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Language Experience and Right Hemisphere Tasks: The Effects of Scanning Habits and Multilingualism

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This study explores the effects of multilingualism and reading scanning habits on right hemisphere (RH) abilities. Native Hebrew speakers and Arabic–Hebrew bilinguals performed three tasks. Experiment 1 employed an odd/even decision paradigm on lateralized displays of bar graphs. Both groups of subjects displayed the expected LVFA within the range previously reported for readers of English. Experiment 2 consisted of a chair identification task designed to tap asymmetry of hemispheric arousal and a chimeric face task designed to tap RH specialization for facial emotion. Neither scanning habits nor language experience affected performance on the chair task. Scanning habits seem to have affected performance on the chimeric faces task: there was no preference for the left smile in these right-to-left readers, as opposed to previous results in the literature using left-to-right readers. Correlations between measures from the three tasks and all the subject's scores on an English proficiency test and on a Hebrew test for the bilinguals reveal tentative relationships between proficiency in a second language and RH abilities. The results do not support the hypothesis that multilingualism can affect the manner in which these nonlanguage tasks are subserved by the RH. They do support the hypothesis that scanning habits particular to specific languages can affect performance asymmetries on some nonlanguage tasks that have been posited to reflect RH specialization. © 1997 Academic Press

Cross-language studies and research on multilinguals have historically been an important source of disconfirming data and generalizing power for neuropsychological research. Studies investigating the effects of orthography and reading direction (e.g., Hasuike, Tseng, & Hung, 1986; Vaid, 1988), the effects of language structure on patterns of language breakdown after brain damage (e.g., Grodzinsky, 1984; Druks & Marshall, 1991), and the lateralization status of sign language (Bellugi, Poizner, & Klima, 1983) have been

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crucial in clarifying the underlying structure of language functions in the brain.

Language experience can be operationalized in many ways, and in fact, this has been defined as one of the major methodological problems in the field (Vaid, 1983). In the context of this report, language experience is operationalized in two ways: by the number of language systems in which the subject is fluent (mono- versus multilingualism), and by a specific characteristic of the languages being tested (reading and writing direction). The focus here is on the effects of these variables on the lateralization status of two tasks which are believed to be subserved by the right hemisphere (RH).

The majority of studies using bilinguals within the lateralization paradigm have concentrated on linguistic tasks. In general, lateralized experiments with normal monolinguals and bilinguals have revealed more similarities than differences. In the auditory modality, bilinguals (like monolinguals) evince a right ear advantage in dichotic listening tasks for all of their languages (Obrzut, Conrad, Bryden, & Boliek, 1988; Piazza-Gordon & Zattore, 1981; Starck, Genesee, Lambert, & Seitz, 1977). In visually lateralized experiments bilinguals again tend to show a right visual field advantage (RVFA) for verbal materials (Vaid, 1988)). All in all, more than 30 years of intensive study seem to suggest that language abilities, whether mono- or multilingual, are organized in a similar way in the left hemisphere (LH) of humans (Paradis, 1990). However, at least one interesting difference between bilinguals and monolinguals has been reported with a nonverbal task. Sewell and Panou (1983) presented visually lateralized verbal and spatial tasks to monolinguals and bilinguals. Both groups showed a RVFA for verbal materials, and monolinguals showed a LVFA for the spatial task. Bilinguals showed no visual field advantage for the spatial task, and this led these investigators to speculate that there is more LH involvement in spatial processing in bilinguals than in monolinguals.

The findings with readers of right-to-left languages have been used to show that the RVFA in verbal visually lateralized tasks is really a reflection of LH specialization for language and not of retinal locus and scanning habits (Barton, Goodglass, & Shai, 1965; Bradshaw, Nettleton, & Taylor, 1981; Faust, Kravetz, & Babkoff, 1993). However, recently, Vaid and Singh (1989) have revived the reading scanning argument for the posited RH specialization for face emotion. They used a version of Levy's face perception task (Levy, Heller, Banich, & Burton, 1983; Levine & Levy, 1986). Here subjects view chimeric faces in free vision. On each page of a booklet either the left or the right half of the face is smiling, and subjects are to choose which face looks ''happier.'' Right handers consistently tend to choose the face in which the smile is on the left as happier, and Levy and her colleagues have interpreted this to reflect RH specialization for the perception of faces and of emotion. Vaid and Singh used this task with readers of Hindi (which is read from left-to-right, as is English) and readers of Urdu and Arabic (which are read from right-to-left). They found the expected left advantage only in their Hindi readers and have cautioned that scanning habits may also affect the asymmetry patterns that have been attributed to hemispheric specialization.

