Case report

'Pure' constructional apraxia – a cognitive analysis of a single case

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Received 21 February 1997
Revised 19 February 1998

We report on a patient affected by selective drawing disabilities. The patient could correctly reproduce and draw simple geometric figures on request, but when he tried to reproduce more complex drawings or to draw common objects he performed very poorly. To identify the cognitive impairment in this patient, we adopted two test batteries based on recent information-processing models of drawing. Results showed that the patient's drawing disabilities were independent of visuo-perceptual and executive impairments. These findings support recent cognitive models of drawing abilities: some intermediate stages of drawing exist at which information is processed to prepare and guide motor output, and which may be selectively disrupted after discrete cerebral lesions.

Keywords: Constructional apraxia, brain lesions, cognitive models, single-case study

1. Introduction

The term 'constructional apraxia' (CA) has been coined to designate a disability in drawing, building and assembling complex forms in the absence of apraxia for single movements or deficits of visuo-spatial analysis [13]. In subsequent years, conflicting interpretations have been proposed about the nature, mechanisms and anatomo-functional correlates of CA, so that the diagnostic label has lost the original meaning and it is now used in a loose descriptive sense, to designate 'all the disturbances that can be observed during the execution of a constructive task' [7]; see also [6, 10].

Recent investigations have suggested that in right and left brain-damaged patients CA may be due to different functional impairments [5, 11]. Such theoretical positions implicitly deny the existence of 'pure constructional apraxia', as originally meant by [13]. For example, to state that CA's causal mechanism specific to right-brain damaged patients is a 'manipulo-spatial disorder' [5] implies that different forms of CA exist (at least two, depending on the cerebral hemisphere lesioned), and that 'constructional disabilities' are part of different syndromes among whose possible expressions is the defect in combinatory activity. These same authors propose that 'inability of concept formation' or 'planning disorders' may play a role in some forms of constructional apraxia, but these formulations are quite vague. The problem remains to identify a syndrome which reveals itself in drawing or assembling and which is not related to any other receptive or executive defect. After the early case studies, no systematic investigations of patients with 'pure' constructional apraxia have been reported. To pursue this target one ought to renew the classical 'single-case' methodology by referring to detailed theoretical models with (hypotheses about) precise definitions of abilities involved in constructional tasks. To this aim, qualitative error analysis may add relevant data [9].

Quite recently, two models of drawing have been proposed [8, 16] which identify cognitive processes involved in copying drawings. The two models differ in several formal and theoretical respects, but both of them foresee four main cognitive steps: visuo-spatial analysis, preparation of the drawing plan, execution and control processes. For our aim it is not relevant to address discrepancies between models at this moment; instead, it must be stressed that these models try to explain different drawing disturbances by hy-

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Behavioural Neurology 11 (1998) 43–49
ISSN 0953-4180 / $8.00

pothesizing damage to one or more cognitive components of the drawing process. To identify these cognitive deficits the authors devised two different, specific test batteries. The first [16] comprises several tests in which a square and a circle have to be drawn or placed in given spatial relationships. Other tasks of the battery, involving the same kind of stimuli, foresee visual matching of two spatial configurations, matching of spatial configurations to spoken sentences, and judgements of synonymity on printed sentence pairs (the patient has to judge whether two sentences describe the same design). The battery is aimed to differentiate between executive defects and drawing disturbances dependent on input modality and to assess the ability to mentally represent spatial relationships. This last cognitive skill ought to correlate with the ability to conceptualize drawing plans.

The second test battery [1, 8] comprises two sections which have been standardized on samples of normal adults. One section taps basic visuo-spatial skills (e.g., estimation of length or orientation of lines, estimation of relative position of points in space), and the other explores more complex visuo-spatial abilities which can be referred to as aspects of spatial cognition (e.g., mental rotation, identification of geometric figures hidden within more complex patterns) [6]. The aim of the authors is to assess visuo-spatial abilities thought to be involved in the preliminary analysis of stimuli, and, on the other hand, several aspects of spatial cognition likely related to the elaboration of the drawing plan. The battery also comprises nonstandardized grapho-motor tasks.

The two testing approaches are thought to tap different components of the drawing process on the basis of an operational task analysis, but they are quite divergent. The former is centered on the appreciation of topological spatial relationships (up/down, right/left) applied to two simple geometric figures; normal subjects are presumed to perform these tasks flawlessly. The latter battery assesses a range of visuo-perceptual and representational mental abilities with several visuo-spatial stimuli; normal performances are distributed over variable ranges.

