

# PERCEIVING LEFT AND IMAGINING RIGHT: DISSOCIATION IN NEGLECT

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## ABSTRACT

Signor Piazza, a patient with a left parieto-occipital haemorrhage and a right thalamic stroke, showed severe right personal neglect (e.g. touching own body parts) and right perceptual neglect in tasks with (e.g. cancelling tasks) or without (e.g. description of a complex picture) motor response. He had also right-sided neglect dyslexia (including single words), without language impairments. However, the patient also presented with a clear left-sided deficit in the representational domain (e.g. imagery tasks). Signor Piazza's pattern of performance suggests dissociation between imagery and perception within the neglect syndrome.

Key words: neglect, visual imagery, stroke, dissociations

## INTRODUCTION

Neglect is not a monolithic entity (Stone, Halligan, Marshall et al., 1998; Robertson and Halligan, 1999). It encompasses different syndromes affecting the perceptual domain (in tasks with or without motor response), the personal domain, i.e. the negligence of one's body parts, or the representational domain (defined as the inability to retrieve information by means of visual imagery, Bisiach and Luzzatti, 1978). Left-sided neglect is more frequent (Kinsbourne, 1987; Bisiach, Capitani, Luzzatti et al., 1981; Mesulam, 1981), severe and long-lasting (Halligan, Marshall and Wade, 1989; Stone, Wilson, Wroot et al., 1991) than right-sided neglect. However, cases of right perceptual neglect have been observed (e.g., Angelelli, De Luca and Spinelli, 1996), particularly in the acute stage of their illness (Halligan et al., 1989; Stone, Halligan and Greenwood, 1993; Bartolomeo, D'Erme and Gainotti, 1994). One case of right personal neglect has also been described (Peru and Pinna, 1997).

Although neglect often affects more than one domain in a single patient (Bisiach and Luzzatti, 1978; Bisiach, Perani, Vallar et al., 1986; Bartolomeo, D'Erme and Gainotti, 1994), patients have been described whose only deficit was in the perceptual domain, whilst other forms of neglect were absent (Bartolomeo et al., 1994; Anderson, 1993; Coslett, 1997; Cantagallo and Della Sala, 1998). Patients showing isolated left representational neglect have also been reported (Coslett, 1997; Guariglia, Padovani, Pantano et al., 1993; Beschin, Cocchini, Della Sala et al., 1997), pointing to a dissociation between perceptual

and representational neglect and challenging the suggestions of a common neuronal or cognitive substrate for modality-specific perception and imagery (Goldenberg, 1998; see also Marshall and Halligan, 1993).

We report the unique case of a patient without language impairments, who not only showed a severe and long-lasting right perceptual and personal neglect but also a left representational neglect.

#### CASE REPORT

Signor Piazza (fictitious name), a 67-year-old right-handed man with 8 years of education, suffered a posterior left-hemisphere haemorrhage in October 1996. He was and always had been right-handed and denied consanguinity for left-handedness. He scored 100% right-handed on the Edinburgh Handedness questionnaire (Oldfield, 1971), and scored + 20 (cut off for right handers = + 9) on Annett's 12-question handedness inventory (Annett, 1967). He did not present with any overt neurological signs (though at onset right hemianopia could not be ruled out with certainty), in particular he did not show proprioceptive or tactile defects in his right arm nor did he show deficits of eye movements. However, his wife reported that soon after his left haemorrhage, he started to bump into obstacles on his right and she noticed that he never combed the right side of his hair. He was referred to the Aphasia Unit of the University of Milan because of his persistent "reading" difficulties. He did not undergo any kind of rehabilitation. We assessed the patient a year later. A series of CT and MRI scans performed at the time of our assessment confirmed the sequelae of the left parieto-occipital haemorrhage but also showed a right thalamic ischemic stroke (Figure 1). Table I shows the summary of the patient's general neuropsychological examination.

