

Effects of Parietal Lesions in Humans on Color and Location Priming

Paola Marangolo and Enrico Di Pace

Centro Ricerche di Neuropsicologia I.R.C.C.S., Rome

Robert Rafal and Donatella Scabini

VA Medical Center, Martinez, CA

Abstract

■ To determine whether the parietal lobes contribute to the selection of nonspatial features known to be processed in the ventral stream, the current study examined the effect of chronic unilateral parietal lobe lesions in humans on color and location priming. Patients and normal controls performed a go/no-go color discrimination task in which either the same color and different color pairs of stimuli (prime and probe) were projected sequentially either in the same hemifield or in

opposite hemifields. Control subjects and patients both showed independent effects of color and location priming. In the patients, primes in either field produced color priming for target probes in the ipsilesional field but not for probes in the contralesional field. This observation implicates the parietal cortex in processing activated codes of stimulus attributes not only for spatial information but also for visual features processed in the ventral visual pathways. ■

INTRODUCTION

Early in visual processing, codes for different stimulus attributes, such as location, color, and shape, are activated in parallel, as is semantic information related to the object (Posner, 1978). Code activation facilitates processing of subsequent stimuli sharing the same code. The current study addresses the neural mechanisms for visual priming—the automatic activation of codes for different stimulus features—specifically examining the role of the parietal cortex in priming of color and location information.

There is considerable evidence for two independent neural pathways involved in the processing of different visual features. The ventral occipito-temporal system is implicated in the processing of features relevant to the identification of objects, such as color or shape, and the dorsal occipito-parietal system is putatively concerned with the selection of the spatial characteristics of visual stimuli, such as their location in space, movement, and other features that afford directed action (Baizer, Ungerleider, & Desimone, 1991; Desimone & Ungerleider, 1989; Mishkin, Ungerleider, & Mackoka, 1983; Morel & Bullier, 1990; Ungerleider & Mishkin, 1982; Zeki et al., 1991; Zrenner et al., 1990). Functional distinctions between these two systems have been identified in human perception by using psychophysical (Livingstone & Hubel, 1987) and positron-emission tomography (PET) techniques (Corbetta, Miezin, Dobmeyer, Shulman, & Peter-

sen, 1991; Corbetta, Miezin, Shulman, & Petersen, 1993; 1995).

Biased competition accounts of visual attention posit that there is competition between activated feature codes and that attention biases those that are relevant to the task at hand, making them available for conscious awareness and appropriate action (Desimone & Duncan, 1995; Duncan, 1996). Attending to different features has been shown to activate the relevant feature module within the dorsal or ventral stream. For instance, differential activation of the parietal and temporal cortex occurs when subjects view moving or color stimuli respectively (Zeki et al., 1991). Similarly, Corbetta and colleagues (1991) found activation of the inferior parietal lobule when subjects were required to selectively attend to the speed of moving bars while attention to the bars' color or shape activated sites closer to the inferior surface of the brain. Attention to locations activates the superior parietal lobule (Corbetta et al., 1993, 1995).

Ultimately, the various feature codes activated in the separate streams of early vision must be integrated to provide percepts of individuated objects with specified features at particular locations. In this regard, location, by some accounts, is special among visual features (Nissen, 1985) in defining candidate objects and in conjoining features sharing the same location into unified object percepts (Treisman, 1988). In this framework, the fate of primed feature codes of shapes and colors may depend on their access to neural structures, such as parietal lobes, subserving spatial representation.

Farah, Wallace, and Vecera (1993) recently outlined a model of how the dorsal (parietal) attentional system might be engaged in feature-based selection even for features represented in the ventral visual system.

The current investigation examined the role of parietal cortex in biasing feature codes activated within ventral as well as dorsal visual pathways. It applies a priming paradigm used by different authors (Di Pace, Marangolo, & Pizzamiglio, 1997; Marangolo, Di Pace, & Pizzamiglio, 1993; Rosch, 1975; Simon, 1988). In these experiments a color prime-stimulus was followed by a color target. The pair of stimuli could either be the same color (both red or green) or a different color (red-green; green-red). Results showed a significant priming effect when both pairs of stimuli were the same color.

In the current report, this paradigm is applied to patients with lesions of the parietal cortex in order to determine the contributions of the parietal lobe to priming of color and location. The approach adapts a classic paradigm, widely used for investigating spatial attention, developed by Posner and colleagues (Posner, 1980; Posner, Walker, Friedrich, & Rafal, 1984, 1987). In their experiments, attention was directed to either visual field (while central fixation was maintained) by means of a visual cue indicating the likely location of a subsequent target. Results with normal subjects showed that the cue facilitates target detection when it corresponds to the same location (valid cue) and inhibits it when it does not (invalid cue). In parietal patients, the increase in reaction times (RTs) found for the invalid trials was larger for contralesional than for ipsilesional targets (Posner et al., 1984, 1987). Posner and colleagues suggested that parietal lesions cause a specific deficit in disengaging attention from ipsilesional events impeding shifts of attention toward contralesional events and that this deficit contributes to the clinical extinction seen in the hemispatial neglect syndrome (Morrow & Ratcliff, 1988). This result has been confirmed in a number of studies using the same paradigm (Baynes, Holtzman, & Volpe, 1986; Petersen, Robinson, & Currie, 1989; Posner et al., 1984, 1987; Posner & Petersen, 1990) and in other paradigms using feature and conjunction visual search tasks (Eglin, Robertson, & Knight, 1989).

The current work examined both color and location priming in neurological patients to investigate the role of the parietal cortex in the selection of a nonspatial feature (color) known to be processed in the ventral stream. To achieve this goal, subjects performed a color priming experiment in which both same-color and different-color pairs of stimuli were projected sequentially either in the same position (same hemifield) or one in the right and the other in the left hemifield and vice versa (see Figure 1). This comparison constituted a measure of any performance cost in shifting attention from one object to another located in a different spatial position (Posner, 1980).

