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Hemispatial Deficits on the Rey-Osterrieth Complex Figure Drawing*

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ABSTRACT

This study presents several measures of hemispatial deficits on the Rey-Osterrieth figure copy that may be easily incorporated into the Denman (1984) scoring system. One hundred and fourteen subjects participated. Newly established indices were compared to criterion measures on the Letter Cancellation Test (LCT). Left-sided omissions, rightward attentional bias, item rotations, and figural rotations on the Rey were significantly greater ($p < .002$) among right-CVA neglecting subjects ($n = 38$) than among nonneglecting right-CVA subjects ($n = 36$), left-CVA subjects ($n = 20$), and nonpatient controls ($n = 20$). However, a subgroup of nonneglecting right-CVAs as defined by the LCT also showed a pattern of hemispatial deficits on the Rey. It may be that the increased complexity of Rey-Osterrieth figure copy renders it more sensitive to hemispatial deficits. Measures of hemispatial deficits from both tests were significantly related to inpatient falls ($p <.0001$).

Hemispatial neglect is a common consequence of brain insult. Although the disorder occurs with lesions to both hemispheres, it is most common, severe, and longlasting following right-brain injury (Chedru, Leblanc, Chedru, & L'hermitte, 1973; Heilman & Valenstein, 1979; Kinsbourne, 1970). Estimates of the frequency of hemispatial neglect among right-hemisphere-injured patients range from 26% to 85% (Fullerton, Mackenzie, & Stout, 1988; Zoccolotti et al., 1989). As others examining this phenomenon have noted, the tendency for many patients to experience spontaneous resolution of symptoms within a few weeks may be primarily responsible for the misconception that hemispatial neglect has a limited impact on long-term functioning (Eglin, Robertson, & Knight, 1989; Zoccolotti et al., 1989). However, numerous reports have found it to be among the most disabling sequelae of stroke (Fullerton et al., 1988; Harlowe & Van Deusen, 1984; Wade, Skilbeck, & Hewer, 1983). Moreover, the presence of hemispatial neglect is an important prognostic indicator and has been shown to be an independent predictor of functional outcomes, including length of hospital stay (Feigenson, McCarthy, Greenberg, & Feigenson, 1977), placement following discharge (Harlowe & Van Deusen, 1984), resumption of activities of daily living (Wade et al., 1983), wheelchair accidents (Webster, Rapport, Godlewski, & Abadee, 1994), and inpatient falls (Webster, Morrill, Rapport, Okamoto, & Abadee, 1994).

Test batteries designed to elicit and measure the severity of hemispatial neglect have been developed (see Wilson, Cockburn, & Halligan, 1987; Lincoln & Clarke, 1987). However, the investment of time and resources required to administer these batteries is often not feasible in everyday clinical practice. The acceptable alternative is to extract more reliable and valid information from the tests given in a standard

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neuropsychological battery.

The most common measures of hemispatial neglect are cancellation and drawing tasks (Andrews, Brocklehurst, Richards, & Laycock, 1980; Fullerton et al., 1988). These are quick tests that are easy to administer at bedside. It has been shown that selected single measures can provide information regarding hemispatial deficits that is comparable to the specialized hemineglect battery (Friedman, 1990). Zoccolotti and colleagues (1989) reported that, in a comparison of tests designed to elicit hemispatial neglect, a letter cancellation test proved most sensitive to hemispatial deficits. However, these authors did not include a drawing task among the measures compared. This may reflect the difficulty in scoring drawing tasks and the lack of normative standards with regard to hemispatial asymmetry.

The Rey-Osterrieth complex figure drawing (Rey, 1944) is a draw-to-copy task that is frequently used in clinical practice to assess a variety of visuospatial and constructional skills. In the absence of a systematic method, most clinicians have interpreted asymmetry on the Rey figure copy using only clinical judgment. Unfortunately, the level of distortion in figure copies produced by right-hemisphere-injured patients often makes it difficult to discern hemispatial deficits from general visuospatial disturbance. Although these problems are usually related, the presence of hemispatial neglect is an important clinical discovery, because even mild hemispatial deficits place the patient at significantly greater risk for accident (Webster, Rapport, et al., 1994).

