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A Study of Perceptual Analysis in a High-Level Autistic Subject with Exceptional Graphic Abilities

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We report here the case study of a patient (E.C.) with an Asperger syndrome, or autism with quasinormal intelligence, who shows an outstanding ability for three-dimensional drawing of inanimate objects (savant syndrome). An assessment of the subsystems proposed in recent models of object recognition evidenced intact perceptual analysis and identification. The initial (or primal sketch), viewer-centered (or 2-1/2-D), or object-centered (3-D) representations and the recognition and name levels were functional. In contrast, E.C.'s pattern of performance in three different types of tasks converge to suggest an anomaly in the hierarchical organization of the local and global parts of a figure: a local interference effect in incongruent hierarchical visual stimuli, a deficit in relating local parts to global form information in impossible figures, and an absence of feature-grouping in graphic recall. The results are discussed in relation to normal visual perception and to current accounts of the savant syndrome in autism.

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Autism is a severe developmental disorder which is, thus far, only defined behaviorally as a major impairment in communicative, emotional, and intellectual functions. Increasing evidence suggests that this affliction has a neurobiological etiology. First, it often cooccurs with epilepsy, mental retardation, or various known neurological syndromes (for a review, Coleman & Gillberg, 1986). Second, neuroimaging and neuropathological studies have evidenced macroscopic and microscopic abnormalities at the level of the cerebellum, limbic system, and cortical areas (for a review, Shopler & Mesibov, 1987). However, neither the exact causal factor nor the pathognomonic lesion site is yet established. Whichever biological factors are involved, they interfere with a cognitive function and result, in turn, in the various behavioral and social manifestations that are observed in this pathology (Frith, Morton, & Leslie's model, 1991). Consequently, one major goal for present researchers is to characterize the nature of this cognitive interface level.

Ten percent of subjects suffering from autism exhibit exceptional levels of performance in some specific domain of knowledge (savant syndrome; Rimland & Fein, 1988). No other clinical entities share this property. These subjects, also called *idiot-savants* or *savants*, are characterized by a dissociation between a severe impairment in a certain range of cognitive or noncognitive abilities and exceptional capacities, relative to their general functioning level and/or relative to normal individuals. Such special abilities have been observed in several domains, most often music, visual or verbal memory, mental calculation, and perspective drawing.

Although the savant syndrome has aroused curiosity for two centuries, case studies are descriptive and seldom model-based. The restricted population of hyperlexics has been more deeply explored (Aram & Healy, 1988), but the attempts to generalize its properties to other areas are still at their early stage (Cobrinick, 1982). Single-case studies of calendrical calculators have revealed some of these subjects' computation strategies, but these have not been linked to a specific cognitive model (Ho, Tsang, & Ho, 1991; Howe & Smith, 1979). Group studies have provided a directory of the areas of special abilities (Hill, 1978) and precision as to their epidemiological relationship to high-level autism (Rimland & Fein, 1988). In that line of research, recent investigations have outlined the independence of special skills from general intelligence (Lincoln, 1990; O'Connor & Hermelin, 1988).

A number of hypotheses have been put forward to explain special abilities in autism. One of the first attempts suggested that these subjects apply a preferential processing mechanism: thereby placing greater importance on the physical characteristics of stimuli over their meaningful aspects (Rimland, 1964). Some more recent suggestions related the special abilities of autistic subjects to a lack of flexibility in the direction of attention (Rimland, 1978). Another suggestion includes a reorganization of long-term memory by the reallocation to other domains of the representational space usually devoted to language (Whaterhouse, 1988). Developmental hypotheses suggest a persistence of processing styles, for example eidetic imagery, which exists only at a particular stage of normal development (Treffert, 1988). Neurally based models have proposed a prevalence of right hemisphere functioning in autism (Rimland & Fein, 1988). Unfortunately, none of these hypotheses have yet received convincing empirical support.