The hypothesis investigated here is that language experience may affect the lateralization status of RH rather than LH tasks. That is, given that language is a primary ability, it may be that LH specialization is the optimal organization scheme and does not vary with language experience. However, given resource limitations on cognitive processes, it may be that the expertise and sophistication of the language function of multilinguals has an effect on the manner in which nonlanguage tasks are organized or accessed in the cortex. Two experiments investigate the effects of multilingualism and reading scanning habits on tasks for which the RH is thought to be specialized. The bilingual subjects were Arab students at Haifa University. The first language of these subjects is Arabic, and the language of teaching at the university is Hebrew; thus, both of the bilinguals' languages are read from right to left. The monolinguals were native Hebrew speakers. Both groups of subjects began learning English in grammar school, so that our ''monolinguals'' have been exposed to a second language since age 9. However, their facility in English is not comparable to that of the Arabic speakers in Hebrew. Thus, the manipulation of language experience here is one of degree, not an all-or-none variable. We also had available the scores of all the subjects on the English part of the university entrance examination. Thus, we could test the relationship between facility of reading in the ''opposite'' direction and performance on our RH tasks. The bilinguals were also tested in Hebrew for the entrance examination, and those scores were used as well. This allowed us to test the relationship between degree of bilingualism and performance on the tasks.

EXPERIMENT 1: ODD/EVEN BAR GRAPHS

Subjects were required to make odd/even judgments on bar graph stimuli presented tachistoscopically (Boles, 1986). Bilateral displays with a central arrow indicating the visual field to which the subjects were to respond were used, as Boles (1990) has shown that this type of display results in larger visual field differences. With presumably monolingual English speakers, this task has resulted in a consistent LVFA of 20–40 msec, interpreted as RH specialization for the task (e.g., Boles, 1986, 1990). This experiment allows the dissociation of the effects of scanning habits and of bilingualism. The scanning directions of both Hebrew and Arabic work to enhance the expected LVFA in the task. The predicted effects of bilingualism are in the opposite direction (following Sewell & Panou, 1983). If the bilinguals show no visual field difference, or a smaller LVFA than monolinguals, this indicates that language experience results in differential RH abilities that subserve nonlinguistic functions or in different access to these functions, and that this effect overrides the effects of scanning habits. In addition, for both groups of subjects, we computed correlations between the laterality scores with proficiency in the reading of English. This analysis can clarify the extent to which reading in a left-to-right language, when it is not the native language of the subjects, can influence performance asymmetries assumed to result from hemispheric differences. We also computed the correlation between response times (RT) on the task and the scores of the bilinguals on the Hebrew part of the university entrance exam. This analysis can identify the relationship between RH abilities and proficiency in the second language.

Method

Subjects

The subjects were 24 native Hebrew speakers and 29 Arabic–Hebrew bilinguals. All were students at the University of Haifa. All the Hebrew speakers were students in the Introductory Psychology course and had not been exposed to any other language until they started learning English at age 9. English as an academic subject was the sum of their exposure to a second language (e.g., they had not spent time in a foreign language environment nor been exposed to a family member speaking languages other than Hebrew) The Arabic speakers were recruited from Psychology and other departments. All of the subjects were right-handed, had no left-handed family members, and had no history of neurological illness.

Materials

The stimuli were six bar graphs representing whole numbers from 1 to 6 (Boles 1986). The bar graphs appeared as vertical rectangles against horizontal reference lines at the 0, 4, and 8 levels. Each bar graph appeared 12 times in each visual field resulting in 144 experimental trials. The bar graphs subtended 2.4×6.7 degrees of visual angle with the inner edge 2° off fixation. The center of the bar graphs was level with the fixation point. Each target bar graph was randomly paired with the others to form bilateral displays. A directional arrow appearing at fixation (<or>) indicated to the subject which visual field contained the target stimulus in a random sequence. Thus a stimulus display on each trial consisted of a directional arrow in the center and two bar graphs, one in each visual field. The stimuli were composed of black lines on a gray background (reversed video).

The stimuli were presented on a Silicon Graphics computer, Personal Iris Model 4D30, which also collected the responses.