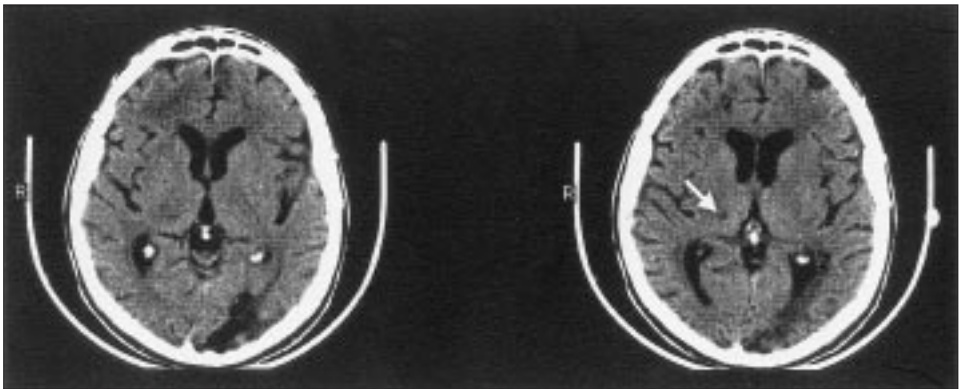


Fig. 1 – Signor Piazza's CT scan showing the left parieto-occipital haemorrhagic lesion and the right thalamic ischemia (indicated by the white arrow).

A standardised neuropsychological assessment (Spinnler and Tognoni, 1987; Novelli, Papagno, Capitani et al., 1986; Folstein, Folstein and McHugh, 1975; Measso, Cavarzeran, Zappalà et al., 1993) demonstrated that he was oriented to time and space, showed no global deterioration, no abstract reasoning difficulties and no verbal short or long-term memory defects. His language showed no impairment on the Standard Language Examination (Ciarli, Marangolo and Basso, 1996) except for reading and copying (neglect dyslexia). The few mistakes that he made in performing the Token Test (De Renzi and Faglioni, 1978) could be accounted for in terms of his right perceptual neglect; for example in item 16 (touch the red circle and the green square) he touched the red circle (which is on the left side of the array) but failed to find the green square (which is on the right side of the array),

TABLE I  
*Signor Piazza's General Neuropsychological Examination Scores Adjusted for Age and Education*  
*(Spinnler and Tognoni, 1987)*

Test (score range)	Signor Piazza's scores	Controls' cut off
Global assessment		
Mini Mental State (0-30)	24.50	23.80
Verbal Abstract Judgements (0-60)	54	32
Attention		
Visual search (0-60)	51.5	30
Memory		
Digit span (0-10)	4.25	3.50
Prose Memory Test (0-16)	9.50	7.50
Word Lists Learning (0-18)	13.4	5.50
Verbal comprehension		
Token Test (0-36)	22	29
Fluency		
Semantic Fluency (0-34)	8*	9
Phonemic Fluency (0-17.5)	11*	16

\* Performance below the cut off score.

maintaining that: "there is not a green square among these tokens". He scored below cut-off in letter and category fluency tasks (Novelli, Papagno, Capitani et al., 1986). In the Milan Acalculia Test (Basso and Capitani, 1979) he performed flawlessly on a few easy items which were presented on the left-side of the testing sheet, but refused to complete the task on the basis that he "could not see well" the other problems presented to him. Although he never showed any face or object recognition problems in everyday life and he passed the screening test, his scores were pathological in all the nine subtests of Visual Object and Space Perception test battery (Warrington and James, 1991). However, a careful analysis of his errors revealed that they were mostly interpretable in terms of right spatial neglect. For instance, in counting the dots, he ignored some of the items on the right side; similarly in multiple-choice arrays he showed a clear position preference for the left responses.

## ASSESSMENT OF NEGLECT

### *Extinction*

The patient's ability to detect double simultaneous stimuli was assessed with a clinical test of extinction (Cocchini, Cubelli, Della Sala et al., 1999). In single presentation trials, he performed at ceiling both in the right and left space in all modalities. In double simultaneous presentation, he showed visual extinction (missing 30% of the stimuli on the right) and some signs of auditory extinction (missing 90% on the right) but no tactile extinction.