A broad range of recent empirical studies have focused on social cognition in autism (for a review, see Leslie & Frith, 1990). These suggest that autistic patients lack a "theory of mind," that is, they cannot make inferences on others' intentionality. However, this "theory of mind" hypothesis does not provide any account of the cognitive processes underlying the accomplishment, or failure, of such inferences (but see Russel, Mauthner, Sharpe, & Tidswell, 1991 for a recent suggestion). Furthermore, the hypothesis cannot explain the savant syndrome. There are thus to this day neither neurological nor functional satisfactory explanations of the savant syndrome.

In spite of the fact that intriguing observations of a neuropsychological nature are available in savants (Selfe, 1977), the cognitive neuropsychology approach remains scarcely employed with these subjects. And yet, such enterprise bears some original implications. Indeed, like focal brain injuries, the savant syndrome realizes a functional isolation of a specific type of processing within a small domain of datum. But while the former produces the *impairment* of a function on a *normal cognitive background,* savants show an *exceptional level* in one domain but *global abnormal cognitive functioning*. The segmentation of cognition enabled by "savant" studies may, with some reservations, contribute to the specification of developing or normal adult cognition. It is assumed, indeed, that such extraordinary abilities in an intellectually impaired subject cannot lack similarities with normal processing. For this purpose, some of the conclusions drawn from the data may be independent of the diagnosis of savant syndrome and even of autism. Importantly, studies of savants also have implications for the understanding of autism assuming that special abilities do not differ qualitatively from the other areas of their cognitive functioning. However, powerful explanations of autistic subjects' special abilities will require that their investigation be based on strong theoretical models.

Therefore, we present here the case study of an autistic subject, E.C., who shows an outstanding ability to duplicate and memorize low-level properties of visual stimuli, an exceptional accuracy for spatial details, and an ability to conceive and memorize drawings of three-dimensional objects. This subject was explored extensively on the basis of recent cognitive models of visual perception. E.C.'s investigation was inspired by the prima facie concern of his drawings with recent opened questions in visual cognition, namely, the distinction between object- and subject-centered descriptions and the local/global hierarchy. The experimental exploration is structured as follows: first, E.C.'s basic perceptual analysis capacities will be exposed, and second, his performance on tasks that examine the hierarchy between local and global levels of a figure will be reported.

CASE REPORT

Clinical and Social History

E.C., a right-handed male, was ages 34 to 36 years old during testing. He comes from a well socialized family without pathological phenotypic abnormalities. E.C.'s delivery was mature, he was 6 lbs. at birth, scored 10 on the Apgar scale, and was nursery-raised. At 10 weeks of age, he contracted a wooping-cough, followed by two seizures without temperature elevation. This incident remained labeled as "encephalitis" in his personal medical case-history. Before he was 2 years old, he stayed in various care-centers because of a moderate autistic syndrome. At 2 years old, the autistic picture was complete. E.C. remained mute until 6, using gestural expressions to communicate with his mother. A full-time pupil at 8, his schooling deteriorated until 15, at which age he had reached a primary school level. Several attempts of preprofessional training failed due to behavioral problems (tantrums, compulsive eating, alcoholism, starving syndrome). Since the age of 19, E.C. has lived in a pilot psychiatric clinic where he is employed as a house-painter and dish-washer. Disregarding occasional tantrums and pathological feeding behaviors, his social skills are rather good, thanks to his drawing trade and to the scientific interest stirred up by his performances.

According to the DSM-III-R (American Psychiatric Association, 1987) diagnostic scale, E.C. obtains a positive score for 10 of 16 items on the infantile autism subscale, 2 points above the minimum required for a diagnosis. His present nonverbal, verbal, motor, and emotional behavior corresponds closely to Wings' (1981) description of Asperger's syndrome, i.e., high-level infantile autism. On the Rimland Behavior Scale (Rimland, 1971), E.C.'s a posteriori score for autistic syndrome during childhood is +5, which meets the criteria for high-level autism (normal score = −20, typical or "low level" autism score = +20). He never presented with any delusions or hallucinations. Yearly electroencephalogram records and one CT scan performed when he was 34 years old failed to reveal any macroscopic cerebral pathological feature.