Procedure

The subjects were seated with their chin in a chin rest that held their eyes 57 cm from the screen. Instructions for both monolinguals and bilinguals were read by the experimenter in Hebrew. The subjects were asked to indicate whether the number represented by the target bar graph was odd or even by pressing one of two keys (ascending or descending arrow) with their right index finger. The subjects first performed a practice set of 36 trials, during which feedback was given about the correctness of the response (happy or sad face at fixation). No feedback was given during the experimental trials. The subjects were asked to respond as quickly and as accurately as possible. The sequence of events on each trial was as follows: A 1000-Hz tone sounded for 100 msec to alert the subject that the trial was beginning, the fixation cross was presented alone for 100 msec, then the screen was blank for another 100 msec. Immediately the stimuli were presented for 50 msec. The subject was given 3 sec to

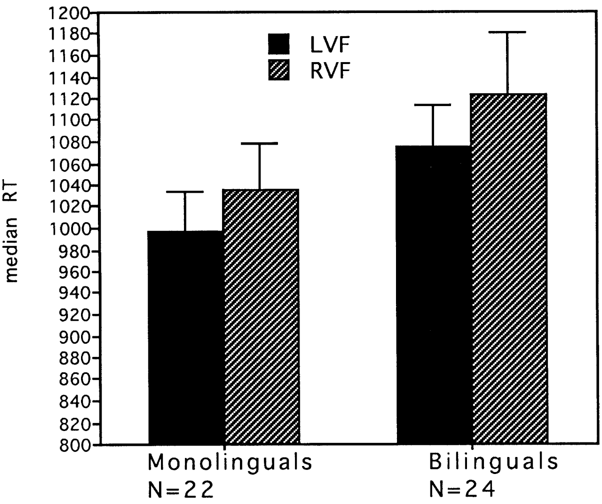


FIG. 1. Performance asymmetry of monolinguals and bilinguals in the bar-graphs task.

respond, and the next trial began after 2 sec. The experimental trials were presented in four blocks of 36. Between the blocks the subjects were allowed to rest. The length of these breaks was not controlled.

Results

Because the dependent variable of interest is response time, we excluded subjects whose accuracy scores were at chance or below (50%). This resulted in 2 of the 24 monolinguals and 5 of the 29 bilinguals being excluded.

RTs shorter than 250 msec and longer than 3000 msec were excluded from data analysis (4.6% of the trials). The mean median RTs in each visual field for the two language groups are illustrated in Fig. 1. An analysis of variance for unequal groups with language experience as a between-group factor and visual field as a within-group factor was performed on median RTs. The interaction between language experience and visual field was not significant ($p > .5$). Although bilinguals as a group responded more slowly than monolinguals (1100 vs 1016 msec), the main effect of language experience was not significant ($p > .17$). The main effect of visual field was significant, $F(1, 44) = 6.78$, $p < .05$, with responses in the LVF being faster than in the RVF (1036 vs 1080 msec). Fifteen of the 22 monolinguals (68%) revealed the expected LVFA, with 6 of the 22 (27%) showing a RVFA and 1 revealing no visual field advantage. Fifteen of the 24 bilinguals showed the expected LVFA (62.5%), with 8 (33%) showing a RVFA and 1 showing no visual field advantage. These frequencies are not different between the language groups.

An ANOVA was performed on the error scores with language experience as a between-group factor and visual field as a within-group factor. This analysis showed only a main effect of language experience, $F(1, 44) = 6.21$, $p < .05$. Bilinguals made significantly more errors (28.30%) than monolinguals (19.73%).

Correlation coefficients between median RT and error scores in each visual field revealed no speed-accuracy trade-offs for all of the subjects as a group or for each language group separately.

We computed correlation coefficients between the scores of the subjects on the language tests (the English test for all of the subjects, and the Hebrew test for the bilinguals) and performance measures from the bar graphs task. For both median RTs and errors we used the scores in each visual field and a laterality quotient ((LVF − RVF)/(LVF + RVF)). For the RT measures, no correlations approached significance. For errors, these computations revealed significant negative relationships between errors in each of the visual fields and the scores of the subjects in the English portion of the university entrance examination (in the LVF, $r(42) = -.317$, $p < .05$; in the RVF, $r(42) = -.384$, $p < .05$). That is, subjects who made fewer errors in the bar graphs task (in both visual fields) tended to be those who had higher scores on the English test. Analyses of each language group separately revealed that for monolinguals alone, this relationship approaches significance only in the RVF ($r(19) = -.359$, $p < .10$), not in the LVF ($r = -.11$). For bilinguals alone this relationship was not significant. Correlations between the English test scores and the error laterality quotient, and between the bilingual's scores on the Hebrew test and any of the performance measures, were not significant.