### *Perceptual Neglect*

The patient's scores in different tests assessing perceptual neglect are laid out in Table II. In the Complex scenes and Description of Objects tasks, he was asked to name all the items he spotted in a large picture or which were laid down on the testing table respectively; in both cases the material was present in front of him throughout the test (see Beschin et al., 1997). In the Raven Coloured Matrices

TABLE II  
*Signor Piazza's Performance on Tasks Assessing: (a) Perceptual Neglect, (b) Perceptual Neglect with Motor response and (c) Personal Neglect*

	Targets detected in the left hemisphere	Targets detected in the right hemisphere
(a) Perceptual Tests		
Verbal description of complex scenes		
Picture 1	14/16	0/10
Picture 2	14/15	2/15
Verbal description of objects	6/6	6/6
Raven Progressive Matrices (position preference out of 36 items)	16	4
(b) Motor Response Tests		
Stars Cancellation	25/27	9/27
Letter Cancellation	18/52	0/52
Lines Cancellation	20/20	20/20
Lines Cancellation Object-Centred	24/24	21/25
(c) Personal Neglect		
Personal Neglect Test – error score	0/3	0/3
Fluff Test - eyes open – right hand	15/15	7/9
– left hand	9/9	12/15
Comb and Razor Test – Comb	12	3
– Razor	14	2

(norms in Basso, Capitani and Laiacona, 1987) the patient chose his answers from six possible answers (2 placed on the right, 2 in the centre, 2 on the left). To assess neglect, right versus left position preference was considered (Colombo, De Renzi and Faglioni, 1976). He showed right neglect in all tasks except for the description of real objects placed on a table in front of him.

He frequently omitted the right part of the lines when reading a full text, showing a clear right neglect dyslexia (Ellis, Flude and Young, 1987). In reading single words he often omitted or made substitution errors at the end of the words, and sometimes he only read letter by letter the first two or three letters of a word. He omitted reading the right part of the words even when they were written from right to left (ottag/gatto, Italian for cat); in this case he missed the beginning of the words (“atto” rather than gatto). Indeed his right neglect was so severe that he made mistakes even with single capital letters (object-centred neglect), reading “I” for “L”, “R” for “B”, or “L” for “E”. No signs of neglect were detected when the words were arranged vertically. His reading errors are summarised in Table III.

Signor Piazza was anosognosic of his neglect (he scored 23/30 in the self-

TABLE III  
*Signor Piazza's Performance on Reading Single Words.*

24 2-4 letter words	Right-sided omissions	16
	Right-sided substitutions	1
24 5-12 letter words	Right-sided omissions	13
	Right-sided substitutions	10
21 5-12 letter reverse words	Right-sided omissions	18
	Right-sided substitutions	3

Omissions: one or more letters were not read.  
 Substitutions: wrong letters were produced.

evaluation questionnaire proposed by Azouvi, Marshall, Samuel et al., 1996, whilst his wife's evaluation of his post-stroke abilities was 6/30; this discrepancy is indicative of anosognosia for neglect) and attributed his reading difficulties to the fact that he was not wearing good enough glasses.

### *Perceptual Neglect with Motor Response*

Signor Piazza also presented right neglect in several perceptual tasks requiring a motor response (Table II).

In cancellation tasks he was asked to cross out stimuli, such as small stars (Wilson, Cockburn and Halligan, 1987), the target letter H (Diller and Weinberg, 1977), and all the segments on an A4 sheet of paper (Albert, 1973). In all tests, except the Line Cancellation Test (Albert, 1973), the patient showed right neglect. To test for the presence of object-centred neglect, he was asked to cross out segments framed into two identical boxes, one on the left and one on the right of the paper (Halligan and Marshall, 1993). In this task he showed hints of right object-centred neglect.

His right neglect was clear also in copying words and drawings. He copied only the first few letters on the left of short (2 to 4 letters) and long (5 to 12 letters) words, both when these were presented in the standard format (neglect of the word endings) or reversed (neglect of the beginning of the words). In copying drawings of real objects (e.g., flowers, a house, a vase) or geometrical shapes he showed a severe right neglect which sometimes was object-centred (Figure 2).