Neuropsychological Assessment

In natural contexts, E.C.'s language is characterized by infantilism, anomalous syntactic structures and, when angry, occasional pronoun reversals. Neologisms, most often errors of suffixation, may occasionally occur. E.C.'s writing is phonetic, with idiosyncratic mistakes. He reads slowly yet correctly, but cannot count, and did not attain a knowledge of calendar regularities.

During conversation, his favorite topics and preoccupations are invariously repeated, without any care for other people's occupation or interests. He shows difficulties in understanding the pun of jokes that take an expression out of its literal meaning. The majority of his difficulties in social cognition comes from an impossibility in adapting secondary aspects of his desideratas to others' priorities or constraints. As an example, he presented a tantrum because a therapist could not promise to him immediately that there would be carpets in his future apartment, 1 year later.

On classical neuropsychological assessments, E.C. shows no praxic difficulties or gnosic abnormalities. His visual acuity is 10/10, and his color discrimination, as assessed by both the Ishihara and the 28 Hues tests, is normal. He has an IQ of 88 on the French version of the WAIS scale (Fig. 1). A closer look at the different subtests reveals exceptional scores on block design and object assembly. A similar profile has been reported in groups of high-functioning autistic subjects (Fig. 1) (Rumsey

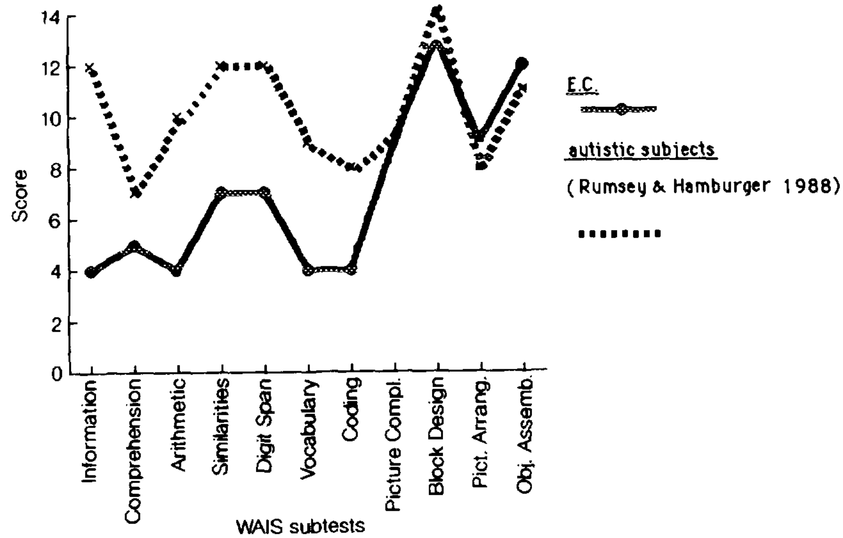

FIG. 1. E.C.'s WAIS profile compared with that of a group of adult autistic subjects (Rumsey & Hamburger, 1988, with permission).

& Hamburger, 1988; but see also Lincoln, Courchesne, Kilman, Elmasian, & Allen, 1988). A general test of academic abilities, the "Echelle collective de niveau intellectuel" (INOP, 1958), was also used on E.C. (Table 1). On this test, E.C. is especially impaired in logical reasoning and categorical judgment, performing like normal children of about 6 years of age. Frequent mistakes suggest confusion between the superordinate, the paratactic members in a category, and the phonological associates.