In a standard color priming procedure, subjects were

instructed to perform a go/no-go task. They pressed a button in response to a red or green target but not in response to a blue one. The association of two colors with a particular response allowed us to dissociate a purely color priming effect from a bias at the response level. In fact, the comparison between Same-Color (i.e., red-red; green-green) and Different-Color trials (i.e., red-green; green-red) indicated whether the priming effects were produced independently of a motor activation component at the response selection level because the prime stimuli were associated with the same response in the two conditions; the comparison between the Different-Color (red-green; green-red) and Irrelevant-Prime trials (blue-red; blue-green) indicated whether a purely motor component contributed to the priming effect. In the first experiment normal individuals were tested. The second experiment studied neurological patients with unilateral right or left posterior association cortex lesions, including the parietal lobe.

EXPERIMENT 1A. CONTROLS

Experiment 1a verified that the stimuli used produced a color priming effect in normals (Di Pace et al., 1997; Marangolo et al., 1993; Rosch, 1975; Simon, 1988) and determined whether the spatial position of the stimuli interacted with a color priming effect.

Results and Discussion

Mean RTs for the correct responses were submitted to a $2 \times 2 \times 2 \times 3$ analysis of variance (ANOVA) for repeated measures with Color (red, green), Target field (left, right), Spatial Priming (same position, different position), and Color Priming (same color, different color, irrelevant prime) as factors. The overall error rate was very low ($< 1\%$).

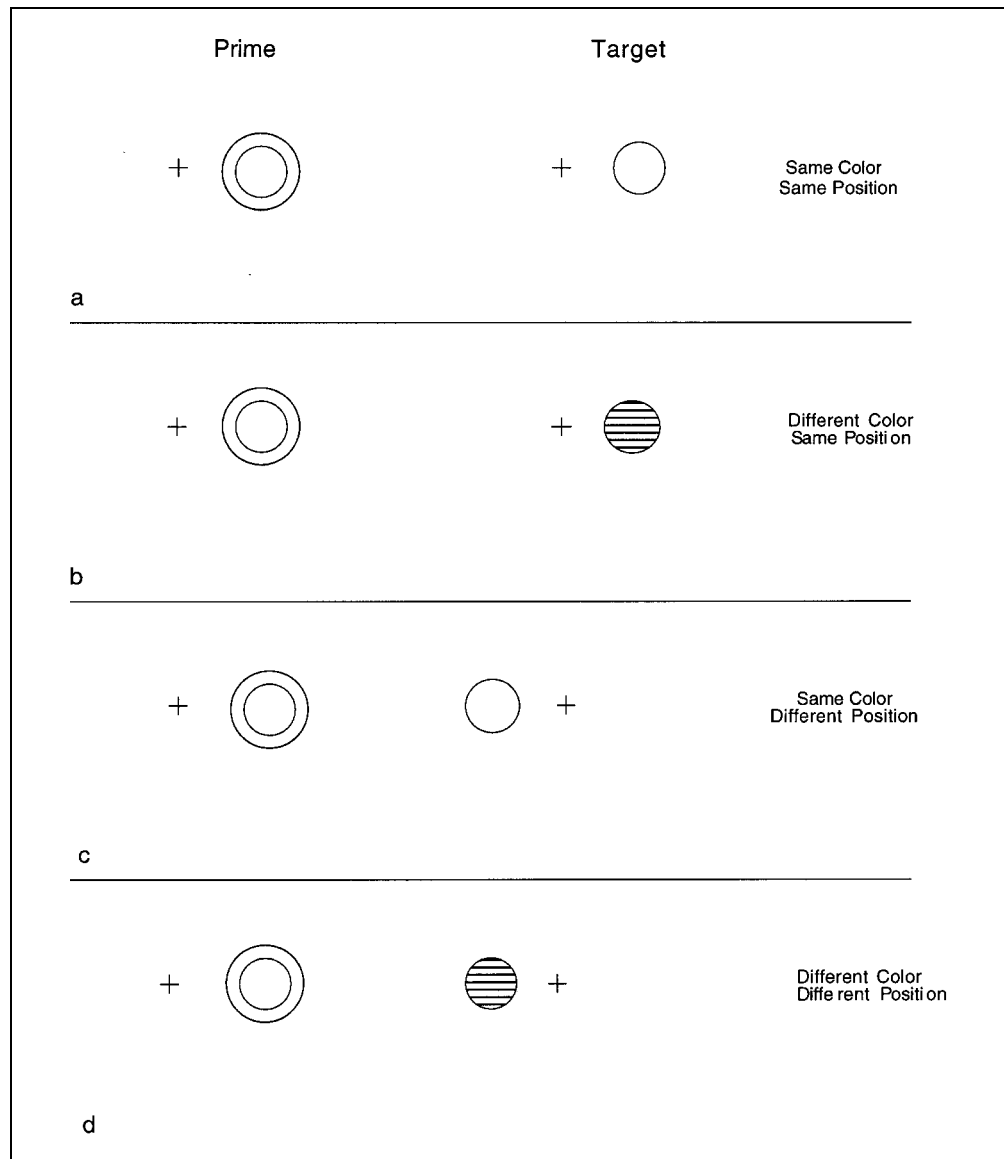
The analysis showed a significant main effect of Color Priming, $F(2, 18) = 20.558, MSE = 5755.74, p < 0.01$. RTs for Same-Color trials were 48 msec faster (359 msec) than Different-Color trials (407 msec), which in turn were 28 msec faster than Irrelevant-Prime trials (435 msec) (see Figure 2).

The main effect of Spatial Priming was also significant, $F(1, 9) = 24.538, MSE = 978.08, p = 0.001$. When prime and target were in the same position, responses were 20 msec faster (391 msec) than when the two stimuli were in different positions (411 msec) (see Figure 3).

No other effect or interaction approached significance.