The purpose of the present study is to present and evaluate measures of hemispatial deficits on the Rey-Osterrieth figure copy that may be easily incorporated into an existing interpretive system (Denman, 1984). Our primary goal was to investigate whether the measures derived from the figure copy were consistent with criterion measures of hemi-inattention on the Letter Cancellation Test (Mesulam, 1985). To that end, we investigated the strength of the relationships between the Rey-Osterrieth and Letter Cancellation Test measures of hemi-inattention. In addition, we examined the indices of hemi-inattention derived from the Rey-Osterrieth by comparing subjects who were grouped according to neglect status defined by performance on the Letter Cancellation Test.

We expected that subjects defined as exhibiting hemispatial neglect on the Letter Cancellation Test would show a similar profile of errors on the Rey-Osterrieth figure copy. We were also interested in whether diagnoses of neglect made using the new indices from the Rey-Osterrieth figure copy would agree with diagnoses made using the Letter Cancellation Test.

Our specific goals were to create guidelines (i.e., cutoff scores) that might be clinically useful in diagnosing neglect using the Rey-Osterrieth figure, and to indicate whether making such a diagnosis would have clinical relevance. Finally, to demonstrate that the indices of hemi-inattention derived from the Rey-Osterrieth were more specific to neglect than to general visuospatial disturbance, we investigated other types of errors commonly committed on the figure copy.

METHOD

Subjects

One hundred and fourteen individuals participated in the study. The sample consisted of 74 right-CVA patients, 20 left-CVA patients, and 20 nonpatient controls. The presence of hemispatial neglect was operationally defined by performance on the Letter Cancellation Test (see Measures). Thirty-eight right-CVA patients were identified as demonstrating hemispatial neglect. The remaining 36 right-CVA patients and the 20 left-CVA patients met criteria for the absence of neglect, which included Letter Cancellation Test performance and a review of hospital records to ensure that there was no history of neglect. All left-CVA patients were without history of alexia or agraphia. Mean age of the total sample was 60.49 years (SD = 8.46; range = 33-76) and mean level of education was 12.73 years (SD = 2.92). Univariate analyses of variance (ANOVA) established that the four groups did not differ significantly with regard to age (F [3,110] = 0.98) or level of education (F [3,110] = 2.52). Mean time from the onset of stroke to neuropsychological assessment was 380 days (SD = 971 days; range = 15-2520 days), and this was not significantly different across the three patient groups, $F(2,91) = 1.78$. Chi-square analyses revealed that the percent of patients with visual field cuts was greater among right-CVA patients with hemispatial neglect (47.37%) than among right-CVA patients without neglect (11.11%) or left-CVA patients (35.00%), $X^2(2) = 11.60, p < .003$.

Site of lesion was confirmed either by computed tomography or magnetic resonance imaging scan, or by a report from a neuroradiologist. When scans were available to us ($n = 65$), areas of damage were plotted on standard brain templates developed by Damasio and Damasio (1989). From these plots, subjects were classified as having parietal-lobe involvement or non-parietal damage. Chi-square analysis revealed that subjects with hemispatial neglect were more likely to have parietal-lobe involvement than were nonneglecting right-CVA patients or left-CVA patients, $X^2(2) = 9.64, p < .001$.

Measures

Letter Cancellation Test (LCT; Mesulam, 1985)

All subjects were administered the LCT using standard procedures that provided unlimited time to cancel all target letters (A) placed among a random array of letters on an 8.5 in. X 11 in. page. LCT omissions left (LCOL) reflects the percent of omitted targets on the left half of the stimulus page (i.e., number of omitted left-sided targets/number of possible left-sided targets). Right-CVA patients whose LCOL score exceeded the maximum value obtained by subjects in the control group (10%) were operationally defined as exhibiting hemispatial neglect. This cutoff also represents a score approximately two standard deviations greater than the mean for normal controls. To ensure that the omissions score reflected hemispatial inattention as opposed to a generalized scanning deficit, classification of neglect also required that left-side omissions exceed right-side omissions by at least 6%.