On the Wechsler memory scale, E.C.'s memory quotient is low (77.5) (Table 2) although comparable to his IQ. His memory performance is below that of normal adults of his age on most verbal subtests (except for the paired associates), but comparable to that of normals for visual memory. E.C. shows no obvious face recognition difficulties in everyday life. However, it is worth noting that in his spontaneous drawings, E.C. exhibits a striking weakness in his ability to reproduce anything resembling a human or animal face, as compared to his exceptional capacity to retain and construct three-dimensional objects and geometrical shapes.

History of the Drawing Behavior

E.C. began to draw in unknown circumstances at about 7 or 8 years of age, without previous scribbling. He immediately realized highly figurative pictures with a good perspective and perfect proportions. He also exhibited an amazing ability to draw complex machines from unusual points of view. The first years, E.C. sketched only from memory. His favorite topics have always been specific types of trucks and central-heating boilers. This specific interest for boilers started when he once accompanied his father to the boiler. Afterward he asked to go back to the boiler repetitively, the characteristic demand mode of autistic sub-

TABLE 1
Number of Correct Responses in Each Subtest of the Academic Ability Test

	Age range (years)[a]			
Subtests	6–7	7–9	9–11	11–13
Matrix	6/6	8/8	10/10	6/12
Category membership	6/6	2/8	2/10	3/12
Vocabulary	6/6	2/8	3/10	3/12
Sentence comprehension	5/8	5/8	2/10	2/12
Detection of differences	3/6	0/8	2/10	3/12
Sequence completion	3/8	3/8		
Verbal analogies		4/8	9/10	7/12
Detection of one difference		3/8		5/12
Digit sequence			2/10	

[a] Age range for which performance is correct in normal subjects.

TABLE 2
E.C.'s Scores on the Subtests of the Wechsler Memory Scale

	E.C.	Normal subjects
Information	4	5.98
Orientation	5	4.96
Mental control	0	6.67
Logical memory	3.5	10.40
Digits	8	10.57
Visual reproduction	12	12.11
Paired associates	15	16.29
Memory quotient	77.5	

jects. At about 10 years of age, he added to these inanimate subjects comic heroes ("Schmurfs") and animate creatures (bulls, policemen). At 11, he entered an art school where he stayed for a period of 9 months. In his family's opinion, his own style was firmly established before and unmodified by his courses at the art school. Moreover, the impossibility to change anything in his rigid performances lead to his expulsion from the art school.

Present Drawing Behavior

E.C. has been followed for 4 years, in his natural settings. Most of the drawings that he produced during the last 15 years have been collected. Figure 2 provides recent examples of the subject's drawing productions. E.C.'s drawing behavior is very regular: he delineates on A4 paper, with lead, fine-tipped marker, or ball-point pen. He is very rigid in his drawing routine and grows upset when his routine is disturbed, (e.g., if there is a small blot on the sheet or a misfunction of the pen). He smokes the pipe while he draws, talking parsimoniously with stereotyped sentences. He is always very concentrated on his work but may require an explanation when sudden surrounding noises occur. When he has access to other sheets, he may use the edge of a sheet as a ruler for his alignments. If not, he can draw perfect lines, circles, elipses or elipsoids. He never uses an eraser, even when using a lead pencil. He never scratches out, and needs not to; in that sense he never makes a mistake: the first line is always the final one. The unusual errors of coterminations are left as they are.

When copying real objects, he gazes at the model every 10 sec or so. E.C. turns his sheet in a convenient way to draw the straight lines in the sagittal plane during a copying task. Consequently, the orientation of the sheet may be completely independent of the model, a performance whose difficulty can be hinted when normal individuals try to find their way in

