured through divided visual field techniques compared to bilateral input conditions. The latter methods may be more sensitive for identification of stable individual differences in lateralized response across tasks.

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REFERENCES

1. Allen, M. J. and Yen, W. M. *Introduction to Measurement Theory*. Brooks/Cole Publishing Company, Monterey, California, 1979.
2. Brysbaert, M. and D'Ydewalle, G. Tachistoscopic presentation of verbal stimuli for assessing cerebral dominance: Reliability data and some practical recommendations. *Neuropsychologia* **28,** 443–455, 1990.
3. Cronbach, L. J. *Essentials of Psychological Testing*, 2nd edn. Harper & Brothers, New York, 1960.
4. Fennell, E. B., Bowers, D. and Satz, P. Within-modal and cross-modal reliabilities of two laterality tests. *Brain. Lang.* **4,** 63–69, 1977.
5. Fennell, E. B., Bowers, D. and Satz. P. Within-modal and cross-modal reliabilities of two laterality tests among left handers. *Percept. Mot. Skills* **45,** 451–456, 1977.
6. Grant, D. W. Sex, reading ability, and visual half-field test–retest reliability. *Percept. Mot. Skills* **54,** 49–50, 1982.
7. Hines, D., Fennell, E. B., Bowers, D. and Satz, P. Left-handers show greater test–retest variability in auditory and visual asymmetry. *Brain. Lang.* **10,** 208–211, 1980.
8. Kim, H. and Levine, S. C. Sources of between-subjects variability in perceptual asymmetries: A meta-analytic review. *Neuropsychologia* **29,** 877–888, 1991.
9. Levy, J. and Reid, M. L. Variations in writing posture and cerebral organization. *Science* **194,** 337–339, 1976.
10. McKeever, W. F. Tachistoscopic methods in neuropsychology. In *Experimental Techniques in Human Neuropsychology*, H. J. Hannay (Editor), pp. 167–211. Oxford University Press, New York, 1986.

11. Raczkowski, D., Kalat, J. W. and Nebes, R. Reliability and validity of some handedness questionnaire items. *Neuropsychologia* **12,** 43–48, 1974.
12. Roszkowski, M. J. and Snelbecker, G. E. Validity and temporal stability of the chimeric face technique for studying hemispheric processing asymmetries: Data from 6- through 14-year-old children. *J. Behav. Assess.* **4,** 209–221, 1982.
13. SAS/STAT User's Guide, Version 6, 4th edn. SAS Inst. Inc., Cary, NC, 1989.