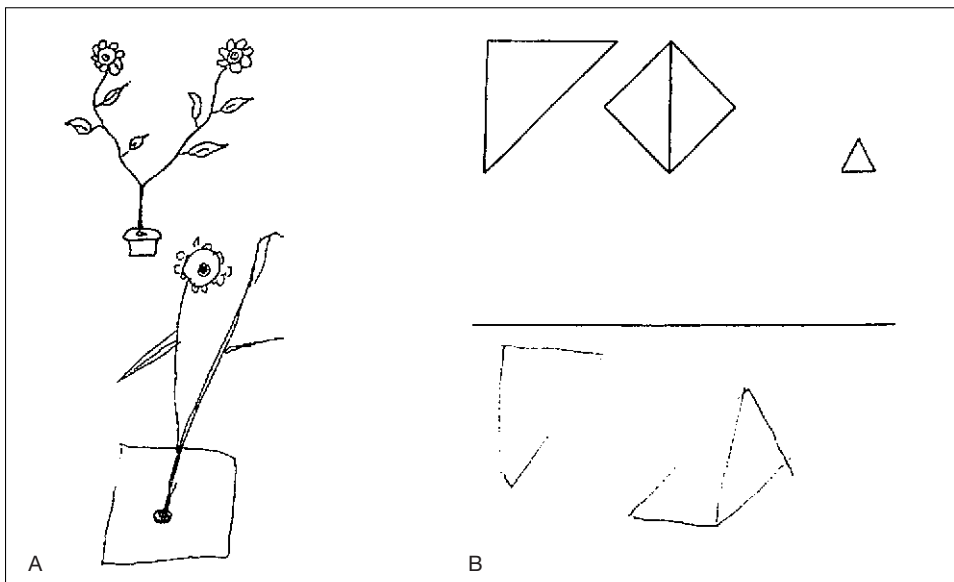


Fig. 2 – (a) Signor Piazza's copying of two flowers: top, original; bottom, patient's copy. (b) Signor Piazza's copy of geometrical shapes: top, original; bottom, patient's copy. He omitted details on the right side of both figures, showing signs typical of right perceptual neglect.

### *Personal Neglect*

Table II shows Signor Piazza's performance in three tests of personal neglect. The Personal Neglect Test (Bisiach et al., 1986) requires the blindfolded participant to touch his right hand with his left and vice versa. The score ranges from a maximum of 0 (prompt and correct) to 3 (no attempt); his performance was normal. In the Fluff Test (Beschin et al., 1997) participants are asked to reach for 24 targets (2 cm sticky circles) attached to the front of their clothes, while in the Comb and Razor Test (Beschin and Robertson, 1997) the score is given as the number of strokes to the right or to the left made in simulating combing and shaving for 30 seconds. Signor Piazza showed a clear right personal neglect on both these tests requiring actions directed towards his body parts.

### *Representational Neglect*

Given that the patient was not aphasic he could be tested with imagery tasks looking for the presence of representational neglect. He performed normally in comparing mental representations concerning shades of colours (23/24) and size (16/16) of everyday objects, length of the tails of different animals (20/20) and the geographical shape of European states (6/7) (tasks modified from Farah, Hammond, Levine et al., 1988), showing that he did not have a general imagery problem. He also performed well in a test of oral spelling of single words chosen to have transparent sound-to-spelling correspondence in Italian (37/40); it is worth noticing that all his three errors were omissions on the left side of the word to be