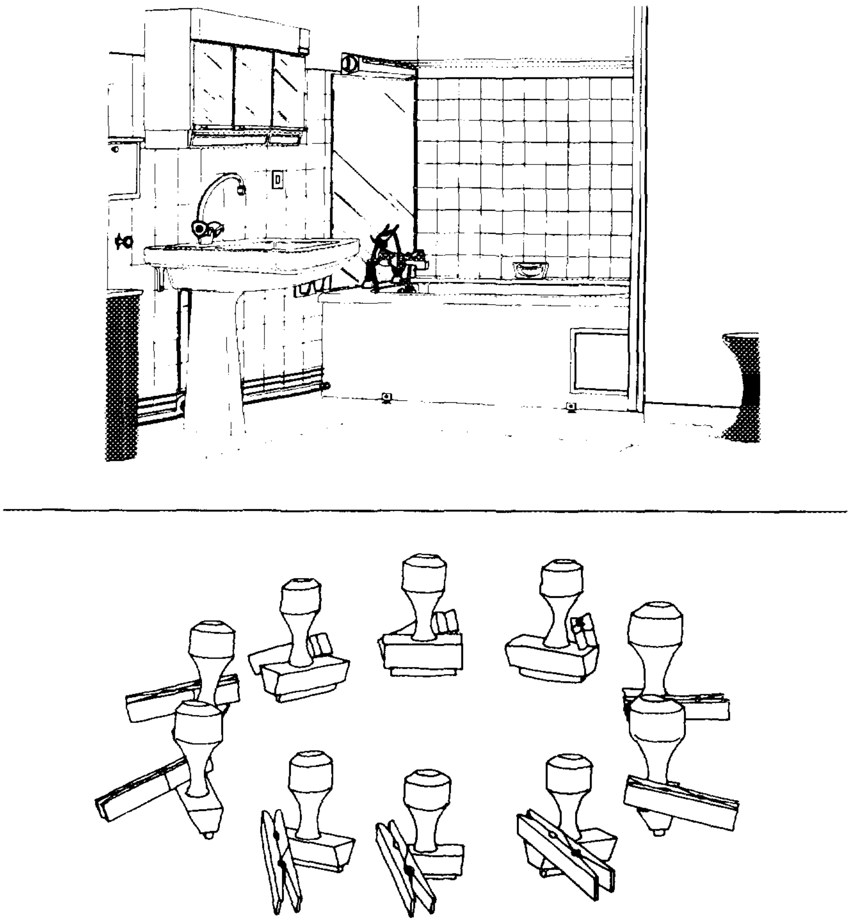

FIG. 2. Two examples of E.C.'s drawings. The upper part shows a spontaneous drawing. In the lower portion of the figure, he was presented with two objects and asked ". . . turn around them in your head, and draw them." He spontaneously disposed the drawings in a circle, beginning by the lower part of the circle. Only for doing the upper drawing did he stand up to examine the back of the objects.

a town with a map upside down. He may reproduce, without a model, his previous works. He was never seen copying an inanimate model without being asked to, but demands frequently to portray young women's faces. In test situations, he frequently asks "et si je me trompe?" [and what if I make a mistake?] and goes on only if someone answers: "c'est pas grave" [it does not matter].

A special note must be made about his imaginary drawings. E.C. composes pictures from his imagination, with recurrent themes (explosion, volcano, upset fat women), obviously topically related to his first preoccupations about motors and boilers. Their backgrounds are sometimes very similar and a whole display may be used repeatedly in several drawings, sometimes with a striking metric similitude. The drawings stop at the edge of the sheet, irrespective of the outline of the configuration in the real world. It is not rare to find a half-complete object or person missing an essential part.

Pictorial Characteristics of E.C.'s Drawings

E.C.'s drawing style is particularly homogeneous. All his productions are line drawings, that is, they represent only the outline of objects and landscapes. He occasionally copies comics whose style look like his own, such as Hergé's "ligne-claire," in which outlines are slightly overmarked. Colored drawings are rare. In his few colored productions, colors are filling in at the end of the work. Coloring is often partial or incomplete. He never uses color hues and a single color fills each closed surface. The same characteristics apply when he produces monotones of grey: a single grey hue is employed for each enclosed surface. Shades are exceptional, always black.