For the systematic investigation of the drawing process, the two test batteries appear to be complementary because they explore visuo-perceptual, representational and executive processing at different levels of detail and from different viewpoints. In the present paper we use both batteries and a series of executive tasks to study long-lasting drawing disturbances in a patient affected by bilateral brain damage.

2. Case report

GM is a 53 year-old, right-handed man with 8 years of education. In June 1992 he presented myocardial infarction followed by a confused state of mind. In a few days he recovered his mental state. A CT scan showed a hypodense area in the right parieto-temporo-occipital junction and a small hypodense lesion in the left parietal lobe.

One month later, the patient came for observation. At that time, he was cooperative and well oriented in time and space. Neurological examination revealed left hemianopia; no elementary motor or somatosensory defect was present and the patient could stand by himself. His visually-guided movements were awkward and imprecise: he could recognize objects but evidenced gross deficits in pointing or reaching them with either arm. However, the patient could successfully imitate transitive and intransitive arm and hand movements with both upper limbs.

The patient showed slow and laborious visual exploration of peripersonal space but no evidence of left hemineglect on sentence reading tasks [14]. Other tasks (line and letter cancellation) for neglect could not be used because of his defect in visually-guided arm movements; verbal description of well-known sites and places was accurate. The patient was given some formal tests of a neuropsychological battery [18]. The patient scored below the normal range only at tests involving presentation of nonverbal material (Table 1): he achieved a pathological score (below the third centile) at Raven's Matrices 1938, and failed the preliminary task of Corsi's block-tapping test. The patient could recognize familiar faces and showed only minor visual errors in recognition and oral naming of 260 line drawings [17], but he failed at a task requiring recognition of fragmented objects' silhouettes (Street's completion test [18]). Attempts at drawing were completely disorganized; the patient could not even trace circles successfully. He could not write his name because of his enormous difficulties in putting a pen on paper and in drawing lines in any direction.

He returned for observation in September 1992, four months after the onset. He could feed and dress himself, could sign his name and walk by himself in familiar surroundings. Visual exploration and visually-guided arm movements had recovered, while left hemianopia persisted as the only neurological defect. At that time, the patient was re-assessed on tasks at which he had obtained pathological scores (Table 1). He could cope with block-tapping task instructions

Table 1
Patient's scores on Mini Mental State Examination and on some neuropsychological tests [18] at 2 and 4 months after onset

Months after onset	2		4	
	Raw score[a]	Graded score[b]	Raw score[a]	Graded score[b]
MMSE	26/30	–	28/30	–
Word span	4	2	NT	
Story recall	8.7/16	2	NT	
Token test	30/36	3	NT	
Verbal fluency	14	2	NT	
Abstract verbal judgements	43/60	2	NT	
Street's completion test	1/14	0	6/14	2
Block-tapping task	0	0	4	1
Supra-span spatial learning	NT	–	4.9	0
Raven's Progressive Matrices	16/48	0	16/48	0
Constructional apraxia	2/14	0	6/14	0

[a] NT = not tested.
[b] Graded scores equal to 2 and 3 mean performances between 15th and 50th centile of normal range; graded score 1 means performance at 5th centile, graded score 0 means pathological performance.

and showed normal visuo-spatial short-term memory. However, he failed in learning supra-span spatial sequences and was still defective on Raven's Matrices. He could write correctly, but achieved a pathological score at the task for constructional apraxia requiring him to copy geometric figures. Thus, GM had greatly improved, and drawing disturbances were the main residual cognitive impairment.

3. Special neuropsychological examination

Four months post-onset, our patient could copy and draw simple figures (square, circle and triangle) in canonical view on command, while he could not draw more complex geometric shapes (Fig. 1). A specific investigation of his executive and visuo-perceptual abilities was performed to identify the nature of his drawing disturbances.

3.1. Executive (grapho-motor) tests

Section 1. Several graphic tasks were given to the patient to obtain a detailed picture of his drawing production and to exploit an error analysis.

(a) Copying geometric figures: we asked the patient to copy Rey complex figures A and B. Moreover, the patient was given a standard copying test which includes 26 figures arranged in 10 tables (Benton Visual Retention test, Form C, Administration C [2]).

(b) Drawing from memory: The same 10 tables of the previous copying task were presented one at a time for 10 seconds. The patient was asked to copy them after they had been removed (Benton Visual Retention test, Form C, Administration A [2]).