Discussion of Experiment 1

Two hypotheses were tested in this experiment. First, we looked at whether reading scanning habits affect the predicted LVFA for this task. Second, we looked at whether multilinguals would reveal a different pattern of performance asymmetry than monolinguals. We had predicted that the scanning habits of Hebrew and Arabic readers would work toward enhancing the LVFA on this task. To test this hypothesis, the data were compared to the results reported by Boles (1987, 1989, 1991, 1992) from six experiments using this task, where the test statistic (*t* test) and the number of subjects were reported. Using Winer's method (as reported by Rosenthal, 1978), a *z*-score was computed for each of these *t*-values using the equation: $Z_t = t/(df/(df - 2))^{1/2}$. This results in a distribution of standard scores for the test statistics. This distribution is presented in Table 1. As can be seen, the test statistic from the present experiment falls within the range of the distribution, and if anything, is on the low end rather than on the high end. Thus, these data do not support the hypothesis that scanning habits enhanced the LVFA advantage for this task.

The second question we looked at was the effect of multilingualism on

TABLE 1
Meta-Analysis of the Degree of LVFA in the Bar-Graphs Task

Study	LVF–RVF	*N*	*t* value	*SD*	Z_t
Boles, 1987	44 msec	16	−2.88	1.07	−2.69
Boles, 1989	23 msec	22	−1.98	1.05	−1.89
Boles, 1991					
Pilot	25 msec	29	−4.51	1.04	−4.34
Experiment 1	26 msec	70	−4.95	1.02	−4.85
Experiment 2	38 msec	60	−4.56	1.02	−4.11
Boles, 1992					
Experiment 3	30 msec	65	−3.4	1.01	−3.37
Present results	43 msec	46	−2.6	1.02	−2.55

RH specialization for this task. The hypothesis rested on the prediction that the multilinguals would reveal a smaller LVFA than the monolinguals. In fact, the bilinguals revealed a LVFA of 48 msec, while the monolinguals showed a LVFA of 38 msec. Thus, we have not replicated Sewell and Panou's finding of a language experience by visual field interaction. The bilinguals reveal evidence for RH specialization for the task to the same degree as do the monolinguals. We do have some evidence that the task may have been more difficult for the bilinguals than for the monolinguals, as evidenced by longer RTS, and more errors. However, this effect does not interact in any way with visual field. The scores of the subjects on the English test were related in a general way to performance on the bar graphs task—subjects who showed a higher level of performance on one also showed this on the other. However, there were no differential effects with the two visual fields.

To summarize, the data do not support the hypothesis that reading scanning habits enhance the LVFA on this RH task. The mean LVFA shown by readers of right-to-left languages is on the same order of magnitude as the mean LVFA shown by readers of a left-to-right language. In addition, although the data reported by Sewell and Panou (1983) suggest that bilingualism may affect the access or availability of RH abilities, the present data do not support the hypothesis that multilingualism affects the abilities that are tapped by the bar graphs task or that these abilities are related to proficiency in the second or third language of the multilingual.

EXPERIMENT 2: CHIMERIC FACES AND CHAIR IDENTIFICATION

Experiment 2 investigates the relationship among multilingualism, reading scanning direction, and the posited RH specialization of the perception of facial emotion. Evidence for this asymmetry rests on clinical reports of deficits in face processing primarily as a result of RH damage (McCarthy & Warrington, 1990) and on many replications of the finding of a left bias on face perception tasks (e.g., Kim, Levine, & Kertesz, 1990; Luh, Rueckert, & Levy, 1991; Hellige et al., 1994; David, 1989, 1993). All of these studies have been done with readers of left-to-right languages (English or Swedish) and find a consistent bias toward the left side of the face. This bias is larger in right-handers than in left-handers and is thought to reflect a RH advantage in processing these stimuli.

Vaid and Singh (1989) have suggested that there is an influence of reading and writing experience on the performance asymmetry in this task, as they found the expected left bias only in readers of a left-to-right language (Hindi) and not in readers of right-to-left languages (Urdu and Arabic). They note that such effects of reading and writing direction are smaller and usually insignificant when a language task is used. Thus, they present evidence for a language habit influencing performance asymmetry on a nonlanguage task, whereas its influence on language tasks is much smaller.