To obtain a quantitative assessment of E.C.'s color use, a realistic colored drawing of a parrot was created using seven different colors. The subject was presented with an uncolored outline copy of the parrot and asked to reproduce it using the same seven-color pen that were used to realize the colored model. There was no time constraint. On this task, color-copying was rough and he reduced from seven to four the number of colors used in the drawing. Textures, hues, and shadows obtained from color juxtaposition or superimposition were omitted. Nevertheless, E.C.'s deficiency in color use cannot be reduced to a sensory deficit, since he is normal on formal tests of color discrimination (see neuropsychological assessment). Therefore, while E.C. has exceptional capacities for contour reproduction, his level of color use is below normal.

EXPERIMENTAL INVESTIGATIONS

Perceptual Analysis

In this first section, a detailed analysis of E.C.'s visual perception and constructional abilities was conducted in order to assess whether qualitative particularities could account for his extraordinary capacities. Recent models (Humphreys & Riddoch, 1987a, 1987b; Ratcliffe & Newcombe, 1982) propose that achieving object recognition requires perceptual analysis and perceptual classification. Perceptual analysis proceeds in three stages: an initial representation resulting from the analysis of the two-dimensional geometry of the image (Marr's Primal Sketch; 1982), a viewer-centered representation composed of the spatial location of surfaces from the observer's viewpoint (Marr's 2-1/2-D), and an object-centered representation that specifies the shape of objects independently of the observation point (Marr's 3-D). Perceptual classification implies matching the viewer-centered or the object-centered representations with a stored lexicon of "object recognition units." Semantic knowledge and the level of image naming can then be accessed.

Initial and Viewer-Centered Representations

Experiment 1: Matching of two-dimensional stimuli. The ability to extract the perceptual characteristics of two-dimensional configurations was assessed using a simple matching task, the Thurstone test. This test consists of 60 black and white geometrical figures. Each figure was presented to the subject and his task was to find it among four distractors. The subject was given unlimited time to complete the task.

On this task, E.C. performed rapidly and accurately with a perfect score. This finding is not surprising given the extreme accuracy achieved in E.C.'s drawings and given that he has no apparent difficulties in object recognition. Thus, E.C. probably succeeds in constructing an accurate initial representation of visual configurations.

Three-Dimensional Analysis and Object-Centered Representations

Experiment 2: Visual illusions. Depth perception depends on the use of binocular and monocular cues. However, in pictorial representations, only monocular cues provide information about the three-dimensional properties of objects. We have thus assessed here E.C.'s sensitivity to such cues using six visual illusions that would depend on the use of monocular depth cues. These were the Ponzo illusion, two variants of the Mueller Lyier illusion, two variants of the Hering illusion, and the Jastrow illusion. For comparison, two illusions that are not related to depth cues were also used, the Zollner and the Poggendorf illusions. Each illusion was presented three times in a random order over a total of 24 trials. The task was to report what was seen (e.g., in the Ponzo illusions, the subject was asked to report which is the longest line). At the end of the testing session, each illusion was presented again to E.C. who was asked to draw what he saw. This was used in order to control any prompting by the question. The exaggeration of a length or an angle was attributed to the perception of the illusion.

E.C.'s performance was compared to that of three normal controls matched for age (average age = 32.2 years) and sex. As is shown in Table 3, E.C. perceives normally the illusions used here. On the depth illusions, E.C. obtained a quasiperfect score (17/18 correct responses), comparable to that reached by controls (average = 14.8, range, 11 to 18). On the Poggendorf and Zollner illusions, E.C. also obtained a score

TABLE 3
Number of Correct Responses on the Illusions Test

Illusion type	controls (*M*)	E.C.
Hering	5/6	6/6
Ponzo	2.1/3	2/3
Jastrow	2.6/3	3/3
Mueller Lyer	5.8/6	6/6
Poggendorf	2/3	2/3
Zollner	3/3	3/3

identical to that of controls (5/6 for E.C. and 5/6 for controls; range, 3 to 6). When asked to draw the figures, E.C. reproduced the illusions in congruence with his behavior in the choice task. Altogether, these results are compatible with an appropriate perception of the monocular depth cues by E.C.