The data provide evidence for two independent components of visual priming: a feature-based component involved in color processing and a location-based component involved in the elaboration of the spatial localization of the stimuli (Kingstone, 1992; Maljkovic & Nakayama, 1996; Posner, 1980; Tanaka & Shimojo, 1996; Treisman, 1988; Treisman & Gelade, 1980). The next ex-

Figure 1. Instances of prime-target pairs varied as a function of color relation and spatial position.



periment further investigated the contribution of the parietal cortex in the selection of these components, specifically to determine whether deficits of spatial attention from parietal lobe injury affect color priming.

EXPERIMENT 1B. PATIENTS

The purpose was to investigate whether there are any differences in feature and location-based components of visual attention after parietal injury. The two groups of patients selected had either right- or left-hemisphere lesions in the posterior association cortex, including the parietal lobe.

Three potential outcomes were possible:

1. A Color Priming and a Spatial Priming effect would be observed in both groups of patients. If different mechanisms are involved in attending to color and loca-

tion, and if the parietal lobe plays no special role in biasing color representations, no interaction between these two object's features should be observed.

2. A significant interaction between Color Priming and Target Field. Any difference in the amount of color priming between contralesional and ipsilesional hemifields would indicate a role of the parietal lobe in the selection of a nonspatial feature.

3. It was also expected that there would be a significant interaction between Spatial Priming and Target Field, based on a number of previous studies of location priming in patients with parietal lesions. Some of these studies indicated that we might expect the costs of disengaging attention from the ipsilesional field to be greater in patients with right-hemisphere lesions than those with left hemisphere lesions (Morrow & Ratcliff, 1988).

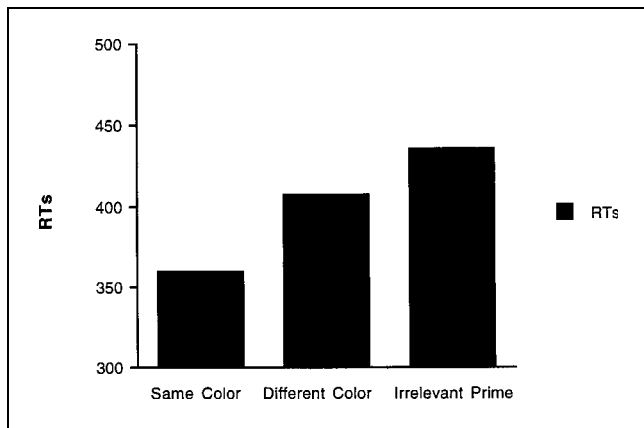


Figure 2. Color priming effects in normal subjects (Experiment 1a).

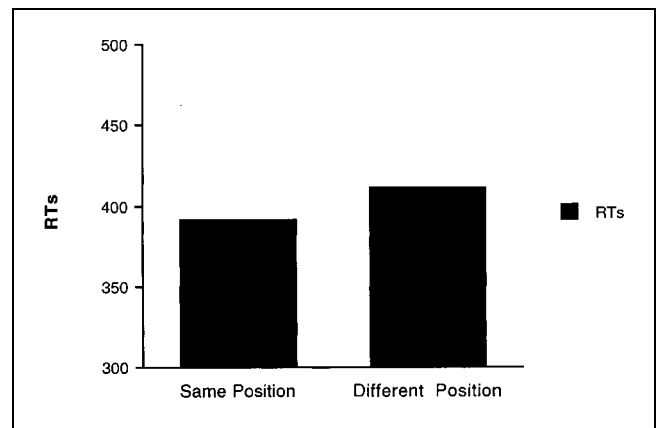


Figure 3. Spatial priming effects in normal subjects (Experiment 1a).

Results

A preliminary analysis showed the presence of a Color Priming effect. Just as in normal subjects, RTs to Same-Color were faster (614 msec) than Different-Color trials (669 msec), which in turn were faster than Irrelevant-Prime trials (719 msec).

As mentioned previously, the comparison between Same-Color and Different-Color trials indicated the presence of a Color Priming effect that was independent of a motor component at the response level, whereas the comparison between Different-Color and Irrelevant-Prime trials only isolated the motor component of the effect. Because we were mainly interested in the elaboration of the color dimension, RTs to Irrelevant-Prime trials were not included in the subsequent analysis.

Mean RTs for correct responses were analyzed in a five-way mixed ANOVA. Side of Lesion (Right, Left) was a between-subjects factor. The within-subjects factors were Color (Red, Green), Target Field (Ipsilesional, Contralesional), Spatial Priming (Same Position, Different Position), and Color Priming (Same-Color, Different-Color).

The overall error rate was very low (1.5%). The analysis confirmed a significant main effect of Color Priming, $F(1, 10) = 16.797$, $MSE = 8409.197$, $p < 0.0025$. RTs for Same-Color trials were 55 msec faster (614 msec) than Different-Color trials (669 msec) (see Figure 4).

The main effect of Spatial Priming approached statistical significance, $F(1, 10) = 3.967$, $MSE = 26394.398$, $p = 0.07$. When prime and target were in the same position, responses were 47 msec faster (618 msec) than when the two stimuli were in different positions (665 msec) (see Figure 5). This trend was present in 10 out of 12 patients (see Table 1).

The difference in RTs for targets appearing in the ipsilesional (630 msec) and contralesional (651 msec) fields did not approach statistical significance ($F(1, 10) = 0.612$, $MSE = 40129.044$, $p = 0.45$). Slower RTs for contralesional targets were observed in only 4 out of 12 patients. Furthermore, the difference in the effects of spatial priming in the ipsilesional (42 msec) and contralesional field (53 msec) did not approach significance ($F(1, 10) = 0.068$, $MSE = 20007.939$, $p = 0.79$). Only 3 out of 12 patients showed greater costs for invalid cues

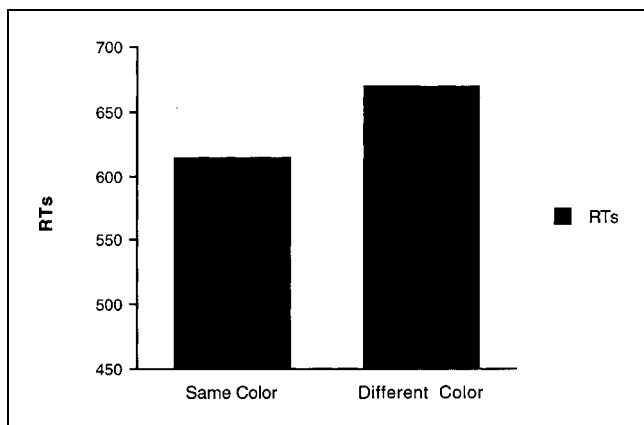


Figure 4. Color priming effects in parietal lesion patients (Experiment 1b).

