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19. SCRIPT DIRECTIONALITY AFFECTS NONLINGUISTIC PERFORMANCE: EVIDENCE FROM HINDI AND URDU

All writing systems are written in a specific linear order; some are written from top to bottom, others from left to right, and still others are written from right to left. Because of this fact about written language, users of scripts with different directionalities acquire differential directional scanning biases arising from their reading/writing experience (van Sommers, 1991). The influence of directional scanning tendencies has been amply documented in studies of verbal memory and perception comparing readers of left-to-right versus right-to-left scripts (see Nachshon, 1985, for a review).

Whether reading habits also influence cognitive processing of nonverbal information has been less well studied, although there is scattered evidence to support such an influence, based largely on readers of Hebrew or Arabic. The aim of the present research was to examine directional scanning effects in a population that has not so far been studied, namely, Hindi and Urdu readers. For reasons that will shortly be discussed, this language pair is perhaps better suited than Hebrew-English for research on the scope of directional scanning effects.

Demonstrating that reading habits "invade" the nonlinguistic domain (Bertelson, 1972) would be of intrinsic interest. However, such a demonstration would further be important because of its implications for the interpretation of perceptual asymmetries observed in tasks purporting to measure cerebral lateralization of function. Just as studies of cerebral lateralization of language using the visual half-field method of stimulus presentation have been scrutinized for the influence of directional scanning effects (e.g., Tramer, Butler, and Mewhort, 1985), so too is it necessary to examine whether scanning biases might also explain, at least in part, performance on measures intended to assess hemispheric specialization for nonlinguistic functions. Even if directional scanning does not provide a sufficient explanation for asymmetries in verbal laterality tests, one cannot thereby conclude that scanning effects are an unlikely source of bias on measures of *nonverbal* laterality. Whether scanning effects do or do not influence nonverbal functioning is an independent, empirical question. Surprisingly, this question has rarely been raised, let alone studied, in the nonverbal laterality literature.

SOME EXAMPLES OF DIRECTIONAL SCANNING EFFECTS

Let us begin by considering the existing literature on scanning effects on tasks involving nonverbal stimuli and tasks. Most studies of this type have compared Israeli with American subjects (e.g., Nachshon, Schefler, and Samocha, 1977), while some have used Japanese or Chinese readers (e.g., Chen, 1981). Subjects in these studies have been asked to copy geometrical shapes (e.g., circle, triangle, horizontal or vertical line), draw objects with an intrinsic front/back (e.g., a dog, a flag), and recall linearly arrayed stimuli.

In one of the earliest studies of figure drawing, for example, it was found that English and Cambodian readers tended to start drawing on the top left hand side of the page while Iranian and Israeli readers started on the top right (Dennis and Raskin, 1960). Using a very different task (inductive reasoning), Harsel and Wales (1987) examined directional differences in problem solving among Japanese and Australians as a function of whether the stimuli were presented horizontally or vertically. They found that Japanese subjects performed better on the vertical version of the test while Australian subjects were better on the horizontal version, but only when the groups were timed on their performance. These examples should suffice to illustrate the potential scope and influence of directional scanning effects in nonlinguistic tasks.

ASYMMETRIES IN DIRECTION OF MOVEMENT

It has been suggested that reading/writing habits are not the sole explanation for observed asymmetries in direction of movement. If this were so, one would expect no biases at all in pre-literate subjects, yet these individuals do in fact show directional preferences. An alternative explanation, then, has been proposed, in terms of innate directional tendencies in muscular movement, with a smoother execution of movements that are directed away from the body (tensor to flexor) than that for movements directed towards the body (van Sommers, 1984).

According to this line of reasoning, different directional biases may be obtained depending on whether the left or the right hand is being used to perform the task. Thus, in drawing a horizontal line most right-handers, regardless or whether their predominant language is written from left-to-right or from right-to-left, should favor a left-to-right direction (in line with the outward directed movement preference) while left-handers should favor a right-to-left direction. Such a difference has in fact been observed (e.g., Dreman, 1974). Moreover, when (American) left-handers perform the task with their right hand, they too show a left-to-right movement preference (Snyder, Grackenbach, and Branford, 1983).