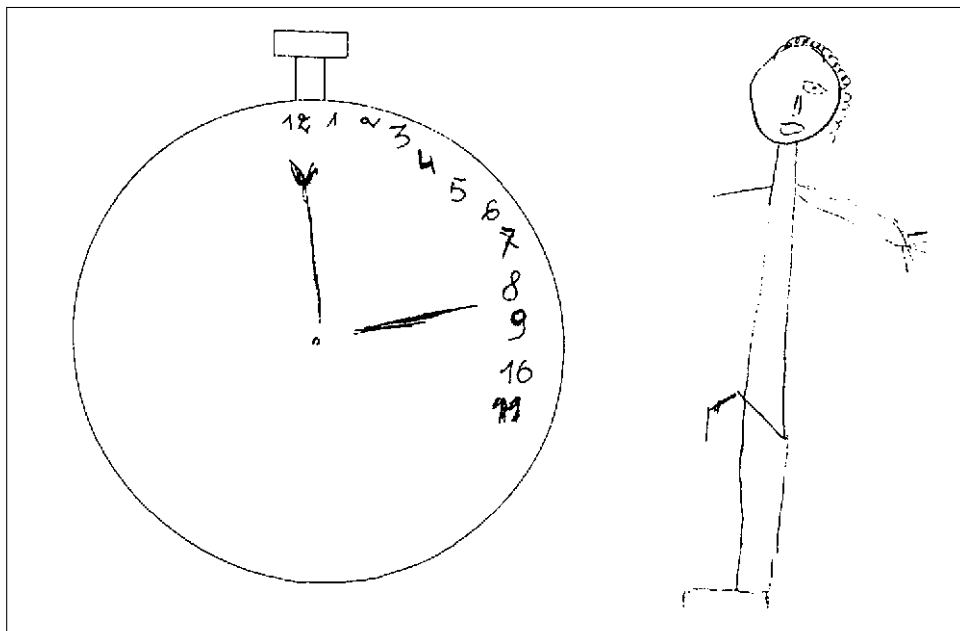


Fig. 3 – Signor Piazza's drawing from memory of a clock and a person. He omitted details on the left of both drawings, showing signs typical of left representational neglect.