Experiment 3: Matching of objects in non-canonical views. The capacity to construct an object-centered (or 3-D) representation from a viewer-centered (or 2-1/2-D) representation is usually assessed by tasks where subjects have to match the noncanonical view of a common object to its canonical view. It is assumed that subjects need to elaborate or access an object-centered representation to succeed in such a task. This task was thus used here with E.C. The stimuli were 26 photographs of common objects presented in canonical views (kindly provided by H. Chertkow). Subjects were required to find among two objects presented in a noncanonical view which one corresponded to the presented object. The distractor and target were visually close. Subjects were instructed not to name aloud the object during the task.

On this task, E.C. matches correctly 100% of the objects with their corresponding noncanonical views. He is thus able to access object-centered representations from noncanonical information. This result, in addition with that of Experiment 2, demonstrates that E.C. can extract and use at a normal level the three-dimensional properties of objects. He can use monocular depth cues for depth perception and derive object-centered representations.

The Perceptual Classification Level

Processing at the level of perceptual classification was assessed by testing E.C.'s ability in tasks that require matching the structural description of an object with its representation in an object lexicon and in a name lexicon.

Experiment 4: Object decision task. The lexicon of object recognition units was tested using an object decision task (Chertkow, Bub, & Seidenberg, 1989). Indeed, to decide whether an object exists or not, subjects have to compare it with the range of object representations stored in long-term memory. For this test, 11 line drawings of nonobjects as well as 11 line drawings of real objects matched for complexity were used. The nonobjects were created by combining parts of different real objects to form novel arrangements (e.g., a saw with a spoon as its blade). The 22 stimuli were presented in random order and E.C. was asked, for each drawing, if it was a known object.

E.C. discriminated quickly and accurately objects from nonobjects, as shown by his perfect performance on this task (32/32). This finding implies that the object form lexicon is functional.

Experiment 5: Color knowledge. In the previous experiment, only black and white figures were used to test E.C.'s object representations. However, as was shown in the case report, E.C. does not spontaneously use colors, ignores color hues, and reduces the number of colors in reproducing a drawing. Yet, color is a major feature which characterizes many common objects. This feature may thus be part of the structural description of objects within the object lexicon. The goal of this experiment was thus to investigate if E.C.'s reduction in color use may relate to a disorder in his knowledge of the color of familiar objects. This was explored using a simple drawing task. Seven line drawings of well-known plants, fruits, and animals were presented to the subject. Each object used was characterized by a specific color (e.g., yellow for a banana). E.C. was asked to color them all with 12 coloring pencils displayed in front of him.

E.C. used the appropriate color for 6/7 objects. This suggests that his knowledge of this physical characteristic of well-known objects is usually accessible. However, one error was made: he colored a mouse pink. This particular choice may be explained by his large acquaintance with comics. Even though minor anomalies in E.C.'s knowledge of colors cannot be readily excluded, it is doubtful that such minor deficiencies account for the reduction in his use of colors.

Experiment 6: Word-to-picture matching task. E.C.'s knowledge of the name of common objects was assessed in this experiment. The subject was asked to point to the line drawing of objects, animals, or body parts corresponding to its name spoken by the examinor. The target object was mixed with four other objects (Chertkow et al., 1989). Two conditions were used in this task. In the first condition, the distractors were unrelated (intercategorial condition) and in the second condition, the distractors belonged to the same superordinate category (intracategorial condition). This second condition allows the detection of impairments in the ability to discriminate between members of the same semantic category (Chertkow et al., 1989). Twenty-two trials were presented to the subject on each condition.