That reading habits may interact with muscular movement asymmetries

is entirely possible. In development, right-handed Israelis show a shift in their directional preference around a time (7–13 years) when their reading/writing skills are becoming firmly entrenched (see Nachshon and Alek, 1981).

CEREBRAL LATERALIZATION FRAMEWORK

Over the last 30 years, a number of studies have sought to relate perceptual asymmetries to hemispheric specialization of function. One popular measure used in these studies involves presenting a word to the subject's left or right visual field. Because of the way the visual system is organized, the retinal image of a word presented in the left visual field (LVF) is initially projected to the right visual cortex while that presented in the right visual field (RVF) is initially projected to the left visual cortex. This means that the left hemisphere has access to the RVF before the right hemisphere does since it takes some time for information to cross the corpus callosum. Right handed people are much better able to read the RVF than the LVF word. This observation is usually interpreted as an indication of a left hemisphere superiority in language processing. Conversely, when nonverbal stimuli, such as faces, are used, a LVF superiority is often observed. This, in turn, is thought to reflect a right hemisphere specialization for facial recognition.

It should be clear from the above discussion that, in readers of a left-to-right script, a RVF superiority for words can be interpreted either within a laterality framework or within a scanning framework. Since both accounts would predict a RVF bias in left-to-right readers, one does not know which is the real explanation or whether both contribute to the asymmetry observed.

TACHISTOSCOPIC STUDIES USING HEBREW SUBJECTS

To disentangle the effects associated with reading habit from those associated with hemispheric specialization of function, some researchers have sought to compare readers of Hebrew (a language read from right to left) with readers of English on a laterality task. The results from these studies present a mixed picture. Some studies obtain a scanning effect independently of a laterality effect; others obtain the reverse, and still others find a joint influence of scanning and laterality.

Apart from methodological differences perhaps contributing to the diversity of the findings, there are potential problems inherent in the use of Hebrew subjects. For one thing, Hebrew does not offer a clear contrast to English since individual letters in Hebrew are written from left to right. Furthermore, arithmetic notation is written from left to right in Hebrew, as is musical notation. While not many students learn how to read music,

almost all learn arithmetic, so that they are exposed fairly early to a left-to-right direction in at least one domain. Moreover, many of the subjects tested in these studies are familiar to some extent with English, having been taught it from fifth grade onwards. They are thus better viewed as "bidirectional" readers. It is not surprising, then, that the evidence from the Hebrew literature is, in fact, mixed.

Fortunately, there exist a few studies conducted with Arabic, Persian and Urdu readers which bear on the question at hand. These languages may be considered to impart a stronger right-to-left scanning bias inasmuch as single letters and words in these languages are written and read from right to left. Moreover, in studies of behavioral differences, Arabic subjects exhibit stronger directional effects than do Israeli subjects (Nachshon, 1985). The results from available verbal laterality studies with readers of Persian, Urdu or Arabic suggest that a laterality explanation is appropriate, for a right visual field (left hemisphere) superiority is found even in these right-to-left readers (e.g., Coulter, 1982; Belin, Pionner, Perrier, and Larmande, 1988; Vaid, 1988).

DIRECTIONAL SCANNING EFFECTS IN A NONVERBAL LATERALITY CONTEXT

The question remains, however, whether directional scanning effects may influence performance on nonlinguistic laterality tasks. This question has never been systematically studied, although researchers have acknowledged this possibility (see Levy, 1976; and Freimuth and Wapner, 1979, in the context of asymmetries in aesthetic preference; and Gilbert and Bakan, 1973, in the context of face perception). As stated earlier, the outcome of this question is independent of the outcome of the scanning effect in laterality studies using verbal stimuli.

To study this question properly, one faces a problem when one considers the pairs of languages normally used in studies of directionality effects. This problem was acknowledged by Dennis who, as early as 1958, remarked:

> While the data . . . are consonant with the handwriting hypothesis, they are not entirely conclusive. The two groups compared no doubt differ in other respects as well as in regard to handwriting. It is unlikely that one can find two groups differing in handwriting but identical in all other respects (p. 294).