The subjects also performed the chair identification task developed by Levine and her colleagues (Levine, Banich, & Koch-Weser, 1984; Kim, Levine, & Kertesz, 1990). In the chair task subjects are presented with two different stimuli (one to each hemisphere) on every trial and then must identify both stimuli among an array of 12 possibilities. The experimental procedure is such that exposure duration is titrated to give subjects enough time to correctly identify only one of the pair of stimuli (chairs, in this case). Under normal circumstances there is no visual field advantage for identifying chairs. Levine and her colleagues have reported that the asymmetry between correctly reported LVF and RVF stimuli is normally distributed among right-handers and correlated with the magnitude of visual field advantages for other tasks. That is, this asymmetry is interpreted as reflecting a bias of attention to one visual field over the other, which is thought to underlie visual field advantages for tasks that usually do result in perceptual asymmetries. Eviatar, Hellige, and Zaidel (1997) found this normal distribution centered around 0 for right-handers, and shifted toward RH arousal for their sample of left-handers. These results suggest an effect of handedness on arousal bias for monolinguals. The present study allows us to test whether bilingualism and/or scanning habits affect the distribution of our right-handed subjects on this measure.

Levine and her colleagues (Levine, 1995) have shown that scores on the chair task correlate with the degree of left-tendency on Levy's face perception task, where subjects with a more aroused RH on the chair task showed larger left-tendencies on the face task, and subjects who seem to have more aroused LHs on the chair task showed smaller asymmetries, or even opposing ones, on the face task. Thus, if scanning habits affect performance asymmetries by influencing the deployment of attention, we will see their effects on both tasks, and this will localize the effects of scanning habits in the face task as affecting arousal asymmetry, not RH specialization for faces.

Method

Subjects

The subjects were 22 native Hebrew speakers and 20 Arabic–Hebrew bilinguals, selected as described in Experiment 1. Fifteen of the Arabic speakers participated in both Experiments 1 and 2; none of the Hebrew speakers participated in both experiments.

Materials

Chair identification task. The stimuli were 20 pairs of chairs presented bilaterally via a computerized tachistoscopic software package. The images of the chairs were digitized versions of the stimuli used by Levine and her colleagues (Levine et al., 1984). On each trial subjects were presented with two different chairs, one in each visual field. Each chair was shown in a window with its inner edge 2° of visual angle from fixation. The windows subtend 2° horizontally and 2.5° vertically. Two choice arrays were used, each consisting of 12 chairs. From each array 10 chairs were used twice, and 2 were never used, to discourage guessing strategies. The chairs in the arrays were presented in three rows of 4 across the screen. The stimuli were presented on a Silicon Graphics computer, Indigo model, which also collected the responses.

Chimeric faces task. The stimuli were copies of the 36 chimeric faces created by Levy and her colleagues (Levy et al., 1983). These were placed in a loose leaf notebook, through which the subjects paged.

Procedure

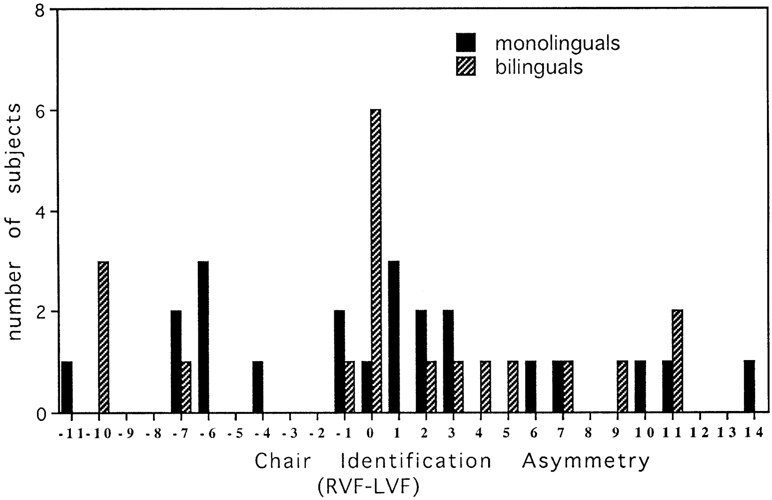
The subjects always performed the chair task before the face task. For the chair task the subjects were seated as described in Experiment 1. The experimenter explained the task in Hebrew to both bilingual and monolingual subjects, showing examples of the stimuli and choice arrays. The subjects performed a practice set of 12 trials with a separate stimulus set and then performed the 20 experimental trials. The initial exposure duration of the target chairs was 60 msec. If both chairs were correctly identified, the next stimulus pair was shown for 15 msec less; if neither chair was correctly identified, the next pair was shown for 15 msec longer; and if one chair was correctly identified, the exposure duration remained the same. Exposure duration never exceeded 210 msec.