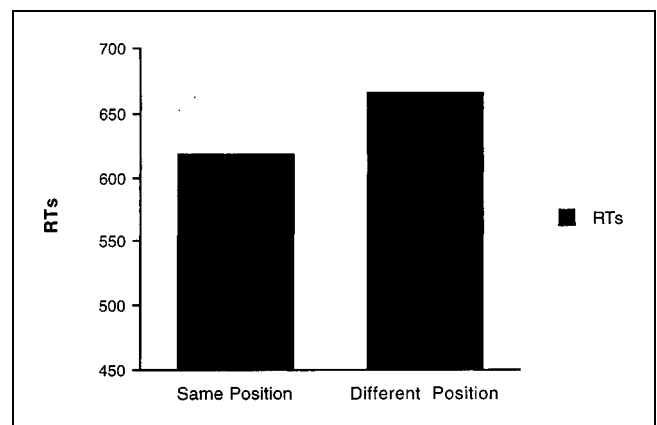


Figure 5. Spatial priming effects in parietal lesion patients (Experiment 1b).

Table 1. Individual Mean RTs for Same and Different Position Trials in Experiment 1b

<i>Patients</i>	<i>Same position</i>	<i>Different position</i>
Right lesions		
K.T.	618.96	641.80
L.P.	525.96	512.06
R.S.	527.62	558.38
J.W.	453.18	486.72
H.T.	734.04	751.80
S.D.	1043.27	1216.06
D.D.M.	708.69	969.62
Left lesions		
R.A.	474.25	510.51
M.K.	559.38	604.00
J.G.	697.03	739.24
L.L.	599.85	608.39
V.D.N.	553.24	520.50

for contralesional than for ipsilesional targets, and of these three, only one had both slower contralesional RTs overall and slower RTs for contralateral targets that could be attributed to an impairment in disengaging from ipsilesional cues (see Table 2).

There was a significant interaction between Color Priming and Target Field, $F(1, 10) = 8.321$, $MSE = 3347.122$, $p < 0.02$. In fact, although RTs to Same-Color trials were faster in the ipsilesional (590 msec) than in the contralesional hemifield (638 msec), RTs to Different-Color trials did not differ from each other (670 versus 668 msec, respectively; see Figure 6). In terms of color priming, this result indicates a stronger facilitation effect in the ipsilesional (80 msec) than in the contralesional (30 msec) hemifield.

The color priming effects for each patient in the ipsilesional and contralesional hemifields (for same and different position, respectively) are shown in Table 3.

Discussion

Results of Experiment 1b in patients confirmed some of the main findings in normal subjects (Experiment 1a). Just like the normal subjects, both groups of patients showed a Color Priming effect. Furthermore, there was a trend toward the presence of a Spatial Priming effect.

Our major finding was a significant two-way interaction between Color Priming and Target Field that showed a decrease in the amount of color priming for

Table 2. Individual Mean RTs for Same and Different Position Trials in Experiment 1b as a Function of the Side of the Target

<i>Patients</i>	<i>Ipsilesional</i>		<i>Contralesional</i>	
	<i>Same position</i>	<i>Different position</i>	<i>Same position</i>	<i>Different position</i>
Right lesions				
K.T.	633.4	656.9	604.5	626.7
L.P.	539.5	518.6	512.4	505.5
R.S. ^a	529.3	599.1	525.9	517.7
J.W.	455.6	458.1	450.8	515.3
H.T.	732.8	753.9	735.3	749.7
S.D. ^a	955.5	1163.8	1131.1	1268.3
D.D.M.	667.3	703.6	750.1	1235.7
Left lesions				
R.A. ^a	460.8	530.3	487.7	490.7
M.K.	554.9	618.3	563.8	589.7
J.G.	699.4	744.4	694.6	734.1
L.L.	581.7	596.4	618	620.4
V.D.N.	569.5	553.3	536.9	487.7

^a Patients with TPJ.

Table 3. Interaction Between Side of Target and Size of Color Priming Effect, for Same and Different Positions, Respectively, Shown Separately for Each Patient in Experiment 1b. Effects are calculated by subtracting Same Color condition RTs from Different Color RTs. Negative values indicate the absence of this effect.

Patients	<i>Side of the target Ipsilesional</i>		<i>Side of the target Contralesional</i>	
	<i>Same position</i>	<i>Different position</i>	<i>Same position</i>	<i>Different position</i>
Right				
K.T.	46	48	28	63
L.P.	68	39	32	-6
R.S.	71	4	-21	39
J.W.	93	67	48	144
H.T.	129	193	78	117
S.D.	-33	169	-96	-123
D.D.M.	96	43	76	-160
Left				
R.A.	75	134	31	-42
M.K.	43	156	119	53
J.G.	19	30	11	-23
L.L.	67	94	44	55
V.D.N.	117	116	120	89

targets in the contralesional hemifield. This was true for primes in both fields: Both ipsilesional and contralesional primes were effective in priming ipsilesional targets, whereas neither ipsilesional nor contralesional primes were effective in priming contralesional targets.

This effect cannot be attributed to a perceptual deficit in color processing: Colors presented in the contralesional field primed responses to ipsilesional targets (in this condition, the priming effect was 98 msec), so the color of the prime was clearly processed in the contralesional field and the deficit was not caused by a lack of activation of color codes by the prime. The absence of a difference between the mean RTs in the two “different-color” conditions in the ipsilesional and contralesional fields, also excludes an explanation in terms of a disengagement deficit from color (see Figure 6).