In what follows I will present data from two groups – Hindi and Urdu readers – that come closest to meeting the criterion that Dennis advocated. Findings from two studies are summarized. The first study compared the performance of Hindi, Urdu and Arabic readers on a nonlinguistic production task (figure drawing), and the second compared these readers on a nonlinguistic perception task (facial affect judgment) that has been used as a measure of right hemisphere involvement.

Before presenting the studies, a brief overview of the historical and structural properties of Hindi and Urdu is provided.

HISTORY AND CHARACTERISTICS OF HINDI AND URDU

Urdu and Hindi are the languages of two different groups originating from the same geographical area – North India – or Delhi, to be more specific. Both are non-colloquial languages created out of the same speech – *Khari Boli* – spoken in the Delhi area several centuries ago. Urdu emerged as the language of contact between Hindu inhabitants and Muslim invaders to India in the 11th century. From this early role, Urdu eventually attained the status of a literary language in the 15th century and by the 17th century was adopted by Muslims throughout India as the language of Islam, thanks to the efforts of wandering mystics, or *sufis*.

Urdu was used alongside Persian, then the language of the courts, and eventually replaced it after the fall of the Mughal empire in the middle of the nineteenth century. The British rulers enforced Urdu as the court language and as the medium of instruction in several states in India.

While Urdu flourished in India for several centuries, modern Hindi was created within the last century when, as Grierson (cited in Narula, 1955: 83) remarked, "Hindi (fell) under the fatal spell of Sanskrit." Furthermore, as Narula (1955) points out, communal sentiments against Urdu, which had been declared the court language of areas with predominantly Muslim populations, also played a part in the evolution of modern Hindi (see Rai, 1991, for a more detailed history).

In current usage, Hindi and Urdu are widely spoken in a core form known as Hindustani in North India and in pockets of south India among Muslims and the descendants of those Hindu castes which once came into intimate contact with them. Urdu is the national language of Pakistan used by over 80 million speakers and, in India, Urdu is one of the 15 regional languages, used as a native language by well over 30 million speakers. Hindi is one of the two official languages of India, the other being English, and is used as a native language by more than 40% of the population.

CHARACTERISTICS OF THE WRITING SYSTEMS OF HINDI AND URDU

Hindi uses the Devanagari writing system which characterizes many of the languages used in North India, and is derived from Sanskrit. Urdu is written in *Nasta'liq*, a form of the Arabic script that was developed in Iran and was adopted in India as the favored style several centuries ago. See Figure 1 for a display of the alphabets of each of the two scripts.

The Hindi writing system is considered to be semi-syllabic, since it has syllable-like properties as well as properties of an alphabetic script. There

Hindi

: ḥ							
अ a	आ ā	इ i	ई ī	उ u	ऊ ū	ऋ ṛ	
ए e	ऐ ai	ओ o	औ ai	ं ṁ			
क k क़ q	ख kh ख़ x	ग g ग़ ġ	घ gh	ङ ṅ			
च c	छ ch	ज j ज़ z	झ jh	ञ ñ			
ट ṭ	ठ ṭh	ड ḍ ड़ ṛ	ढ ḍh ढ़ ṛh	ण ṇ			
त t	थ th	द d	ध dh	न n			
प p	फ ph फ़ f	ब b	भ bh	म m			
य y	र r	ल l	व v				
श ś	ष ṣ	स s	ह h				

Urdu

ا — *alif*	د d *dāl*	ض *z *zvād*	م m *mīm*				
ب b *be*	ڈ ḍ *ḍal*	ط *t *toe*	ن n *nūn*				
پ p *pe*	ذ *z *zāl*	ظ *z *zoe*	و v *vāo*				
ت t *te*	ر r *re*	ع ' *'ain*	ہ h *choṭī he*				
ٹ ṭ *ṭe*	ڑ ṛ *ṛe*	غ ġ *ġain*	ی y *ye*				
ث *s *se*	ز z *ze*	ف f *fe*					
ج j *jīm*	ژ ż *że*	ق q *qāf*					
چ c *ce*	س s *sīn*	ک k *kāf*					
ح *h *baṛī he*	ش ś *śīn*	گ g *gāf*					
خ x *xe*	ص *s *svād*	ل l *lām*					