(c) Drawing on request: the patient was asked to draw on command 5 unstructured geometric elements (vertical, horizontal, oblique, parallel, crossed lines), 4 simple geometric shapes (square, circle, triangle, rectangle), and 4 objects (flower, tree, umbrella, face).

Rey figures were corrected according to standard procedures [4, 15]. The two administrations of the Benton Visual Retention tests (copying and drawing from memory) were scored according to standard procedures (number of tables correctly reproduced [2]). The reproduction of each figure was also scored separately according to the following criteria: 1 point was assigned when all lines, and only those, of the drawing were present, with correct spatial relationships; partially altered or spatially disorganized drawings scored 0. Formal features of the graphic productions were evaluated by adopting qualitative error analysis [9]. The same criteria were applied for scoring drawing on request.

Section 2. To ascertain whether the patient's drawing disabilities could be ascribed to purely graphomotor defects we followed Roncato et al.'s methodology [16]. Their battery comprises the following tasks:

(a) Copying by drawing: the patient was presented with a series of designs depicting one square and one circle in different positions (e.g., the square above the circle; the circle on the top-left corner of the square). Each of the 8 possible designs was shown twice for a total of 16 trials. The patient had to copy designs without time constraints.

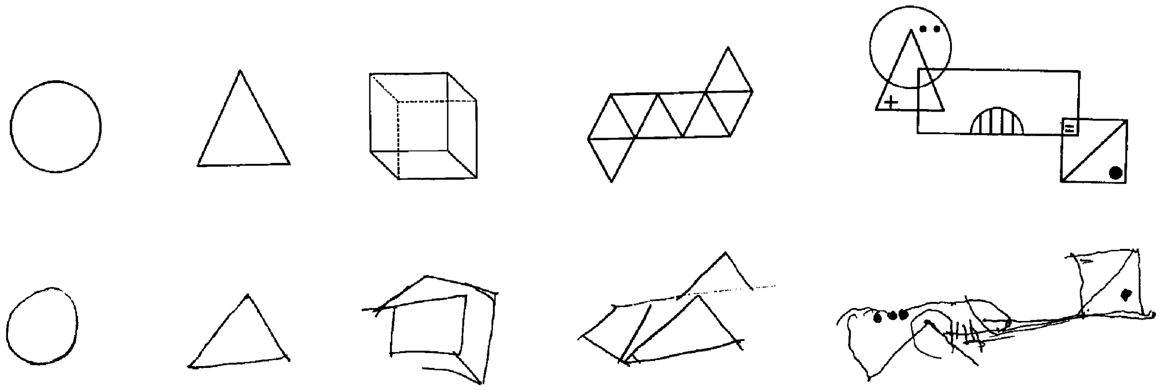


Fig. 1. Copying geometric shapes: models on upper row, patient's copies on lower row. The first four models are taken from [18], the fifth one is the Rey Complex Figure B.

(b) Copying with objects: the same designs as in a) were given to the patient. He had to reproduce the designs' spatial disposition by means of one plastic square and one plastic circle.

(c) Drawing on command: the patient was asked to draw a series of drawings containing a square and a circle following instructions dictated by the examiner (e.g., draw a square on the right of a circle). Different relative positions of the elements were tested; a total of 16 trials was given without time constraints.

(d) Positioning tokens on command: the same instructions as in c) were given to the patient. He had to reproduce the spatial arrangement described by the examiner by means of a plastic square and a circle. Sixteen trials were given.

For all tasks of this section 1 point is assigned for each correct execution; normative data are not available, but the comparisons among tasks are the most relevant findings [16].

Table 2
Scores at grapho-motor tasks

	Patient's scores
Section 1	
Copying of Rey figure A	4/36[a]
Copying of Rey figure B	4.5/31[a]
Benton Visual Retention test, Form C:	
– copying (Administration C)	3/10[a]
– drawing from memory (Administration A)	2/10[a]
Drawing on request:	
– geometrical elements	5/5
– geometrical figures	4/4
– objects	0/4
Section 2	
Copying drawing	12/16
Copying with objects	11/16
Drawing on command	14/16
Positioning objects on command	13/16

[a]Means below controls' fifth centile.
Norms are taken from [4, 15, 2] for the first three tests, respectively. Norms are not available for drawing on request and Section 2 tasks.