On the other hand, the effects on color priming do not simply reflect some kind of response bias. As previously mentioned, statistical analyses were performed only on those trials that were free of a bias at the response level. As a consequence, no variation in the amount of color priming can be explained in terms of response bias. Therefore, although parietal lesions do not impair early selection for perceptual processing and seem to act at a later level, the effect occurs before the selection of the response. Our suggestion is that the lack of color priming observed in the contralesional hemifield is due to a deficit in the attentional mecha-

nisms that allow target processing to be biased by information activated by the prime. Hence, color features in the contralesional field activate priming, but targets in the same field do not benefit from priming.

GENERAL DISCUSSION

The aim of the present work was to investigate the role of the parietal lobes in the selection of a feature, such

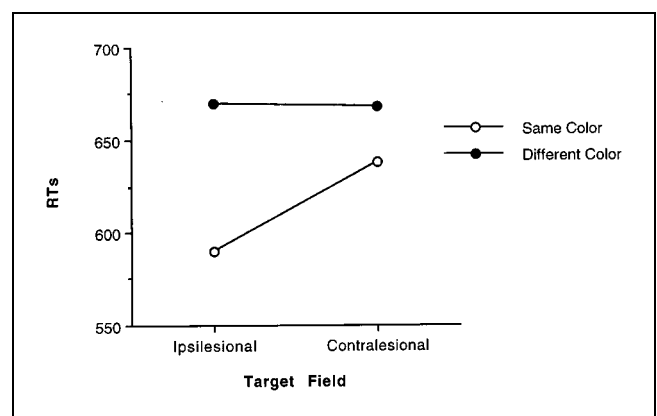


Figure 6. Color priming effects as a function of target field in Experiment 1b. Open circles refer to same-color trials; filled circles refer to different-color trials.

as color, with no intrinsic spatial information. Four conclusions can be drawn from our data:

1. Both normal individuals and patients with parietal lesions showed independent priming effects for color and location.

2. In the patients, primes presented in the contralesional field produced as much color priming for targets in the ipsilesional field as did primes presented in the ipsilesional field.

3. There was a significant decrement in color priming for targets appearing in the contralesional field. This effect was observed irrespective of lesion side and of whether the prime was in the ipsilesional or contralesional field.

4. The lack of benefit from color priming for contralesional targets occurred in the absence of any disengagement deficit for location or for color.

Independence of Color and Location Priming

Our evidence for independent mechanisms for priming of color and location codes, reported here, converges with results of other attentional studies with normal subjects using discrimination tasks (Maljkovic & Nakayama, 1994, 1996; Tanaka & Shimojo, 1996). The studies of Maljkovic and Nakayama (1996) and Robertson (1996) showed that the location and color of stimuli in a search task primed the subsequent processing of those features and that these priming effects were independent of one another.

Generation of Color Priming in the Contralesional Field

Patients tended to be slower to detect contralesional targets, and this was quite pronounced in some patients. Nevertheless, primes in the contralesional field produced color priming for targets appearing in the ipsilesional field, indicating that color codes were generated as effectively by contralesional as by ipsilesional primes. This observation converges with a now extensive literature for implicit processing of visual information in the field that is contralesional to parietal lobe lesions. Even in the absence of awareness of the contralesional stimulus, information about it can be fully processed up to a semantic level of analysis (McGlinchey-Berroth, Milberg, Verfaellie, Alexander, & Kilduff, 1993). Two previous studies, using a flanker task, have demonstrated that colors in the contralesional field may activate their associated response channels as effectively as ipsilesional flankers (Audet, Bub, & Lecours, 1991; Cohen, Ivry, Rafal, & Kohn, 1995). Because parietal lesions did not impair the activation of color codes from contralesional stimuli, color priming appears to be generated within the ventral stream in which color information is processed.

Impaired Contralesional Color Priming

The salient new finding of the current study was a decrement in the amount of color priming for targets presented in the contralesional hemifield. Because, as just discussed, parietal lesions did not prevent the generation of priming of contralesional color codes, this finding is consistent with the hypothesis that the parietal cortex is a neural substrate for attentional processes involved in the representation of an object's attributes in a form that can bias subsequent perception and transduce perception into action (Farah et al., 1993; Goodale & Milner, 1992). Importantly, the current results indicate that the role of the parietal cortex in processing activated codes of stimulus attributes to bias subsequent to perception and behavior is not limited to spatial information, but also applies to visual features processed in the ventral visual pathways.

This conclusion contrasts with the more conventional view that the dorsal pathway is specialized for processing, and attending to, spatial information. The clearest evidence of an involvement of the dorsal pathway in a location-based attentional system comes from studies of patients with unilateral parietal damage. Patients with neglect are unable to detect or to respond to stimuli in the space contralateral to the lesion. Now, there is growing evidence that the spatial reference frame can be object based as well as based on the retinotopic or environmental reference frame. Nevertheless, hemispatial neglect from right parietal lobe lesions is inherently a spatial deficit; that is, it is the left side of something that is neglected whether it is the left visual field, the left side of egocentric space, or the left side of an object (Behrmann & Moscovitch, 1994; Behrmann & Tipper, 1994; Driver & Halligan, 1991; Driver, Baylis, Goodrich, & Rafal, 1994; Hillis & Caramazza, 1991; Ladavas, 1987).