Fig. 1. Hindi and Urdu Scripts.

is a direct correspondence between letters and sounds in Hindi, with very little ambiguity. This is not the case in Urdu. As described by Narang (1986), Urdu is derived from the Semitic family and represents three phonological layers: the indigenous layer of the Indo-Aryan, and the borrowed layers of the Semitic and Iranian. Since the borrowed Semitic model was deficient in retroflexion, aspiration, nasalization and vocalics, the Urdu

system added a total of seventeen sounds to represent these distinctions. It also accepted six new consonantals not present in the indigenous spoken language and retained seven consonantal letters which had lost their distinct sounds. As such, there are many letters in Urdu which refer to the same sound, and which letter one uses depends on knowledge of the context. This makes Urdu a more difficult script to master, relative to Hindi.

On the spoken level, the two languages have the same dialectal base and for the most part the same grammar. They share a core lexicon (Kelkar, 1968) to such a degree that speakers of Hindi from India are thought by Pakistanis to be speaking Urdu, and vice versa. Thus, the major difference between the two languages lies at the written level.

In addition to the orthographic differences mentioned above, a salient difference between the two scripts is in the direction in which they are written: Hindi is written from left to right while Urdu is written from right to left. This striking difference in script direction makes it possible to study the role of directional scanning tendencies directly by comparing Hindi and Urdu readers. Since the two scripts are essentially identical on the spoken level (i.e., in their phonology, semantics, and syntax) any differences in performance must be related to orthographic differences. This provides a much tighter control than has been possible in the existing literature on directionality or laterality differences.

STUDY 1: EFFECT OF SCRIPT DIRECTIONALITY ON ASYMMETRIES IN LINE DRAWINGS

As a first step in studying behavioral repercussions of script direction we chose a task – free hand figure drawing – that has previously been used in the literature to examine both cultural and biological influences. The task simply required subjects to draw some simple line drawings of common objects. In our first experiment (Singh and Vaid, 1987) we compared the performance of three groups of readers (Hindi, Urdu, and Arabic) on this task. A follow-up experiment (Singh, Vaid, and Sakhuja, 1987) compared right- vs. left-handers on a similar task using a different set of figures.

Method

Subjects. Subjects for the primary study included 55 male and female Hindi-English readers, 38 male and female Urdu readers with little knowledge of written Hindi and 82 predominantly female Arabic readers with no knowledge of English. All subjects were right-handed adults. For the follow-up study, subjects included 16 Hindi right-handers, 16 Hindi left-handers, 16 Urdu right-handers and 16 Urdu left-handers. All subjects in the follow-up study were girls ranging from 9–13 years of age.

Stimuli and Procedure. Subjects were given a sheet divided into six sections. At the top center of each section was the name of an item that they were to sketch in that section of the page. The items to be drawn were written in English for the South Asian sample and in Arabic for the Arab sample. The items to be drawn included three non-directional, filler items, i.e., a house, a hand, and a tree and three items with a front/back. The directional items in the primary study were: a profile of a face, an elephant, and a bicycle. The directional items in the follow-up study were a fish, an arrow and a flag.

Subjects were instructed to draw each of the six items in the space provided using their dominant hand. They were to draw the figures fairly quickly, without too much attention to detail or elaboration, and could draw the items in any order.

The Arabic subjects were tested in a city in Saudi Arabia by a white, female English teacher. The Hindi and Urdu data for the primary study were collected by a male Indian Muslim in the north Indian city of New Delhi. For the follow-up study, a Hindu female graduate student in Meerut did the testing. None of the examiners knew the purpose or rationale behind the study.

Three dependent measures were of interest: the starting location of the drawings (top left, top right, or other), the sequence of drawing the six items (left to right, right to left, or other) and the direction in which the three directional items were shown facing (leftward or rightward).

Results

Starting Location and Drawing Order. There was a clear difference across groups in the location on the page that subjects began the task. Nearly all the Hindi subjects started their drawings on the top left of the page; this finding is consistent with the observations of van Sommers (1984: 122) using English readers and with findings from three other left-to-right linguistic groups (Dennis and Raskin, 1960). The vast majority of Urdu and Arabic subjects instead began on the top right of the page, consistent with Dennis and Raskin's (1960) finding with Israeli and Iranian subjects.