Results. Our patient's drawing disabilities were more evident when he had to manage simple geometric figures in noncanonical views or complex geometrical patterns (Table 2). The copy of Rey figure B, which is basically composed of four simple elements which the patient could successfully copy as single stimuli, demonstrated the detrimental effect of stimulus complexity (Fig. 1). Drawing from memory was similar to copying performance, at a slightly lower level of accuracy (correct reproductions: 5/26 and 8/26 figures, respectively). In drawing on request, the patient could draw simple elements and figures, but none of his pictures of objects was recognizable.

Qualitative analysis of drawing tasks showed that a great majority of our patient's errors (31/39) consisted in spatial distortions, defined as graphic productions in which some resemblance to the model could be recognized but lines were drawn in wrong spatial relationships. In a few cases he produced simplifications (4/39), i.e., simpler geometrical figures instead of more complex ones (e.g., a square for a rhombus); his pictures were unrecognizable only when he drew objects on command. No perseverations (duplication of figures or lines within figures), omissions or closing-in phenomena were observed. Therefore, the patient's difficulties were elicited by the presence of complex spatial relationships in the model, and his errors were essentially spatial in nature.

On Roncato et al.'s tasks [16] the patient achieved fairly good scores, although he made quite a few errors in these very simple tasks. The main finding of this section is that the patient showed a similar accuracy in reproducing spatial topological relationships by drawing and by use of plastic tokens both with a visual model and on command. This finding suggests that, at least with such simple figures, the bottleneck of his drawing process was not at grapho-motor executive level. On the other hand, his performance was very similar with verbal descriptions and visual models; thus, prima facie evidence from the drawing-on-command task was not suggestive of a specific defect in visual exploration.

In summary, grapho-motor task results suggested that our patient's defect was spatial in nature, and that his disorders could not be ascribed to an executive impairment or to a defect in visual exploration.

3.2. Visuo-perceptual and representational level

Section 1. Roncato et al.'s battery [16] comprised three tasks not involving motor output. These tasks were devised to assess the patient's ability to visually explore visuo-spatial arrays and derive mental representations or spatial relationships from verbal descriptions. As pointed out in the introduction, these tasks involve only two simple geometric figures (square and circle) and explore topological spatial relationships between these two entities.

(a) Visual matching: the patient was presented with two designs (one above the other) each containing one square and one circle in varying reciprocal spatial relationships. In half of the trials the two designs were the same, and in the other half the elements in the two designs had different relative positions. The patient had to judge whether the designs were identical or different; a total of 112 trials was given. No time limit was imposed for judgements.

(b) Design-spoken sentence matching: the patient was given designs containing one square and one circle in certain relative positions (e.g., the circle to the left of the square). Then he was read a sentence describing the position of the elements in the design, or a different one (e.g., the circle is to the right of the square). The patient had to decide whether the description applied to the design or not. In half the trials the spoken sentence matched the design, in the other half it did not; a total of 20 trials was given.

(c) Synonymity judgements with printed sentence pairs: the patient was presented with pairs of printed sentences depicting relative positions of the circle and the square. The task was to decide whether sentences described the same configuration (e.g., the square is on the right of the circle – the circle is on the left of the square) or not. In half the trials sentences were synonymous and in the other half they were not; a total of 20 trials were presented.

Normal subjects are thought to perform flawlessly on this section, but normative data are not available [16]. Therefore, the patient's performances were evaluated by calculating a nonparametric index (A′) of his discrimination ability on these yes-no response tasks.

Section 2. The tasks for visuo-spatial analysis included in Angelini and Grossi's battery [1] require subjects to estimate:

(a) the length of 20 lines;
(b) the orientation of 10 lines;
(c) the width of 20 angles; and
(d) the relative positions of 12 points.

These tasks have the format of four-choice recognition, with stimuli presented on the left and the four-choice display presented on the right. Stimuli are presented one at a time and subjects have to point to the only item identical to the stimulus among the distractors. Each correct response scores 1 point. Tasks contain items of gradually increasing complexity. For instance, in the length of line task, the difference in length between stimuli and distractors gradually decreases. In the first items of the line orientation task the distractors' slopes differ from those of the stimuli by 30°, while in the last items it differs by 15°. In the point position task, the first items require subjects to judge the position of only 1 point, and in the last items of 2 or 3 points.