The face task was performed in free vision. The subjects were asked to leaf through the pages of the book with no time constraints. For each pair of faces on a page, the subject pointed to the top or bottom face, indicating the one that looked happier. Subjects were allowed to respond ‘‘I can’t decide.’’ Subject selections were recorded on an answer sheet, indicating whether they chose the face with the smile on the left or on the right.

Results

Chair Identification

The dependent variable was the difference in correct identification of chairs in the two visual fields (RVF–LVF). Thus, a positive number indicates that more chairs were correctly identified in the RVF than in the LVF (interpreted as LH arousal bias) and a negative number is interpreted as RH arousal bias. An independent-groups *t*-test revealed that the language groups do not differ, $t(41) = .045$, $p > .5$ (monolinguals, 0.545; bilinguals, 0.45). The



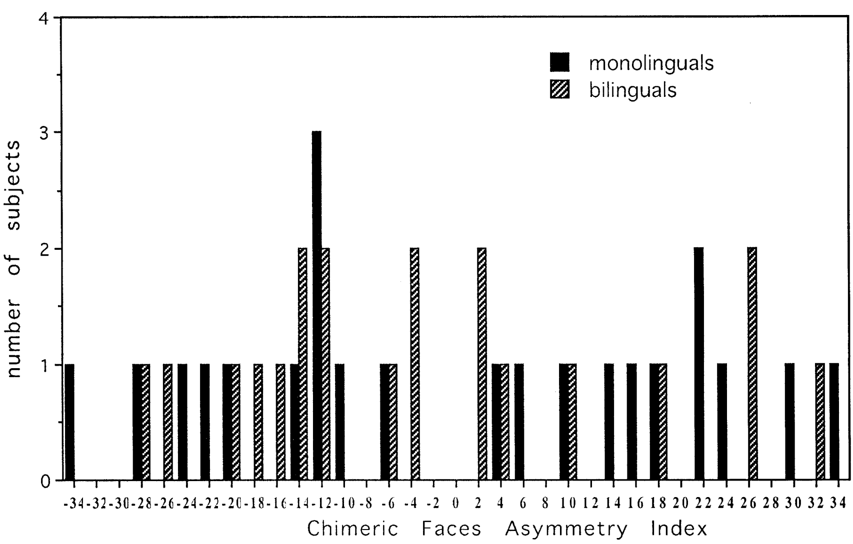


FIG. 2. (Top) Distribution of subjects on the chair identification task. (Bottom) Distribution of subjects on the chimeric faces task.

distribution of scores for both groups is shown at the top panel in Fig. 2. A test of equality of variances revealed that these are equal between the groups, $\chi^2_{(1)} = .001, p > .5$.

To determine whether subject's responses were internally consistent, we computed a split-half reliability measure as the correlation between the

TABLE 2
Mean Asymmetry Scores on the Chimeric Faces Task (R-L)/36

	Mean	*SEM*
Monolinguals	−0.074	0.11
Bilinguals	0.003	0.12

asymmetry measures (RVF–LVF) on odd and even numbered trials. Both groups of subjects reveal reliable patterns: monolinguals $r(20) = .62$, bilinguals $r(18) = .71$.

We computed correlation coefficients between the difference scores on the chair task and the subject's scores on the English test. For all of the subjects, and for the monolinguals alone, there is no relationship between these scores ($r(40) = .193$; $r(20) = .001$). For the bilinguals, there is a negative relationship that approaches significance, $r(18) = -.421$, $p < .1$. Thus, subjects who revealed a RH bias on the chair task tended to be those who had higher scores on the English test. There is no relationship between the scores of the bilinguals on the Hebrew test and on the chair task.

Chimeric Faces

The dependent variable was the number of times subjects chose the face with the smile on the right minus the number of times they chose the face with the smile on the left divided by the total number of faces (36). A positive score indicates a preference for the right smile (LH) and a negative score indicates a preference for the left smile (RH). The mean asymmetry scores and standard errors are shown in Table 2. The asymmetry scores of the monolinguals and bilinguals do not differ, $t(41) = -.461$, $p > .5$. In addition, neither group revealed the predicted bias for the face with the smile on the left ($p > .5$); that is, the mean asymmetry scores do not differ significantly from 0. The distributions of the difference scores (right–left) for monolinguals and bilinguals are shown at the bottom in Fig. 2.

In order to see if the subject's responses were internally consistent, we computed a reliability measure as the correlation between asymmetry scores for odd and even numbered trials. Both groups reveal highly reliable patterns, monolinguals $r(20) = .85$, bilinguals $r(18) = .88$.