With regard to drawing order, while nearly 70% of Hindi readers used a left-to-right drawing sequence, this was true of less than 20% of Urdu or Arabic subjects who instead favored some other sequence, typically a right-to-left or zigzag order.

The Facing of Objects. The direction in which the three experimental figures in the primary study (bicycle, elephant, profile) were faced by each group is summarized in Table 1A, along with chi square values. There was a marked difference in object orientation direction of the Hindi subjects versus that of the Arab subjects. The performance of Urdu subjects fell

between these two extremes. Specifically, the majority of Hindi subjects faced each of the three directional figures leftward. Arab subjects, in contrast, showed a significant rightward bias on the bicycle and elephant, and showed no bias on the profile drawing. Urdu subjects showed a leftward bias on the elephant and the face, with no significant bias on the bicycle. Comparing across groups, we found that Hindi subjects were significantly more leftward-facing than Arabic subjects across all three items, and were more leftward-facing than Urdu subjects on two of the three items (they did not differ on the profile). Furthermore, Arabic subjects were significantly more rightward-facing than Urdu subjects on all three items (see Table 1B for chi-square values).

The leftward bias on the profile item in both Hindi and Urdu groups and the lack of a rightward bias on this item among the Arabic subjects is noteworthy. It is consistent with Jensen's (1952) report of a marked leftward orientation for profile drawing in a number of linguistic groups, irrespective of script directionality, and may reflect a common convention in face drawing instruction.

While we did not record the starting position of each drawing, van Sommers (1984) has shown that direction of facing of an object reflects the starting position and direction of initial stroke used to draw the object. He further points out that since the directional component (e.g., the trunk of the elephant, or the handle of the bicycle) is usually drawn first, the figure will end up facing left or right simply because the initial stroke is from

TABLE 1

A. Leftward bias in figure drawing orientation

Group	Profile	Bicycle	Elephant
Hindi Ss	89.1%	90.9%	92.7%
(n = 55) chi-sq.	33.6**	36.8**	40.2**
Urdu Ss	86.8%	57.9%	68.4%
(n = 38) chi-sq.	20.6**	0.9	20.6**
Arab Ss	45.2%	34.1%	36.6%
(n = 82) chi-sq.	0.8	8.2*	5.9*

B. Summary of chi squares for group comparisons

	Profile	Bicycle	Elephant
Hindi vs. Urdu	0.1	15.3**	8.4**
Hindi vs. Arab	27.1**	43.3**	33.4**
Arab vs. Urdu	18.5**	6.1*	10.7**

* $p < 0.02$

** $p < 0.01$ or beyond

left-to-right or from right-to-left, respectively, reflecting the direction of writing (Van Sommers, 1984; 1991).

Handedness Effects. Since previous studies of figure drawing with English readers have noted a handedness difference (e.g., Snyder *et al.*, 1983; van Sommers, 1984) we were interested in testing for it as well. In our follow-up study which compared left- and right-handed Hindi and Urdu subjects we found a significant group difference between the right-handers such that Hindi subjects were more likely than Urdu readers to show a leftward figure orientation, consistent with our previous finding. However, the performance of the left-handers was unaffected by reading habits inasmuch as both Hindi and Urdu left-handers tended to orient the figures toward the right (less than 25% of their overall drawings were oriented towards the left).

Thus, the results from our follow-up study suggest that both handedness and reading direction separately influence figure orientation and that the effects of reading direction emerge only among right handers.

STUDY 2: SCRIPT DIRECTIONALITY INFLUENCE ON ASYMETRIES IN FACIAL AFFECT PERCEPTION

To extend the scope of our investigation of script directionality effects, in our next study (Vaid and Singh, 1989) we used a task that has been employed by previous investigators in a laterality context. This task, involving facial affect judgments, was developed by Campbell (1978) and adapted by Jerre Levy and associates (e.g., Heller and Levy, 1981; Levy, Heller, Banich, and Burton, 1983; Levine and Levy, 1986) and has since been used by several other researchers in the laterality literature (e.g., Hellige, Bloch, and Taylor, 1988; Best, 1987; Jaeger, Borod, and Peselow, 1987) as an index of right hemisphere involvement.