Letter Cancellation Test starting point from left (LCSPL) reflects the location of the first target cancelled by the subject in percent of mm from the left-most target. The LCSPL score was calculated by measuring the horizontal distance from the left-most target on the LCT to the first target cancelled by the subject, and dividing this length by the total horizontal distance from the left-most to the right-most target on the LCT. Thus, a higher LCSPL score reflects a more rightward initiation on the task, and this represents a measure of attentional bias to right space (Webster, Rapport, et al., 1994). For example, a subject obtaining an LCSPL score of 67% began the task by cancelling a target located approximately two-thirds of the distance from the left edge of the stimulus area. Descriptive statistics regarding group differences in omissions and starting point on the LCT are provided in Table 1.

Rey-Osterrieth Complex Figure Drawing (Rey, 1944)

The Rey figure copy was administered to all subjects using the standard procedures described in the Denman Memory Battery (Denman, 1984). In addition to the total raw score and age-corrected scaled score produced by the standard Denman protocol, each Rey was given seven special scores.

Two indices of hemispatial neglect were created: Rey-omissions and Rey-zeros. Rey-omissions-left (ReyOL) and Rey-omissions-right (ReyOR) reflect the percent of omitted items on the left and right halves of the figure, respectively. These are items that were not attempted by the subject during the copy of the figure. In contrast, Rey-zeros-left (ReyZL) and Rey-zeros-right (ReyZR) reflect the percent of left- and right-sided items that were awarded zero points, including omitted items. Because a subject may receive zero points on a Rey item due to neglect or general visuospatial disturbance, we expected that a score reflecting the number of omitted items would be more consistent with LCT-defined neglect than would a score reflecting the number of zero-point responses. Percent scores were used for these indices because the number of items comprising

Table 1. Descriptive Statistics for Group Comparisons of LCT Performance.

		Group[1]			
Variable		Neglect	Nonneglect	Left-CVA	Control
Omissions Left %	*M*	65.38[a]	5.21[b]	3.52[b]	2.67[b] *
	SD	31.69	5.13	4.99	4.07
Omissions Right %	*M*	23.51[a]	4.17[b]	6.36[b]	2.73[b] *
	SD	23.71	5.01	6.84	2.86
LCT Starting Point	*M*	69.27[a]	30.77[b]	4.14[c]	11.32[c] *
(% from Left)	*SD*	34.60	38.34	6.49	9.15

Note. Means having the same superscript do not differ according to Newman-Keuls post-hoc test.

[1]. $F(3, 110)$

* $p < .0001$.

the left- and right-side scores were not equal, and converting the data to percent of possible items on that side of the figure better facilitated comparison of the two scores.

Items included in the Rey-omissions and Rey-zeros scores correspond to those items identified by Denman as belonging to the left (i.e., items 1, 4, 17, 18, 19, 20, 21, 23, and 24) and right (i.e., items 5, 6, 8, 9, 10, 11, 12, 13, 14, 15) halves of the standard figure scoring. Items at midline or assigned to both halves of the figure in the Denman scoring system (i.e., items 2, 3, 7, 16, and 22) were not included in hemispatial score variables. Thus, clinicians familiar with the Denman system may calculate the Rey-omissions and Rey-zeros indices from the standard item scores.

Attentional bias to right space on the Rey is represented by the Rey starting point from left (ReySPL) score, which reflects the subject's starting point on the task in percent of mm from the left-most point on the figure. Subjects were defined as exhibiting attentional bias on the Rey Copy when the starting point began rightward of the vertical midline of the large rectangle (Denman item 16). This point represents the maximum value obtained by any control subject and corresponds to a point on the figure that is approximately two standard deviations rightward of the mean starting point for controls.

Each figure copy was examined for additional errors that included item repetitions and conflations, as well as rotation of the figure and separate items within the figure (Kirk & Kelly, 1986). Item repetitions represents the total number of Denman items that were duplicated in the copy. Conflation reflects the incorporation of one item within another item (e.g., placing the small square 18 within the large rectangle 3, with the two items sharing the lower left corner). The presence of figure and item rotations were defined at 30° from stimulus orientation.