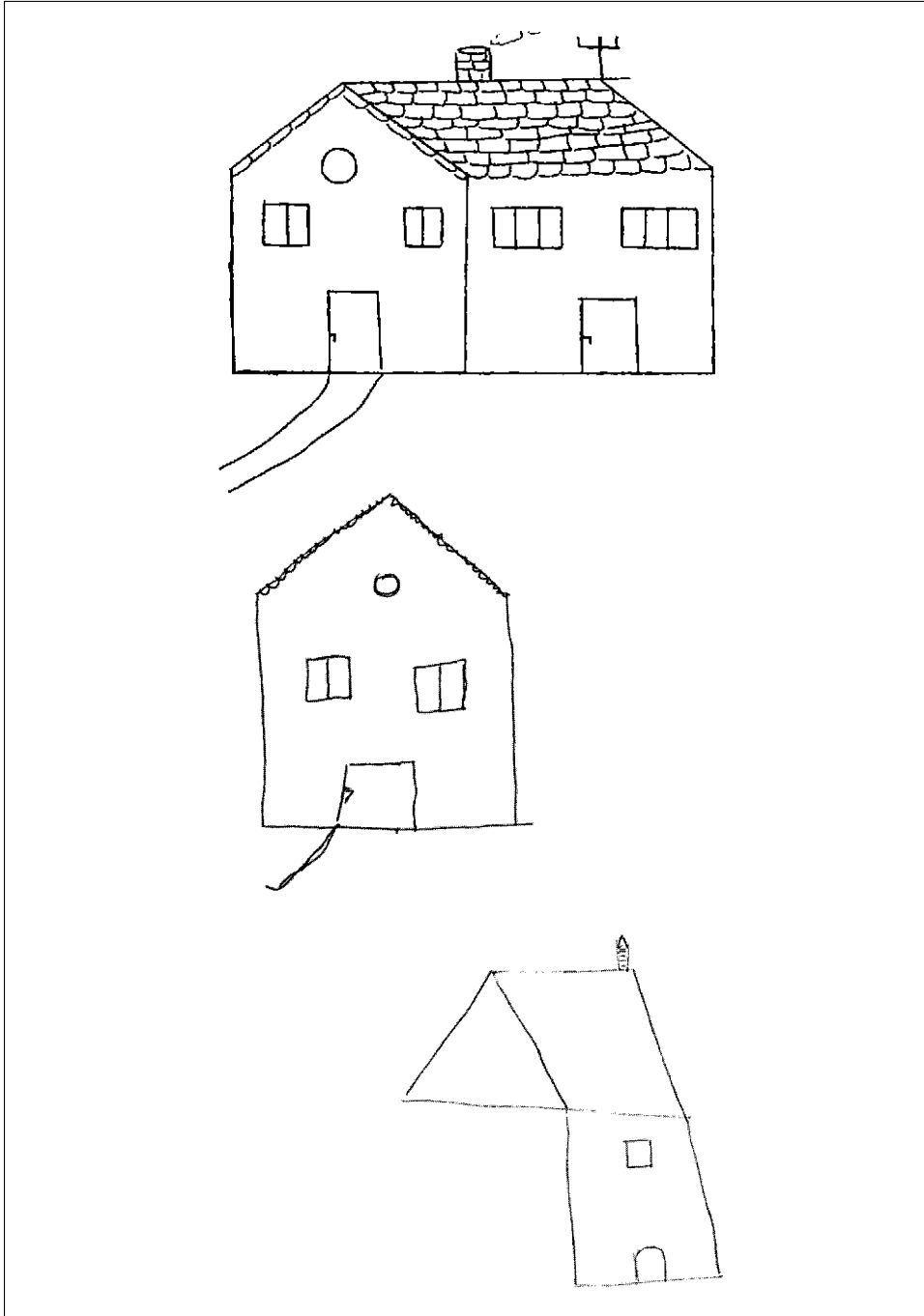


Fig. 4 – Signor Piazza's performance in drawing from memory and copying a house. He was shown the outline of a house (top), asked to copy it (center), and then asked to draw a house from memory (bottom). Signor Piazza neglected details on the right when copying (right perceptual neglect), and drew from memory an incomplete picture on the left (left representational neglect).

spelt. However, when he was asked to draw from memory he showed signs of left neglect (Figure 3). The contrast between right neglect in copying and left neglect in drawing from memory was indeed striking (Figure 4).

Signor Piazza's performances in a battery of tests assessing visual representational neglect are shown in Table IV.

TABLE IV  
*Signor Piazza's Performance on Tasks Assessing Representational Neglect*

Test	Targets detected in the left hemispace	Targets detected in the right hemispace
Verbal recall of new complex pictures		
Picture 1		
Immediate recall	2/22	5/18
15 minutes delay recall	1/22	4/18
2 day delay recall	1/22	4/18
Picture 2		
Immediate recall	1/12	4/8
Recall delay of 15 minutes	0/12	3/8
Verbal description of familiar places		
Duomo Square: First viewpoint	2	8
Opposite viewpoint	0	6
His kitchen	2/8	7/8
His dining-room	1/10	6/8
Fluff Test – eyes closed	11/15	9/9
Tactile Maze – eyes closed		
Accuracy	24/24	24/24
Searching time (secs.)	64.1	40.6
Clock Test	3/9	9/9

In the Verbal Recall tasks he was asked to examine a picture representing a complex scene and describe it immediately after it was covered, then with a 15-minute delay and finally after an interval of two days (Beschin et al., 1997). To avoid as much as possible interference of the perceptual neglect, the picture was put on the left of his visual field. It is also worth underlining that his poor left performance cannot be accounted for by his right object centred neglect. In the test of "Familiar places" he was asked to describe from memory, from two opposite viewpoints, the Piazza del Duomo of Milan (Bisiach and Luzzatti, 1978), which he knew very well, as well as the rooms of his own home, where he has been living for the last 25 years. Right and left were considered in respect to the entrance door, with his wife's performance serving as a control. He neglected left details from the imagined scenes (Table IV). His representational deficits became manifest when he was taken to Piazza del Duomo and asked to turn his steps towards given locations, near to the Square but not visible from it. With his back to the Cathedral, he had no trouble in making for locations to his right such as La Scala. However, he appeared completely disoriented when asked to head for locations to his left; for instance he could not bend towards Via Torino (to the left), kept saying that he knew it was near there and was baffled by his failures. Moreover, his first hesitant steps to any given location he was asked to head to were towards the right.



His left neglect for mental representations was manifest also in the Fluff Test (Beschin et al., 1997) performed with eyes closed, which can be thought of as a representational task (Reed and Farah, 1995; Denes, 1999), as well as in a modified version of the Clock Test (Grossi, Modafferi, Pelosi et al., 1989) whereby he was asked to tell whether, given a stated hour, the hands would be on the right or on the left side of a clock. In the Tactile Maze (Beschin, Cazzani, Cubelli et al., 1996) the patient was blindfolded and had to find, as soon as possible, a marble placed in one of the 16 hollows of a wooden maze. In this task of tactile search, his accuracy was at ceiling, but his searching times for stimuli in the left half of the maze were significantly slower than those for right stimuli ( $t_{46} = 2.615$ ,  $p < 0.02$ ).