This and the following section of Angelini and Grossi's [1] battery have been standardized on samples of normal adults. Since performances on most tasks are significantly influenced by educational level, we compared the patient's scores with those of matched normal controls. For one of these tasks, line orientation judgements, a longer standardized task is available, which features different testing and scoring methods [3]. We also assessed our patient on this test.

Section 3. The second section of Angelini and Grossi's battery [1] comprises visuo-spatial tasks which require subjects to mentally represent spatial relationships. Subjects are required:

(a) to perform 10 mental rotations;

Table 3
Patient's scores at visuo-perceptual and representational tests

	Patient's scores	Control's Mean
Section 1		
Visual match	A′=0.96	–
Sentence-design match	A′=0.89	–
Sentence-sentence match	A′=0.87	–
Section 2		
Line length	18/20	15,7
Line orientation	7/10	5,4
Angle width	3/10[a]	4,6
Point position	9/12	9,6
Benton line-orientation test	27/30	25.6
Section 3		
Mental rotation	4/10[a]	6,3
Shape identification	6/10[a]	7,9
Hidden shapes	0/10[a]	5,8
Mental construction	0/20[a]	15

[a]Means below controls' fifth centile. Controls' range refers to subjects of age and education matching those of the patient [1].

(b) to recognize 10 complex nonsense shapes;
(c) to identify 10 geometric figures hidden within more complex patterns; and
(d) to mentally assemble parts of geometric figures.

The first three tasks of this section have the same multiple-choice recognition format as tasks of the first section. Stimuli for the mental construction task consist of 10 squares randomly subdivided into four parts. These subcomponents are shown in the display and subjects are required to identify with which line two parts are contiguous. Two questions are foreseen for each stimulus for a total of 20 questions. Each correct response scores 1 point (maximum score: 20).

The patient's results were compared with those obtained by normal controls matched for age and education [1].

Results. The patient performed successfully in tasks of Section 1, thus showing his good perceptual appreciation and mental representation of simple topological relationships (Table 3). Findings of Section 2 demonstrated the patient's intact abilities to discriminate line length, line orientation, and spatial disposition of points. Retention of basic visuo-spatial abilities is also confirmed by Benton et al.'s task results [3]. The only pathological performance on this section was the appreciation of angle width, but this task is very difficult for normal subjects too, as revealed by the very low normative results. Moreover, judgements about angle width might require more complex spatial representational abilities.

This finding could tie in with results from Section 3. Our patient showed pathological results at all tasks of this section. He could not rotate mental images, although he could generate them, as shown by his good verbal description of places. The patient could not successfully perform on any other tasks (i.e., recognition of complex shapes, mental construction tasks, identification of hidden figures) requiring mental representations.

In summary, our patient had retained visuo-spatial abilities, but showed defects at complex representational tasks.

4. Discussion

Our patient could correctly reproduce and draw on request only single geometric figures in their canonical views. When he tried to reproduce more complex drawings or to draw common objects on request, his graphic productions were very poor. We tried to identify the nature of the drawing disorders by means of two cognitively-oriented test batteries which may be considered complementary because they assess cognitive performances from different angles [8, 16].

Tests of Roncato et al.'s battery [16] disclosed no relevant defects of visuo-perceptual and representational abilities, at the level of simple topological spatial relationships. Moreover, this test battery excluded any defect at the executive level, since drawing productions were comparable to composition by tokens, both under the guidance of a visual model and when the patient had to cope with verbal instructions. This observation fits well with data from other copying tasks in which the patient proved able to reproduce single geometric elements and figures (e.g., parallel lines, triangle, rectangle), but failed to process stimuli in which figural components were assembled with complex spatial relationships. Another clue, suggesting that our patient's drawing disabilities must arise from a defect in elaborating spatial attributes of drawings, was obtained from error analysis: most of our patient's errors were gross spatial distortions.

Further investigation ruled out a defect in visuo-perceptual appreciation of spatial features and coordinates. Instead, our patient failed specifically at so-called representational tests, which imply the ability to conceptualize complex spatial relationships. According to Angelini and Grossi [1], such failures should correlate with impaired 'central' elaboration of the drawing plan: patients selectively unable to solve spatial representational tasks ought to be unable to plan drawing execution. Drawing simple figures may proceed through the activation of overlearned motor subroutines ('constructional lexicon'), while reproducing complex figures requires sequential activation of several subroutines, after making a visuo- spatial analysis and segmenting the model [13, 8].