Hospital Incident Reports

Official incident reports were examined to determine the number of falls experienced by the subjects while they were inpatients on the Rehabilitation ward.

Procedure

After release of information and informed consent were obtained, subjects completed the neuropsychological assessment in one or two sessions. Rey figure drawings were scored by two independent raters and disagreements between raters were resolved by a third rater. Incident reports of falls were tabulated following hospital discharge.

RESULTS

Initial interscorer reliability for Rey figure total score reached .97 ($p < .0001$). A Bonferroni adjustment was adopted to control experimentwise error at $p = .05$, and alpha was set at .002 for all analyses. Pearson product-moment correlations revealed strong relationships between the LCT index of hemispatial neglect (LCOL) and both of the Rey figure indices of hemispatial neglect (ReyOL and ReyZL). The indices of attentional bias to right space on the LCT (LCSPL) and the Rey figure (ReySPL) were also strongly related. As can be seen in Table 2, all of the indices were significantly interrelated, with correlation coefficients ranging from .56 to .96 ($p < .0001$).

Analyses of variance (ANOVA) with Newman-Keuls post-hoc tests ($p < .05$), when appropriate were conducted on the Rey figure scores, with Group as the between-subjects factor. Table 3 presents the means, standard deviations, and significance levels for each variable. Group differences in the age-corrected Denman scaled score were significant, $F(3, 110) = 39.76$, $p < .0001$. Post-hoc analyses revealed that the mean age-corrected Denman scale score was lower among the Neglect Group than among all other groups. The mean age-corrected Denman scale score was also lower

Table 2. Intercorrelations of Letter Cancellation and Rey Figure Copy Variables.

	LCOL	LCSPL	ReyOL	ReyZL
LCSPL	0.68			
ReyOL	0.80	0.63		
ReyZL	0.79	0.64	0.96	
ReySPL	0.56	0.59	0.57	0.65

Note. $r(113)$; all $p < .0001$

Table 3. Descriptive Statistics and Significance Levels for Group Comparisons of Rey Figure Copy Variables.

		Group[1]			
Variable		Neglect	Nonneglect	Left-CVA	Control
Denman Scale	*M*	1.24[a]	5.14[b]	5.15[b]	8.90[c]**
	SD	0.91	3.46	3.48	1.94
Omissions Left %	*M*	0.68[a]	0.17[b]	0.12[c]	0.03[c]**
	SD	0.27	0.21	0.14	0.05
Omissions Right %	*M*	0.21[a]	0.05[b]	0.06[b]	0.01[b]**
	SD	0.17	0.08	0.12	0.02
Zeros Left %	*M*	0.76[a]	0.25[b]	0.15[c]	0.04[c]**
	SD	0.23	0.23	0.17	0.05
Zeros Right %	*M*	0.32[a]	0.10[b]	0.10[b]	0.01[b]**
	SD	0.22	0.12	0.15	0.03
Rey Starting Point	*M*	66.34[a]	32.66[b]	10.06[c]	13.65[c]**
(% from Left)	*SD*	31.13	31.12	10.89	13.68
Item Repetitions	*M*	2.05[a]	1.36[a]	1.40[a]	0.40[b]*
	SD	1.68	1.66	1.64	0.68
Conflations	*M*	1.21[a]	0.83[a]	0.80[a]	0.15[b]*
	SD	0.96	1.00	1.24	0.37
Item Rotations	*M*	0.92[a]	0.31[b]	0.35[b]	0.00[b]**
	SD	1.17	1.06	0.49	0.00
Figure Rotation[2]		31.58[a]	11.11[b]	0.00[b]	0.00[b]**

Note. Means having the same superscript do not differ according to Newman-Keuls post-hoc test.
1. $F(3, 110)$
2. $X^2(3)$; refers to percent of subjects in each group.
* $p < .002$ ** $p < .0001$.

among the Nonneglect and Left-CVA groups than among the Nonpatient Control Group; however, the Nonneglect and Left-CVA groups did not differ significantly.