The patient also showed left representational neglect when he was asked to retrieve from memory (and list the visualised items aloud) visual scenes new to him and to which he was exposed for sufficient time to analyse them properly (Table IV).

## DISCUSSION

Signor Piazza showed right perceptual, visuo-motor and personal neglect but left neglect for visual representations both for new material and familiar scenes. The case of this patient supports the notion of the existence of right perceptual neglect in right-handed patients (Angelelli et al., 1996). It also adds to the scant observations that right neglect can be severe (De la Sayette, Le Doze, Bouvard et al., 1992) and long-lasting (Bergego, Pradat-Diehl, Durand et al., 1992). In addition it testifies to the existence of neglect for one's body parts for the right personal hemispace. This is worth underlining because to date only one case has been reported of a patient showing right personal neglect (Peru and Pinna, 1997). At odds with the case of L.D., reported by Peru and Pinna (1997), whose neglect completely recovered in a few months suggesting to the authors that the phenomenon might be transient, Signor Piazza showed a persistent right personal neglect.

The most intriguing aspect of this case is the dissociation he shows between right perceptual and left representational neglect.

Since the seminal paper by Bisiach and Luzzatti (1978), several cases have been reported of patients affected by representational neglect in addition to perceptual neglect (Bisiach, Luzzatti and Perani, 1979; Baxter and Warrington, 1983), including cases reporting right-sided hallucinations (Mesulam, 1981; Chamorro, Sacco, Ciecierski et al., 1990) or indicating the possibility of right-sided "dreams" (Doricchi, Guariglia, Paolucci et al., 1991). However, recently, patients have been observed showing isolated left representational neglect (Guariglia et al., 1993; Beschin et al., 1997; Coslett, 1997). The specific representational neglect of these patients contrasts with that of other patients whose single deficit is in the perceptual domain (Bartolomeo et al., 1994; Anderson, 1993; Coslett, 1997; Cantagallo and Della Sala, 1998). These different patterns of deficits attest that representation and perception can be dissociated in neglect, supporting the need of fractionating the syndrome

(Halligan and Marshall, 1992; Marshall and Halligan, 1993; Cubelli, Nichelli, Bonito et al., 1991) as has been the case for aphasia or amnesia. Moreover, in the absence of an explicit model encompassing the relationship between perception and imagery, the cases presenting with isolated deficits in one or the other cognitive domains while suggesting a double dissociation, cannot support it conclusively. A within-subject double dissociation, such as that presented by Signor Piazza, adds stronger evidence to the argument.

Dissociations in neglect have been reported also within individual patients with bilateral (De Lacy Costello and Warrington, 1987) or unilateral lesions (Cubelli et al., 1991; Kashiwagi et al., 1990; Riddoch, Humphreys, Luckhurst et al., 1995). However, patients JOH (De Lacy Costello and Warrington, 1987), EL (Riddoch et al., 1995), AR (Cubelli et al., 1991) and YY (Kashiwagi, Kashiwagi, Nishimagi et al., 1990) all showed right neglect for verbal tasks, such as reading or object naming, and left neglect for tasks such as line bisection, target search and copying (though EL and AR also show right neglect in word searching). To reconcile these observations of “paradoxical” (or “dual”) neglect with the postulated hemispheric asymmetry in directing attention, they have been often interpreted in terms of task-specific hemispheric activation. In the instance of the reported cases of paradoxical neglect, the verbal nature of some of the tasks would add to the activation of the left hemisphere whilst visuo-spatial tasks would activate the right. This interpretation cannot easily account for Signor Piazza’s unique dissociation unless one assumes a differential role of the right and left hemispheres in distributing attention to fulfil the needs of representational and perceptual tasks respectively. The observation that representational neglect has never been reported in association with left hemisphere damage (Bartolomeo et al., 1994) might give some support to this hypothesis. However, the rarity of right-sided perceptual neglect makes this possibility unlikely. Furthermore, Riddoch et al. (1995) reporting the case of the patient EL, whose paradoxical neglect changed sides within the same task according to cue alteration, demonstrated that the hemisphere activation hypothesis may be too simplistic. For instance EL neglected the right side of the standard (i.e. a single page of lines) Line Cancellation Test (Albert, 1973). However he omitted targets on the left when they were framed within bounded strips (i.e., when EL was forced to code “each page as containing two separate objects”, Riddoch et al., 1995, p. 592).