Two apraxic patients with right posterior cerebral lesions have been described who showed gross spatial distortions in reproducing complex models, and who had a relatively selective deficit in representational tasks [1] and [16, Case 1]. Although these patients have not been studied with the present thorough methodology, their performances were compatible with an impairment independent of visuo-perceptual and executive levels, which could be considered equivalent to that identified in the present patient.

Roncato et al. reported another patient (Case 3) with a right parietal lesion, who showed drawing errors similar to those made by our patient, but whose performance at their test battery was suggestive of an executive defect. This observation strongly supports the need for detailed assessments of visuo-perceptual, representational and executive abilities, as well as for analyses of drawing productions, to gain insight into the nature of a single patient's drawing disabilities.

To summarize, our patient's drawing disorders were independent of *elementary* visuo-perceptual and executive impairments, although some defects were observed in complex, representational tasks. The present case study supports the idea that, between the visuo-perceptual analysis and the realization of graphic output, some intermediate stages of drawing exist, at which information is processed to prepare and guide motor output, and which may be selectively disrupted after cerebral lesions. According to both cognitive models we have referred to [8, 16], 'central' stages of drawing are related to 'representational' abilities, i.e., to abstract spatial thought, but their relationships remain to be explicated.

The present case study is an attempt to study constructional apraxia on the basis of cognitively-oriented models. This approach has allowed us to obtain a detailed assessment of the patient's drawing disabilities by means of specific testing batteries. The evidence presented here seems to follow theoretical predictions. However, further clinical and experimental studies are necessary to verify validity and heuristic value of these models.

On the other hand, it is worth remembering that these models address the drawing process only. This leaves open several questions about the kind of visuo-spatial analysis, representational abilities and motor/executive processing required in other constructional tasks (e.g., building three-dimensional forms), and their relationships with abilities involved in drawing.

References

[1] R. Angelini and D. Grossi, *La terapia razionale dei disordini costruttivi*, Centro di Riabilitazione S. Lucia, Roma, 1993.

[2] A.L. Benton, *Manuale del Visual Retention Test (It. Ed.)*, O.S., Firenze, 1963.

[3] A.L. Benton, N.R. Varney and K. Hamsher, Visuo-spatial judgement: a clinical test, *Archives of Neurology (Chicago)* **35** (1978), 364–367.

[4] L. Bortolani, E. De Renzi and P. Faglioni, Test di memoria non verbale di impiego diagnostico, *Archivio di Psichiatria, Neurologia e Psicologia* **54** (1993), 477–486.

[5] G.A. Carlesimo, L. Fadda L and C. Caltagirone, Basic mechanisms of constructional apraxia in unilateral brain-damaged patients: role of visuo-perceptual and executive disorders, *Journal of Clinical and Experimental Neuropsychology* **15** (1993), 342–358.

[6] E. De Renzi, *Disorders of space exploration and cognition*, Wiley & Sons, New York, 1982.

[7] G. Gainotti, Constructional apraxia, in: *Handbook of Clinical Neurology*, Vol. 45, Fredericks JAM, ed., Elsevier, Amsterdam, 1985, pp. 491–506.

[8] D. Grossi, *La riabilitazione della cognizione spaziale*, Masson, Milano, 1991.

[9] D. Grossi, G. Correra, C. Calise and L. Trojano, Selective constructional disabilities after right subcortical stroke. A premorbid and follow-up study, *Italian Journal of Neurological Sciences* **17** (1996), 241–248.

[10] D. Grossi and L. Trojano, Aprassia costruttiva, in: *Manuale di Neuropsicologia*, II ed., F. Denes and L. Pizzamiglio, eds, Zanichelli, Bologna, 1996, pp. 594–606.

[11] A. Kirk and A. Kertesz, Hemispheric contributions to drawing, *Neuropsychologia* **27** (1989), 881–886.

[12] A. Kirk and A. Kertesz, Subcortical contributions to drawing, *Brain and Cognition* **21** (1993), 57–70.

[13] K. Kleist, *Gehirnpathologie*, Barth, Leipzig, 1934.