Two 4 X 2 ANOVAs, with Group as the between-subjects factor and Side of Figure (Left vs. Right) as the within-subjects factor, were conducted on omissions and zero-point responses to determine whether subjects with neglect demonstrated the characteristic pattern of asymmetry in errors on the Rey figure. The ANOVA examining left versus right omissions revealed main effects for Group ($F[3, 110] = 54.86, p < .0001$) and Side of Figure ($F[3, 110] = 169.12, p < .0001$), as well as a Group X Side interaction ($F[3, 110] = 42.72, p < .0001$). Post-hoc analyses of main effects revealed that total omissions were greater among the Neglect Group than among all other groups, and that total left-sided omissions were greater than right-sided omissions. As expected, post-hoc comparisons of cell means revealed that the Neglect Group committed more left-sided than right-sided omissions. Interestingly, the Right-CVA Nonneglect Group also committed more left-sided omissions than did the Left-CVA and Control groups, and showed a significant preponderance of left- versus right-sided omissions. Left versus right omissions among the Left-CVA and Control groups were not significantly different (see Table 2). Thus, with neglect status determined by LCT results, both the

Right-CVA Neglect and Right-CVA Nonneglect groups showed a pattern of asymmetry in omissions, suggesting a left hemispatial deficit on the Rey figure copy.

Because the Rey-Zero score encompasses omissions, the results of the 4 X 2 ANOVA examining zero-point responses were essentially similar to those obtained for Rey omissions. The analysis again revealed main effects for Group (F [3, 110] = 69.11, $p < .0001$) and Side of Figure (F[3, 110] = 123.23), as well as a Group X Side interaction (F[3, 110] = 26.86, $p < .0001$). One difference in the pattern of the main effect post-hoc results was that both the Right-CVA Nonneglect and the Left-CVA groups obtained a greater total number of zero-point responses than did the Control Group. Thus, the Rey-Zero score revealed overall differences between the patient and nonpatient groups. Again, the Right-CVA Neglect and Nonneglect groups obtained significantly more left- versus right-sided zero-point errors, whereas no predominance of side of error was seen in the Left-CVA or Control groups.

Univariate ANOVA revealed group differences in attentional bias as measured by ReySPL, $F(3, 110) = 26.75$, $p < .0001$. Post-hoc analyses indicated that attentional bias was greatest among the Neglect Group; however, both the Right-CVA Neglect and Nonneglect Groups showed greater attentional bias on the Rey figure than did the Left-CVA and Nonpatient Control Groups, whose starting points did not significantly differ (see Table 2). Interestingly, the same pattern of results was seen with attentional bias as measured by LCSPL, $F(3, 110) = 26.25$, $p < .0001$. Again, attentional bias was greater among the Neglect Group than among all other groups, but was also significantly greater among the Nonneglect Group than among the Left-CVA and Nonpatient Control groups (see Table 1).

To investigate whether diagnosis of neglect using Rey figure indices could be comparable to diagnoses made using the criterion LCT, we examined diagnostic "hit rates" using various cutoff scores on the ReyOL and ReyZL. As with the LCT criteria for defining neglect, to ensure that the measure was tapping hemispatial deficits versus generalized visuospatial impairment, subjects were identified as exhibiting neglect on the Rey figure only when the number of left-side errors exceeded the number of right-side errors.

The optimal cutoff score for maximizing ReyOL-LCOL agreement in classification of hemispatial neglect was 33% (three omissions of left-side items), and this resulted in an overall agreement rate of 92.11%. Using the optimal cutoff score, one subject from the LCT Neglect Group (2.63%) did not evidence neglect as defined by ReyOL (false negative). Seven subjects from the LCT Nonneglect Group (19.44%) were identified as exhibiting neglect on the Rey figure; however, 5 of these "false positive" subjects (13.89%) showed signs of hemi-inattention in rightward attentional bias on the on the Rey figure (ReySPL) and the LCT (LCSPL). One subject from the Left-CVA Group (5.0%) was misclassified as exhibiting neglect on the Rey figure (false positive). A ReyOL cutoff score of 22% (two omissions) yielded an overall agreement rate of 85% with classifications of neglect made using the LCT. The majority of disagreements in classification involved false positive diagnoses of subjects in the Nonneglect Group ($n = 12$); however, 7 of these subjects showed attentional bias to right space. Four Left-CVA subjects (20%) were also misclassified as false positives.