There is evidence from a number of sources that the parietal lobe may also play a role in attending to object representations independently of any spatial reference frame. Patients with Balint's syndrome due to bilateral parietal lesions dramatically illustrate that parietal lesions severely impair the simultaneous processing of competing information between objects that share the same retinal location (see Rafal, in press, for a review). For example, Luria (1959) systematically explored the issue of what constitutes an object for a patient with Balint's syndrome. Shown a six-pointed star made up of two outlined triangles drawn in a single color, Luria's patient saw a star. When the two triangles were drawn in different colors, the patient saw only one triangle. When shown two adjacent circles, the patient saw only one of them; yet, when the two circles were connected by a line, the patient saw a single object (a dumbbell or spectacles). Using a similar approach, Humphreys and Riddoch (1991) provided elegant experimental evidence

demonstrating the object-based restriction of attention in Balint's syndrome and the principles operating in early vision for generating objects for attentional selection. Two patients were shown 32 circles that were all red, all green, or half red and half green. The task was simply to report whether each display contained one or two colors. The critical test was when the displays contained two colors. In one condition, the spaces between the circles contained randomly placed black lines. In two other conditions, the lines connected either pairs of same-colored circles or pairs of different-colored circles. Both patients were better at correctly reporting the presence of two colors when the lines connected different-colored pairs of circles. Circles connected by a line were perceived as a single object (e.g., as a dumbbell). When each object contained both red and green, the patient was able to report the presence of the two colors. When the lines connected same-color circles so that each object contained only a single color, only one color was perceived. These results cannot be interpreted only by an explanation in terms of damage to a location-based component of attention; it seems likely that the dimensions of the other object interact with the subject's inability to attend to visual stimuli.

Jakobson, Archibald, Carey, and Goodale (1991) provided further demonstrations of the role of the parietal cortex in the selection of an object's features. In their study, a patient who had recovered from Balint's syndrome was unable to use information about the size, shape, and orientation of objects to control the posture of his hand and fingers during a grasping movement even though he could use this same information to identify and describe these same objects. Therefore, it was not only the spatial location of the object that was apparently inaccessible for controlling movement in this patient, but the intrinsic characteristics of the object as well.

In a study comparing patients with unilateral lesions of the left and right posterior association cortex, Egly, Driver, and Rafal (1994) showed that the patients with left-hemisphere lesions exhibited a deficit in shifting attention between objects, whereas those with right-hemisphere lesions had a deficit only in shifting attention between locations. Confirmation of a left-hemisphere specialization for shifting attention between objects was also provided by a study in a split brain patient (Egly, Rafal, Driver, & Starreveld, 1994). Nevertheless, there is recent evidence that patients with hemispatial neglect due to right parietal lesions also have an impairment in disengaging attention from objects independent of location. Husain, Shapiro, Martin, and Kennard (1997) have shown that right parietal lesions causing hemispatial neglect cause a disorder in the temporal, as well as spatial, regulation of attention in which patients are slow to disengage attention from one object to process a succeeding object at the same location—

even under conditions in which all stimuli were presented at fixation.

In the current study, the deficit in contralesional priming of color was manifest in both right- and left-hemisphere lesioned patients. Thus, it provides further evidence that both right and left parietal lobes are involved in attending to nonspatial attributes of visual stimuli.

Lack of an Extinctionlike RT Pattern (Disengage Deficit)

One unexpected result of the current study was that it failed to replicate the "extinctionlike-RT pattern" described by Posner and colleagues (1984, 1987); this has been seen in several other studies and laboratories besides ours (Friedrich, Egly, Rafal, & Beck, in press; Morrow & Ratcliff, 1988; Petersen et al., 1989). Only 1 out of 12 patients in the current study had a pattern of results consistent with an extinctionlike RT pattern, and given the degree of variability in the data, no special significance can be attached to the results of any single patient. Because several of the patients in the current study were also participants in a recent study in which a disengage deficit was observed in patients with lesions involving the temporo-parietal junction (TPJ, including area 22) (Friedrich et al., in press), the failure to observe this pattern in the current study cannot be attributed to patient selection criteria. Even those patients who had lesions in the TPJ and who showed the extinctionlike-RT pattern in the work of Friedrich and colleagues did not show this pattern in the current study (see Table 2).

We must then look to difference in task requirements as a possible explanation for the failure to replicate this ordinarily very robust lesion effect. In all previous studies demonstrating an extinctionlike-RT pattern in patients with parietal lesions, the task has involved a simple manual RT response on detecting a suprathreshold target. This study differed from previous patient work by employing a go/no-go discrimination task. In the current task, there was only a short interval between the cue and the target (this was selected because a previous study have found the most robust extinctionlike-RT pattern at short cue-target intervals), and the emphasis of task requirements on discriminating color may have eliminated the emphasis on localizing the target that is implicit in detection tasks. Nevertheless, a significant spatial cueing effect of 47 msec was observed, so it is clear that the lack of an extinctionlike-RT pattern cannot be attributed to a failure of the cues to produce a spatial orienting effect. At this point, it remains unclear whether the failure to replicate the extinctionlike-RT pattern in the current study was due to the perceptual or motor requirements of the go/no-go discrimination task used here or to some other factors. What is clear is that the deficit in color priming in the contralesional field shown

here is independent from the “disengagement deficit” inferred by the extinctionlike-RT pattern found in detection tasks.

METHODS

Experiment 1a. Controls

Subjects

Three male and seven female subjects, ranging from 25 to 40 years of age, participated in the experiment. All subjects reported being right handed and having normal or corrected-to-normal vision.

Apparatus

An IBM computer generated the stimuli and recorded the RTs. The screen was located 57 cm away from the subjects.

Stimuli and Conditions

Four blocks of 144 pairs of stimuli were used. Prime stimuli consisted of colored rings; dimensions were 1.2 cm for the inner edge (subtending a visual angle of 1.2°) and 2.5 cm for the outer one (2.5° of visual angle). Target stimuli consisted of colored dots, 1.2 cm in diameter. The colors of both stimuli were red, green, or blue. The luminance of the three colors was 15.2 cd/m². They were generated using the graphic instructions of the

MEL program (Schneider, 1988). The stimuli were presented against a gray background with a luminance of 1.9 cd/m². Each stimulus could be presented 4.6° either to the right or to the left of the fixation point.