The task requires subjects to decide which of two photographs of asymmetrically smiling faces looks happier. Our intention in using this task was to test whether directional scanning effects might be generating the asymmetries otherwise attributed to laterality effects. The possibility of a reading habit bias had been raised only in passing in one of the dozen or more studies that have used this task as a laterality measure but was never studied.

Method

Subjects. Four groups of right-handed adults and two groups of left-handers were tested. Right-handed subjects included 35 left-to-right (Hindi) readers, 57 bidirectional (Urdu/Hindi) readers, 17 right-to-left (Arabic) readers and

22 illiterate speakers of Hindi/Urdu. Left handed subjects included 19 Hindi readers and 12 Urdu/Hindi readers.

Stimuli and Procedure. Stimuli from Levy *et al.* (1983) were used. They consisted of 36 pairs of photos of male faces, prepared as asymmetric composites such that either the left or the right half of the face was smiling. A given pair thus included a left-smile and a right-smile. Subjects were tested individually using a booklet containing the stimulus pairs presented in free vision (as was done in the studies by Levy and associates). The faces were counterbalanced such that the smile was on the left side in the top photo in half the cases and in the bottom photo in the remaining cases. Subjects' task was simply to decide which of the two faces of a given pair looked happier. The experimenter (blind to the purpose of the study) recorded whether the top or the bottom face was chosen.

Data Coding and Analysis. Following Levy *et al.* (1983), a laterality measure was computed per subject. The total number of pairs with a leftward smile were subtracted from the total number with a rightward smile, and this value was divided by the total number of pairs in the test (36). This yielded an asymmetry score varying from negative to positive values, with a negative score signalling a leftward preference. The asymmetry scores were analyzed in an analysis of variance. A frequency analysis, comparing the incidence of leftward versus rightward and no preference across groups was also performed on the data. Finally a reliability test was done.

Results

Reliability. The split-half reliability measure (Pearson correlation) revealed that the scores of all but two groups were reliable (see Table 2). The unreliable groups were the illiterates and the Hindi left handers. The results of these two groups on the other analyses must therefore be regarded as carrying no information with regard to the question at hand.

Asymmetry Scores. The asymmetry scores ranged from –0.286 for the Hindi right handers to +0.072 for the Arabic subjects. The analysis of variance for the right-handers revealed a significant Group effect [$F(3, 130) = 6.05$, $p < 0.007$] such that Hindi subjects were significantly more leftward in their asymmetry scores as compared to all other right-handed groups ($p < 0.01$). Furthermore, there were no differences between the Arab and Urdu subjects' performance (0.072 vs. 0.022, respectively). The analysis of variance comparing left handers revealed a two-way interaction of Group by Hand [$F(1, 119) = 7.33$, $p < 0.007$], indicating a greater leftward preference among Hindi than Urdu right-handers ($p < 0.05$), and a greater leftward prefer-

TABLE 2
Split-half reliability values for facial affect judgment test

Group	N	Pearson r
A. Right-Handers		
Hindi	35	0.71*
Arab	17	0.84*
Urdu	57	0.62*
Illiterate	22	0.02
B. Left-Handers		
Hindi	19	0.18
Urdu	12	0.88*

$p < 0.05$ or beyond.

ence among Hindi right-handers relative to Hindi left-handers ($p < 0.05$). No differences were found between Urdu right and left-handers, or between Hindi and Urdu left-handers.

Frequency of Leftward Bias. Subjects were classified as showing a significant ($p < 0.05$) left bias, a right bias or no bias. Nearly 70% of Hindi right-handed subjects and 77% of Arabic readers manifested a significant bias in either direction, as compared to 42% of Urdu right-handers and 18% of the illiterates. Among the left-handers 33% of the Urdu readers and 26% of the Hindi readers showed a significant preference in either direction.