The optimal ReyZL cutoff score for identifying hemispatial neglect was 55% (five zero-point responses); This resulted in an overall agreement rate with LCT-defined neglect of 89%. However, the profile of errors in classification using the ReyZL index was less desirable than that seen with ReyOL, due to an increase in the rate of "false negatives": Using the ReyZL to identify patients at risk resulted in 6 subjects in the Neglect Group (15.79%) being misclassified as nonneglecters. The rate of false positive errors using the optimal ReyZL cutoff score was comparable to the optimal ReyOL cutoff score: Five Nonneglect subjects (13.89%) and 1 Left-CVA subject (5.0%) were classified as having hemispatial neglect (false positives).

A simple method of using the age-corrected

Denman scaled score cutoff two standard deviations below the mean (i.e., scaled score < 4) resulted in a 75% agreement rate with LCT classifications. One Neglect, 17 Nonneglect, and 11 Left-CVA subjects were classified differently than when using the LCT cutoffs.

To test the clinical relevance of assessing hemispatial neglect using either the LCT or the Rey figure, we examined the relationship between the indices of neglect and hospital incident reports of inpatient falls. Pearson product-moment correlations revealed that both LCOL ($r[113] = .32, p < .0001$) and ReyOL ($r[113] = .41, p < .0001$) were significantly correlated with falls. An r-to-z transformation comparison of the two correlation coefficients (Zar, 1984) was used to test the hypothesis that ReyOL accounted for a greater portion of the variance in inpatient falls than did LCOL. The 6.57% increase in explained variance provided by the ReyOL was nonsignificant, $z = .775, p = .225$. The relationship between inpatient falls and the indices of rightward orienting bias appeared weak and was not significant, given the adjustment for experiment-wise error (LCSPL $r[113] = .22, p < .013$; ReySPL $r[113] = .17, p < .039$).

However, we noted an extreme outlier in our sample regarding inpatient falls: One right-CVA patient experienced 15 falls during his inpatient stay, whereas the maximum number of falls among all other patients was four. Following removal of the outlier, the correlations between inpatient falls and both LCOL ($r[112] = .35, p < .0001$) and ReyOL ($r[112] = .44, p < .0001$) increased slightly. Removal of the outlier resulted in a more dramatic difference in the analysis of rightward attentional bias: Both LCSPL ($r[112] = .38, p < .0001$) and ReySPL ($r[112] = .30, p < .0001$) were significantly related to inpatient falls.

Finally, a series of analyses were conducted to examine other types of errors commonly committed on the Rey figure copy. The Neglect Group was significantly more likely to rotate the figure copy ($X^2[3] = 16.48, p < .001$) and to rotate items within the figure ($F[3, 110] = 6.20, p < .002$) than were the Nonneglect, Left-CVA, and Nonpatient Control groups. Post-hoc investigation of this result revealed that 14 of 16 patients who rotated the figure copy also demonstrated marked attentional bias as measured by the Rey starting point left (ReySPL), and 15 of the 16 patients showed attentional bias on either the Rey figure or the LCT.

Group differences were also found in the number of items repeated in the copy of the figure, $F(3, 110) = 5.70, p < .002$. Post-hoc tests indicated that the number of items repeated in the copy of the figure was greater among the three patient groups than among the Nonpatient Control Group; however, mean item repetitions between the Neglect, Nonneglect, and Left-CVA groups were not significantly different. An examination of conflation errors revealed similar results, $F(3, 110) = 5.36, p < .002$. Conflation errors were also more likely to occur among all three patient groups than among the Nonpatient Controls; again, the number of conflation errors between the Neglect, Nonneglect, and Left-CVA groups did not significantly differ.