In each block, the prime and the target appeared in the same position in 75% of the trials (valid cue) and in a different position in 25% of the trials (invalid cue). They were the same color in 66% of the trials (same-response, same-color; i.e., red-red; green-green; blue-blue) and a different color in 34% of the trials (same-response, different-color; i.e., red-green; green-red; Irrelevant-Prime trials: different-response, different-color; blue-red; blue-green). The levels of the 4 variables (color, target field, spatial priming, and color priming) were randomized according to the described percentage in each block. The 144 pairs of stimuli were randomly presented in each block.

Procedure

Each trial began with a display containing a fixation cross located in the center of the screen. After 1000 msec the prime stimulus appeared for 100 msec. After an interval of 200 msec, the target stimulus was presented until the subject made a response, up to 2000 msec. Following each response, a visual feedback indicated response accuracy, and after 1000 msec the next trial began.

Subjects had to perform a go/no-go task; they were instructed to press the space bar on the computer key-

Table 4. Clinical Data for Patients in Experiment 1b

Patient	Age (years)	Sex	Lesion				Clinical signs ^{a,b}				
			Hemisphere	Cause	Volume	Vintage	Par.	Sen.	Neg.	Ext.	Aph.
K.T.	47	F	Right	Astrocytoma	46.3 cc	1975	-	-	-	-	-
L.P.	71	M	Right	Vascular	6.1 cc	1992	-	-	-	-	-
R.S.	50	M	Right	Vascular	80.1 cc	1991	-	+	-	-	-
J.W.	74	M	Right	Vascular	25.5 cc	1986	-	-	-	-	-
H.T.	83	M	Right	Vascular	7.9 cc	1993	-	-	-	-	-
S.D.	60	F	Right	Vascular	83.2 cc	1994	+	+	+	+	-
D.D.M.	71	M	Right	Vascular	98.4 cc	1991	-	-	-	-	-
R.A.	64	M	Left	Vascular	71.1 cc	1991	-	-	-	-	+
M.K.	50	M	Left	Trauma ^c	33.4 cc	1968	-	-	-	-	+
J.G.	64	M	Left	Vascular	3.8 cc	1993	-	-	-	-	-
L.L.	66	M	Left	Vascular	51.8 cc	1992	-	-	-	-	+
V.D.N.	69	M	Left	Vascular	17.6 cc	1992	-	-	-	-	+

^a At time of testing.

^b Par = hemiparesis; Sen = hemisensory deficit; Neg = visual hemineglect; Ext = visual extinction; Aph = aphasia; M = male; F = female.

^c Shrapnel wound.

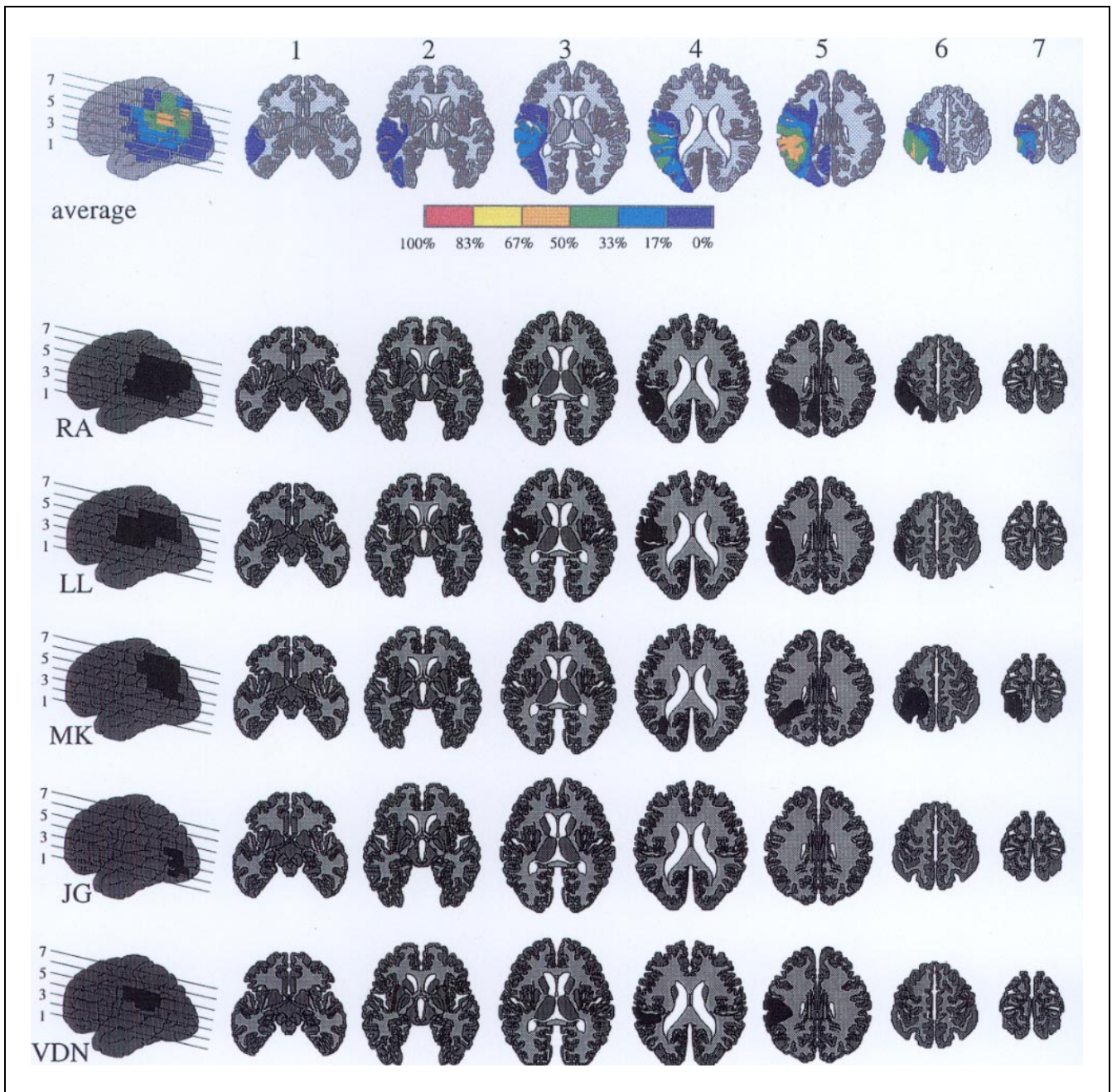


Figure 7a. Neuroimage reconstructions are shown for each patient: patients with left-hemisphere lesions are shown in Figure 7a and those with right-hemisphere lesions in Figure 7b. The top row in Figure 7a shows the averaged lesion extent in all patients with all lesions reflected onto the left. The scale refers to the percentage of patients with lesions in that area. The lines on the lateral reconstruction indicate corresponding axial cuts.