We classified the subjects as biased or unbiased using the binomial approximation to the normal curve ($\alpha = .05$). Thus, choosing the right smile six or more times more often than the left smile resulted in the subject being classified as having a bias to the right (LH), a difference score more than -6 resulted in a classification of left bias (RH), and subjects with scores in between were classified as unbiased. The frequency and means of this

TABLE 3
Classification of Subjects as Right, Left, or Unbiased on the Chimeric Faces Task

	Monolinguals			Bilinguals		
	Mean	*SD*	*N*	Mean	*SD*	*N*
Right-biased (LH)	0.547	0.239	10	0.628	0.24	5
Left-biased (RH)	−0.503	0.236	11	−0.461	0.185	10
Unbiased	0.111	—	1	0	0.104	5

classification are shown in Table 3. Language experience does not differentiate between the groups ($\chi^2_{(2)} = 4.28$, $p > .05$). It can be seen that 50% of the subjects in both groups do reveal the expected bias toward the smile on the left. The groups differ in how the rest of the subjects are distributed among the unbiased or right side preference groups. An analysis of these frequencies does reveal a significant difference ($\chi^2_{(1)} = 4.28$, $p < .05$). The bilinguals are equally divided between unbiased ($N = 5$) and right preference ($N = 5$), while of the 11 monolinguals who do not show the left preference, 10 show a right preference, and only 1 was classified as unbiased.

We computed correlations between the scores on the face task and the subject's scores on the language tests. The only relationship that approached significance is a positive one between bias on the face task and scores on the Hebrew test for bilinguals, $r(18) = .41$, $p < .1$. Thus, subjects who tended to choose the face with the smile on the right as happier (LH specialization) tended to be those who had higher scores on the Hebrew test.

Levine and her colleagues (Levine et al., 1984) have reported that biases on the two tasks are related and suggest that the arousal asymmetry as measured by the chair task underlies the degree of left bias in the face task. We did not find such a relationship in our data; the correlations between subject's scores on the two tasks were not significant ($p > .5$).

Discussion of Experiment 2

Experiment 2 investigated the effects of multilingualism and reading scanning habits on a measure of arousal asymmetry and on a measure of RH specialization for facial emotion. In the chair identification task both groups of subjects revealed a normal distribution of asymmetry scores centered around zero. These data replicate the findings of Levine and her colleagues and do not support the hypothesis that reading scanning habits affect performance on this task. The weak relationship between the direction of arousal bias and the bilingual's scores on the English test suggests that there may be some relationship between arousal bias and facility in a left–right language. The possible implications of this are discussed below. The distribution of the bilinguals did not differ from the monolinguals, suggesting that language experience is not related to asymmetry of arousal bias.

TABLE 4
Meta-Analysis of the Degree of Left-Bias on the Chimeric Faces Task in Readers of Left-to-Right and Right-to-Left Languages

Study	*N*	*t* value	Z_t
Cherry, 1992 (Time 1)	20	−4.20	−3.96
Christman & Hackworth, 1993 (happy stimuli)	58	−3.17	−3.11
David, 1989	60	−8.41	−8.24
David, 1993 (control subjects)	23	−8.60	−8.35
Hellige et al., 1994	56	−5.38	−5.27
Hellige, Bloch, & Taylor, 1988	120	−9.08	−8.99
Kim et al., 1990 (left & right handers)	63	−2.79	−2.73
Kim & Levine, 1992	32	−5.79	−5.62
Levine & Levy, 1986	180	−9.21	−9.16
Levy et al., 1983	111	−7.255	−7.05
Luh, Rueckert, & Levy, 1991	64	−7.03	−6.89
Mattingly et al., 1993 (control subjects)	12	−6.97	−6.34
Mattingly et al., 1994 (control subjects)	30	−2.131	−2.07
Wirsen et al., 1990	60	−4.07	−3.99
Vaid & Singh, 1989			
Hindi readers	35	−4.33	−4.20
Urdu readers	**57**	**.45**	**.44**
Arabic readers	**17**	**.62**	**.58**
Present study			
Hebrew readers	**22**	**−.67**	**−.64**
Arabic readers	**20**	**.25**	**.023**

Note. All data are from right handers, except where indicated. Data from right-to-left readers are in boldface.