DISCUSSION

Indices created to reflect hemispatial neglect on the Rey figure copy were strongly associated with a standard measure of hemispatial neglect derived from the Letter Cancellation Test (LCT). As expected, right-CVA patients identified as having hemispatial neglect on the LCT omitted more left- versus right-sided items on the Rey figure copy and omitted more left-sided items than did right-CVA patients who successfully cancelled left-space targets on the LCT, left-CVA patients, and controls. It was found that attentional bias to right space, as measured by LCT and the Rey figure copy starting point, was more pronounced among patients identified as hemineglecters on the LCT. However, the right-CVA group identified as nonneglecters on the LCT also showed a predominance of left- versus right-sided Rey omissions and greater attentional bias than did the Left-CVA and Control groups. This suggests that some of the right-CVA patients classified by LCT performance as "nonneglecters" demonstrated a pattern on the Rey figure copy consistent with left hemispatial deficits.

The results also indicated a pattern in the differences in diagnoses of neglect made using omissions on the LCT and Rey figure: Diagnostic disagreements primarily involved cases in which subjects performed within normal limits on the LCT and were identified as exhibiting hemispatial neglect on the Rey figure. This raises the possibility that the diagnostic differences reflect the increased constructional demand required by the Rey figure copy, which places parietal-injured patients, who are more prone to neglect, at a greater disadvantage. However, a majority of these "nonneglecting" subjects who were seen to exhibit neglect on the Rey figure also showed other subtle signs of the neglect syndrome, such as attentional bias to right space, which appears to be more a function of covert attention than of constructional ability (see Posner, Walker, Fredrich, & Rafal, 1984).

It may be that omissions on the Rey figure copy are a more sensitive index of hemispatial neglect than are omissions on a standard LCT. Because hemispatial neglect appears to be highly involved with attentional functions, patients often show variability on different tasks designed to elicit the disorder (Bisiach, Perani, Valar, & Berti, 1986; DeLacy, Costello, & Warrington, 1987; Leicester, Sidman, Stoddard, & Mohr, 1969). As prior research has shown (Eglin et al., 1989; Mesulam, 1985), some of the factors that may influence the expression of hemispatial neglect include the complexity of the stimulus and the complexity of the response. Thus, one hypothesis is that the Rey figure copy, perhaps by virtue of its increased complexity, better elicits the neglect phenomenon than does the standard LCT. Unfortunately, the present study did not directly manipulate complexity as a variable; therefore, we may only speculate about the role it may play in the assessment of neglect using the Rey figure copy.

The clinical relevance of including a specific assessment of hemispatial neglect is evidenced in the relationship between omissions on the LCT and the Rey figure copy and inpatient falls. Consistent with the notion that the Rey figure copy may be more sensitive to neglect than the LCT, it was found that Rey omissions-left accounted for a greater portion of the variance in inpatient falls than did LCT omissions-left; however, the increase in explained variance was not statistically significant.

As expected, the number of omitted items on the left side of the figure (Rey omissions-left) appeared to be a more sensitive index of neglect than were the number of zero-point responses (which includes omissions) or the Denman scale score. The Rey-zeros index appeared more sensitive to general impairment than to hemispatial deficit, as both left- and right-hemisphere-injured patients obtained more zero-point responses than did the controls. Left-sided omissions and left-sided zero-point responses on the Rey figure copy were equally correlated with left-sided omissions on the LCT; however, the use of Rey-zeros to define hemispatial neglect produced an unacceptable rate of "false negative" diagnostic decision errors. When the goal is to identify patients at risk due to hemispatial neglect, the misclassifications of neglecting patients that occurred using the Rey-zero index are considered less acceptable than the tendency for the Rey-omissions index to identify additional right-CVA patients who may truly be at increased risk.

As one might expect, the Denman scaled score also appears to reflect general impairment, but was of limited value in identifying hemispatial deficits. Age-corrected Denman scale score was lower among the right-CVA and left-CVA patient groups than among the controls. This is consistent with previous reports indicating that the Rey figure total score is sensitive to a variety of neurologic conditions, yet is relatively insensitive in distinguishing specific disease types (Binder, 1982; King, 1981).