board as rapidly as possible only when the target was red or green and not to press it when it was blue. They were instructed to maintain fixation throughout each trial. The experimenter used a camera to monitor eye positions. Before the experimental blocks, subjects were trained with a block of practice trials that they performed until they felt confident with the experimental requirements.

Experiment 1b. Patients

Subjects

Twelve patients with unilateral lesions of the posterior association cortex, including the parietal lobe, were selected. Only one patient had clinical manifestations of neglect. All had previously participated in a variety of neurobehavioral research studies. They ranged in age

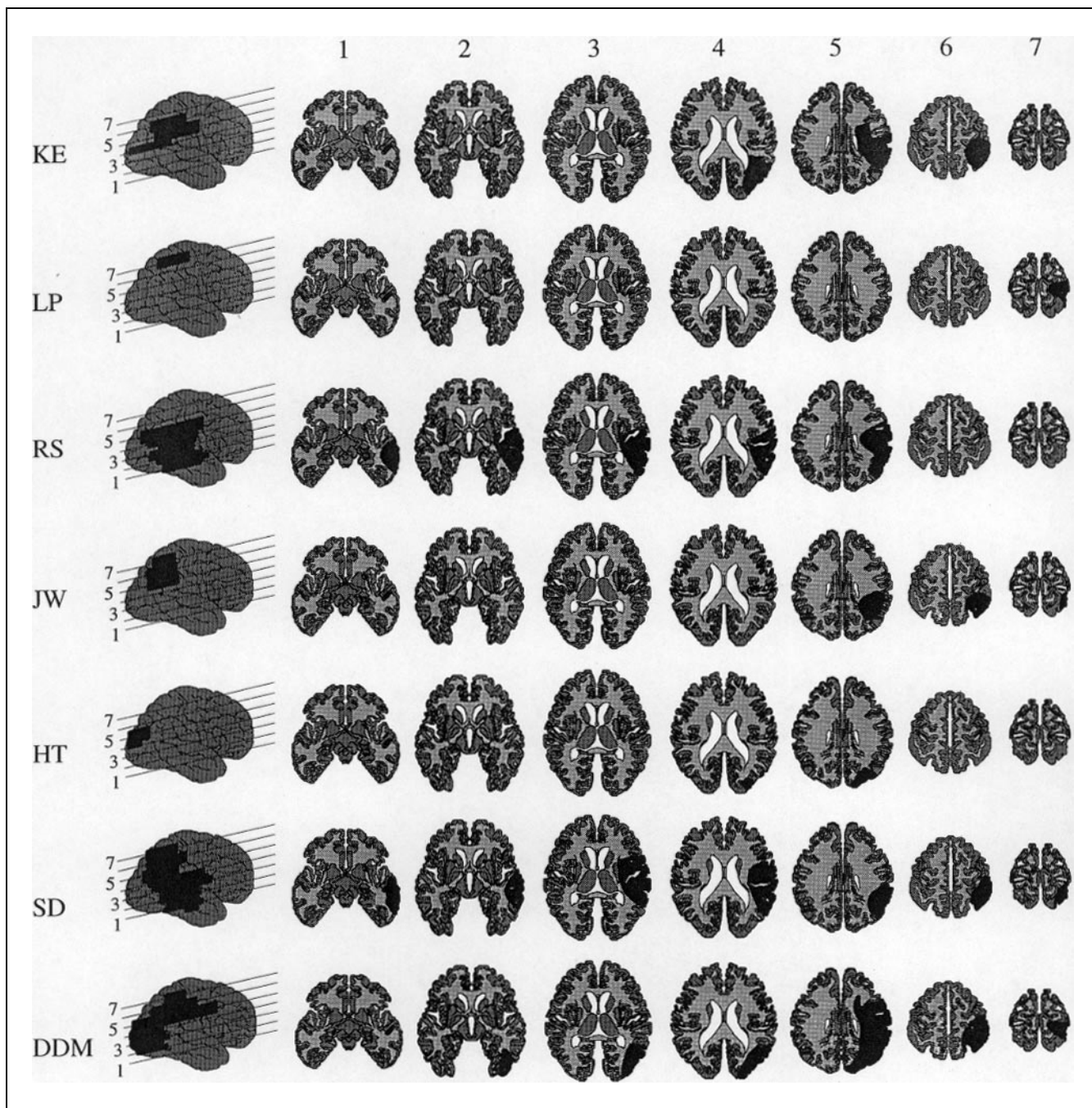


Figure 7b. See Figure 7a caption for details.

from 47 to 83 years. In seven patients the lesion was in the right hemisphere and in five it was in the left hemisphere. Table 4 provides clinical information about the patients in each group.

Neuroimaging reconstructions of each patient's lesion are shown in Figures 7a and b. The method for reconstruction from the magnetic resonance imaging or computed tomography scans is described by Frey, Woods, Knight, and Scabini (1987).

Stimuli and Procedure

The stimuli and procedure for Experiment 1b were identical to those of Experiment 1a.

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Reprint requests should be sent to Paola Marangolo, Centro Ricerche, I.R.C.C.S. Clinica St. Lucia, Via Ardeatina 306, 00179 Rome, Italy, or via e-mail: Marangolo@Uniroma1.it.

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