A chi square analysis of those who showed a significant bias indicated that, among right handers, significantly more Hindi readers ($p < 0.05$) than either Urdu or Arabic readers showed a leftward bias, a leftward bias was found in 83% of Hindi readers versus 54% of Urdu subjects (n.s.) and only 31% of Arabic readers.

Discussion

The results from the facial affect perception task provide partial support for a reading scan hypothesis inasmuch as the observed bias was strongest in Hindi readers and weakest in Arabic readers, being in between for the bi-directional readers. Since the Arabic readers did not show a strong, significant rightward bias, but only a tendency toward a rightward bias, it is not clear whether this reflects the small sample size of this group or an actual interaction of scanning tendency with laterality effect, resulting in the weaker biases observed for this group.

Although handedness was examined, the results from the Hindi groups are inconclusive with regard to the effects of this variable since the performance of the Hindi left handers was statistically unreliable. The fact

that there was no difference between right- and left-handed Urdu/Hindi readers is an ambiguous finding: it may indicate a genuine effect of reading scan and a lack of handedness effect on this task, or it may reflect an obscured handedness effect resulting in part from the existence of "hidden lefthanders" in the right-handed group, given the suppression of left-handedness in Muslim cultures. While the latter possibility is plausible we do not think it accounts entirely for the results, since the actual (manifest) left-handers studied might be expected to be particularly strongly left-handed, if they were able to resist societal pressures to be right-handed. Since these left-handers performed in the same way as the ostensibly right-handed group, this may suggest that the task is tapping non-biological differences.

Interestingly, of all of the subgroups that have been studied on the facial affect perception task, the only subjects that have not shown a leftward bias were pre-literate 5 years olds (their mean asymmetry score was –0.092; Levine and Levy, 1986). Only a quarter of the 20 subjects in this group according to Levine and Levy showed a significant asymmetry at all. We submit that a reading-habit interpretation may at least in part account for this group's poor performance on the task, apart from the explanations forwarded by Levine and Levy in terms of fatigue or random responding.

SUMMARY AND CONCLUSION

In our first study (Vaid and Singh, 1987) evidence was presented for an effect associated with script directionality on a nonlinguistic production task. Whereas left-to-right readers (Hindi) began their drawings at the top left of the page and proceeded to draw the other figures in a left to right order, the right-to-left readers (Urdu, Arabic) tended to start at the top right and proceed in a right to left order. Furthermore, the groups differed in the direction in which they oriented the three directional figures, with a leftward orientation favored by the left-to-right readers and a rightward one favored by the right-to-left readers. A follow-up study (Singh, Vaid, and Sakhuja, 1987) corroborated the difference between Hindi and Urdu right-handers but found an overall rightward bias for Hindi and Urdu left-handers.

Although only three figures were used in each of the two experiments, van Sommers (1984) has demonstrated with (right-handed) left-to-right readers that when drawing such objects as cars, fish, shoes, pipes, glasses, cutlery, the spines of books, the quills of feathers, the blades of tools, the fronts of houses, the heads of dogs, crocodiles, birds, etc., the objects' front is drawn first and, given the left-to-right direction of the initial stroke, these objects end up facing left.

The "invasion" of script directionality into a nonlinguistic domain such as figure drawing (at least among right-handers) in our study is particu-

larly striking given that subjects were not aware of the purpose of the study (the experimenters themselves were blind to the purpose) and thus could not be behaving in accordance with any expectations about the purpose, or "demand characteristics". We have since conducted numerous follow-up studies with Hindi and Urdu right- and left-handers using a variety of production and perceptual tasks ranging from line bisection, line length estimations for lines of a targeted length drawn from left-to-right vs. right-to-left and circle drawing direction (Vaid and Singh, 1991). For the most part the results corroborate our figure orientation data.

The second study summarized here showed the operation of scanning biases on a nonlinguistic perceptual task thought to tap hemisphere differences in affect judgment (Vaid and Singh, 1989). Inasmuch as reading habits were indeed found to be present, this study, along with others in the literature should serve to alert researchers to the importance of including readers with different directional scanning biases in laterality studies. That reading habits appear to be more influential on ostensibly nonlinguistic tasks than on verbal laterality tasks is an unexpected but on reflection perhaps not altogether surprising conclusion of the present research.

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