Starting point on the Rey, the other index of hemispatial deficit derived from the figure copy, was also strongly related to its counterpart on the LCT. Both the LCT and Rey figure indices of rightward orienting bias were associated with inpatient falls; however, this finding must be interpreted with caution, because it appeared only following removal of an extreme outlier in the data. Most patients who exhibit rightward attentional bias also exhibit the classic hemineglect deficits in left-space exploration (i.e., omissions in left space). This is supported by the finding of a strong relationship between the measures of hemispatial neglect and attentional bias. However, there are numerous cases in which patients exhibit rightward attentional bias in the absence of frank left neglect. These are patients who initiate tasks to the far right, yet who are able to move leftward and obtain overall scores that fall within the normal range.

It remains unclear whether rightward attentional bias represents a milder form of hemispatial neglect, a component of the hemineglect syndrome, or a related, but distinct, deficit. Regardless, we have previously reported that rightward attentional bias, even in the absence of deficits in left-space exploration, is associated with increased risk for wheelchair accidents (Webster, Rapport, et al., 1994). Thus, in cases in which a patient demonstrates rightward attentional bias yet performs within normal limits on measures of left-space exploration, it is advisable to carry out further investigations of hemispatial functioning to determine whether there are conditions in which deficits may appear that place the patient at greater risk.

Other indices of impairment on the Rey figure copy seen more frequently among patients with hemineglect include problems in the angular orientation of the response. Patients with hemineglect were more likely to rotate both the entire figure and separate items within the figure than were right-CVA nonneglecters, left-CVAs, and controls. It may be that the increased rotational errors seen among the hemineglecting patients in this study reflect general visuospatial impairment associated with a greater likelihood of parietal involvement (see O'Reilly, Kosslyn, Marsolek, & Chabris, 1990; Peronnet & Farah, 1989; Ratcliff, 1978). However, the notion that there may be neglect-specific problems with rotation of stimuli is not without precedent (see Rapport, Webster, & Dutra, 1994; Weinberg, Diller, Gerstman, & Schulman, 1976). In the present study, all but one of the patients producing rotational errors on the Rey figure copy also displayed attentional bias to right space. Thus, it may be that the pull of attention to right space evidenced by these patients with hemispatial deficits also results in a distortional pulling of the stimuli in that direction. Unfortunately, the issue of deficits in rotation of stimuli cannot be adequately addressed by the measures included in the present study.

Item repetitions were greater among all three patient groups than among the controls. It may be that item repetitions reflect the greater disorganization of the copy strategy seen among the brain-injured patients. Conflation errors were also more prevalent among all patient groups than among the controls. Therefore, it appears that item repetitions and conflation are general pathognomonic signs not specific to hemispatial neglect or right-hemisphere insult.

In summary, the present results indicate that clinical information comparable to that obtained from the LCT regarding hemispatial deficits can be garnered from a more detailed interpretation of the Rey figure copy. For clinicians who do not routinely administer a neglect-specific measure in their standard test battery, our system of evaluating the Rey figure offers a method of screening for hemispatial deficits without including additional tests. In many cases, the information obtained from the Rey figure copy may be useful in an adjunct manner to support or disconfirm ongoing assessment hypotheses.

RECOMMENDED CLINICAL GUIDELINES

In an effort to improve the clinical utility of the Rey figure copy, we suggest the following guidelines for interpretation of hemispatial deficits:

1. Given an asymmetric error profile (left greater than right), clear diagnosis of hemispatial neglect can be made with the presence of three or more omissions of items (33%) that are included on the left side of the Denman-scored Rey figure copy (92% correct classification). Particularly in the presence of rightward attentional bias, an asymmetric error profile containing two left-sided omissions (22%) indicates a very strong likeli-

hood of hemispatial neglect (85% correct classification; $z = -3.8$). For purposes of identifying patients at risk, we recommend adopting the latter criterion, which represents a more cautious approach to patient management.

2. The presence of attentional bias is indicated when the patient begins the figure copy by drawing any portion of the figure that is rightward of the vertical midline of the large rectangle (i.e., Denman item 16). Rightward attentional bias, even in the absence of left neglect, is a clinically important phenomenon that has been shown to be a pathognomonic marker of increased risk for accident.

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