The results of the chimeric face task support the hypothesis proposed by Vaid and Singh (1989) that reading scanning habits affect performance asymmetry. Table 4 presents the findings of 15 studies with English speakers and 1 study with Swedish speakers (Wirsen, Klinteberg, Levander, & Schalling, 1990), together with the results of Vaid and Singh (1989), and findings from the present study. In order to be able to compare the performance asymmetries in these different studies, the values of the *t*-statistic which were either reported or computed from the data were again standardized using Winer's $Z_t = t/[df/(df - 2)]^{1/2}$ score (Rosenthal, 1978). It can be seen that all of the studies using readers of left–right languages result in a significant left bias, while the studies using readers of right–left languages do not.

We did find an effect of language experience on the distribution of subjects who did not show a left preference. The reason for this is not clear, and given the small number of subjects in these groups, we do not want to interpret this finding. We are continuing to test native Hebrew and Arabic readers in order to explore this effect.

Levine et al. (1984) have suggested that the left bias on the face task is a result of two factors: RH specialization and hemispheric arousal bias. We suggested that scanning habits may affect biases on the faces task via characteristic arousal bias, and that if that were true, we would see the effects of scanning habits on the chair task. Our results do not support this hypothesis: there are no effects of scanning habits on the chair task, and no relationship between performance on the chair and faces tasks.

Although they only approach significance, the correlations of bias measures from our tasks and the bilingual's scores on the Hebrew and English part of the university entrance examinations are interesting. The chair task scores are positively related to the English scores ($p < .1$), such that the more subjects were biased toward the LVF (RH), the higher their scores. The face task scores revealed that the more subjects were biased toward the smile on the right (LH), the higher their scores on the Hebrew test. It may be possible to interpret these tentative findings in terms of reading scanning habits. That is, English is read from left to right, and subjects who are biased to pay attention to the LVF (those who reveal a RH bias on the chair task) are those who achieved higher scores on the test. The same logic works for the relationship between face bias and the Hebrew scores: Hebrew is read from right to left, and subjects who were biased to choose the face with the smile on the right achieved higher scores on the Hebrew test. Of course, it is not clear why this is not true of the chair and English scores of the native Hebrew speakers, and these speculations must be tested directly.

CONCLUSIONS

The goal of the experiments presented here was to investigate the effects of multilingualism and scanning habits on the lateralization status of two nonlinguistic tasks which have been thought to be subserved by the RH. Experiment 1 used a spatial task and Experiment 2 used a face perception task. Both experiments show no effect of multilingualism per se, and Experiment 2 revealed an effect of scanning habits. Thus, being fluent in more than one language does not seem to affect the ability of subjects to access these RH abilities. These results converge with the point made by Paradis (1995) that multilingualism can be seen as an elaboration and sophistication of the language system and not as a qualitatively different system from that of monolinguals.

In the chimeric faces task, English, Swedish, and Hindi readers show a bias toward the left side of the face, which does not appear in Hebrew, Urdu, and Arabic readers. Vaid and Singh (1989) write that it is not clear whether this effect of reading direction on the left bias is due to differences between readers of different languages in the spatial distribution of attention or in mental scanning. The distribution of scores on the chair identification task reveals that on this measure of the distribution of spatial attention, readers of right-to-left languages do not differ from readers of left-to-right languages. Heron (1957) proposed that scanning habits are composed of two mechanisms: the first is the scan in the direction in which the language is read (e.g., to the right in English and to the left in Hebrew and Arabic) and the second is the scan for the first element of the text (to the left in English and to the right in Hebrew and Arabic). Eviatar (1995) has shown that the second mechanism seems to affect the movement of covert attention in a tachistoscopic letter matching task, such that readers of English took longer to disregard an irrelevant stimulus in the LVF, with the opposite pattern revealed by readers of Hebrew. Thus, it may be that this scan for the first element biases attention of English readers to the left side of the page, and of Hebrew and Arabic readers to the right side of the page, and this bias then affects the performance asymmetry for facial emotion, such that the left bias is apparent only in readers of left-to-right languages.

The major point of interest here is that these results show an effect of a language-related skill on the laterality measure of a nonlanguage task. This is especially interesting because it has been shown that reading direction typically has negligible effects on laterality measures of language tasks. It has usually been proposed that hemispheric specialization for language results in such strong performance asymmetries that these override the weak effects of reading direction. This may be an adequate description of the LVFA in the bar graphs task, but was not the case for the chimeric faces task. These findings suggest that it may be useful to delimit the conditions under which reading scanning directions will affect performance asymmetries and the factors (e.g., hemispheric specialization for the task, the presentation of attentional cues, unilateral or biliateral tachistoscopic presentation, etc.) which enhance or mitigate these effects.

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