Indeed, Robertson, Halligan, Bergego et al. (1994) reported that 17 out of 90 patients with right-hemisphere lesions showed some signs of paradoxical neglect. Some of them also showed dissociating performance between left-sided omissions in letter cancellation and the crowding of numbers on the left side in drawing from memory a clock face (see also Figures 2.7 and 2.8 in Robertson and Halligan, 1999). These authors interpreted their findings ad hoc as the effect of a compensatory scanning strategy, resulting from rehabilitation, which would produce an anomalous right-sided hemi-inattention in some tasks but not in others. Along these lines, one should interpret our patient’s performance in terms of a rightwards over-compensation in all visuo-perceptual tasks, which require scanning of the stimuli more overtly than representational tasks. The persistent right-sided neglect in everyday tasks, the anosognosia of his neglect, the absence

of any rehabilitation, the probable link between his perceptual neglect and his left hemisphere lesion, makes Robertson et al.'s (1994) account of paradoxical neglect an implausible interpretation of Signor Piazza's dissociating pattern of deficits.

Therefore, from an anatomical point of view, it is difficult to account for Signor Piazza's double neglect by assuming that one or the other of the two lesions might have caused both the left representational and the right perceptual neglect. Alternatively, the left hemisphere damage might have caused the right perceptual and personal neglect whilst the right subcortical lesion (Watson and Heilman, 1979; Ferro, Cantinho, Levy et al., 1993) might be responsible for the left representational defect. We saw the patient after he had had both the right and the left stroke thus making it hard to draw final conclusions on the anatomical counterpart of the extraordinary dissociation he showed. Considering also his clinical history (e.g., perceptual neglect observed by his wife soon after his left stroke), the attribution of the right perceptual and personal neglect to his left lesion and of the representational neglect to his right is a more conservative hypothesis.

It is worth recalling that Weintraub, Daffner, Ahem et al. (1996) claimed that bilateral brain lesions are more likely to give rise to right sided neglect. At odds with this claim, Vuilleumier, Hester, Assal et al. (1996) reported the case of a patient with right parietal damage whose left neglect disappeared following a left frontal lesion. Finally, Venneri, Pentore, Coticelli et al. (1998) followed up two patients with Alzheimer's Disease, therefore affected by bilateral degeneration, who showed severe left neglect. However, representational neglect was not assessed in either of the above cases. Future observations on non-aphasic patients with bilateral lesions should determine whether or not there is evidence of representational neglect for either side of "space". If one envisages the existence of left and right vectors deploying attention to carry out either perceptual or representational tasks, it is possible to postulate that a different pattern of neglect might emerge according to which vectors are impaired. It may well be the case that imagery and perception make use of only partly overlapping networks, which may also differ in cerebral dominance, those subserving representations being more lateralised to the right.

Whatever anatomical interpretation one favours, the case of Signor Piazza strongly supports the hypothesis of a dissociation between perceptual and representational neglect which is difficult to dismiss on the basis of possible differential compensatory mechanisms, a criticism raised to account for some of the pure representational cases (Bartolomeo et al., 1994). This neat dissociation between perceptual and representational deficits challenges some accepted theories of neglect (see also Anderson, 1993, and Coslett, 1997). For instance, it is hard to reconcile the patient's deficits with the hypothesis that unilateral neglect is caused by an impairment of a spatial representation system common to perception and imagery (Bisiach, 1993), or with the hypothesis that neglect is caused by an imbalance between left and right antagonistic attentional vectors common to percepts and images (Kinsbourne, 1987). Indeed, any theory which assumes a unitary attentional system for imagery and the processing of extrapersonal space or postulates that visual perception and representation share

the same neural substrate should come to terms with the clear dissociation shown by Signor Piazza. His neuropsychological profile provides strong evidence to support the hypothesis that neglect is a multifarious entity (Manoach, O'Connor and Weintraub, 1996; Marshall and Halligan, 1993; Halligan and Marshall, 1992, 1994) possibly subserved by a distributed network (Daffner, Ahern, Weintraub et al., 1990). The relative asymmetry of this distributed network might be different for perception and representation.

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