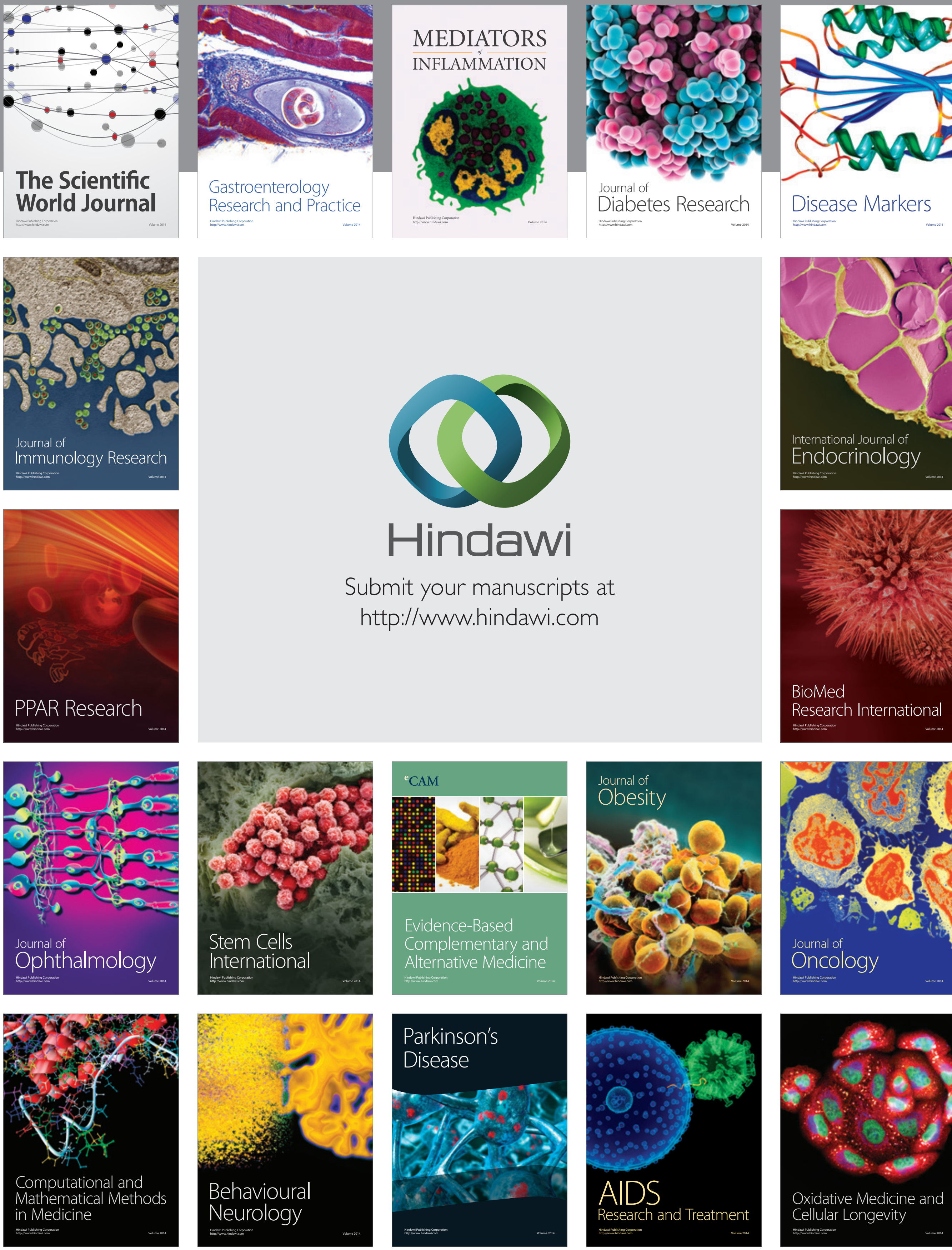
[14] L. Pizzamiglio, A. Judica, C. Razzano and P. Zoccolotti, Toward a comprehensive diagnosis of visuo-spatial disorders in unilateral brain-damaged patients, *Psychological Assessment* **5** (1989), 199–218.

[15] A. Rey, *Manual of complex figure (It. Ed.)*, Organizzazioni Speciali, Firenze, 1959.

[16] S. Roncato, G. Sartori, J. Masterson and R. Rumiati, Constructional apraxia: an information processing analysis, *Cognitive Neuropsychology* **4** (1987), 113–129.

[17] J.G. Snodgrass and M. Vanderwaert, Standardized set of 260 pictures: norms for name agreement, image agreement, familiarity and visual complexity, *Journal of Experimental Psychology: Human Learning and Memory* **6** (1980), 174–215.

[18] H. Spinnler and G. Tognoni, Standardizzazione e taratura italiana di tests neuropsicologici, *Italian Journal of Neurological Sciences*, Supp. 8 to N. **6**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