For the first condition (intercategorial), E.C. obtained a perfect score (22/22) and on the second condition (intracategorial) only one error was made (21/22). This ability to match pictures to words indicates that the object name system is functional. This is consistent with Van-Lancker, Cornelius, Kreiman, Tolnick, et al. observation (1988) that even low-functioning autistic subjects are able to name objects on the basis of their pictorial representation.

Experiment 7: Identification of fragmented figures. E.C.'s perfect performance on the object decision task (Experiment 4) strongly suggests that the object lexicon is normally functioning. However, the data from that experiment does not allow the detection of subtle differences, since subjects are at ceiling. There are reasons to suspect that such differences exist and, more precisely, that there is an overfunctioning of that system. Apart from the extraordinary ability that the subject exhibits in visual reconstruction, an overfunctioning of this subsystem can be hypothesized on the basis of an independent observation. Indeed, Shah and Frith (1983) showed that autistic subjects recognize embedded figures better than normal, mental age matched controls. A very precise description of objects in the object lexicon or an overfunctioning of the object recognition unit level may explain these subjects' high performance level. Therefore, we used two tasks for which controls are not at ceiling in order to assess if E.C. would show a better performance level.

On the first task, 18 items from the Graded picture series (Gollin, 1960) were used. These are outline drawings of common objects. Five representations of each object are created, each containing an increasing amount of contour lines and internal details. Thus, the first card represents the most reduced description of a given object, while the fifth card is a relatively complete representation. The procedure used was the following: after a familiarization phase, the subject was shown each card successively at decreasing levels of degradation. Thus, the most degraded card was shown first. The subject was allowed 20 sec to name the object that the card represented. If he failed on a given card, the following more complete representation of the object was displayed. This was continued until the subject supplied the correct answer. After a 5-min distracting task, a verbal free recall of the exposed patterns was asked.

In order to obtain a score on the Graded picture naming task, the following quotation was used: for a given object, a correct recognition at the most degraded level (Card 1) was given a perfect score (1). From this perfect score, a 20% decrement was applied for each level of completion required for identification. For example, if a subject required the third level of completion before identifying a given stimulus, his score on that stimulus was 0.6. In the impossibility of naming an object when complete, the subject was given a score of 0. Consequently, the best possible score on the test was 18 (18 × 1). The subject's performance was compared to that of five normal subjects matched according to age (M = 35.6) and sex. Four professional draftsmen matched according to sex but younger than E.C. (M = 22) were added to the control group. These gifted controls were used in the present task, as well as in that of Experiments 8 and 10 because these were cases for which training was suspected to influence performance. In none of these tasks however, did the gifted controls perform differently from untrained controls. Therefore, in all cases, the scores of the two control groups were pooled. In the present test, the range of scores for controls was 14.6 to 17.6 with an average of 16.1. E.C.'s performance on that test was well within that range (15.8), while his free recall score was 9/18, slightly lower than that of controls (M = 13.3; range, 11 to 17).

In the second task, the Hooper test (Hooper, 1957), subjects were asked to identify 30 line drawings of common objects cut into two to five pieces and scrambled. E.C. produced the correct name for 25/30 scrambled objects, a score comparable to that of normal subjects (M = 25.2; range, 23 to 27). E.C.'s results on the Hooper and Graded series are congruent, both showing normal but not exceptional performance levels. Thus, E.C. constructs a structural description of objects from recognizable (Hooper) and unrecognizable (Graded series) features and succeeds in matching this structural description with a stored visual representation. However, he is not better than normal and gifted controls on these tasks. Thus, the results from the two tasks used here are not compatible with an overfunctioning of the object recognition units in E.C.

Local/Global Hierarchy

The goal of the previous section was to examine whether E.C.'s exceptional graphic performance could be accounted for by an impairment or an overfunctioning of some of the perceptual subsystems involved in object perception. Results from this first section failed to reveal any qualitative or quantitative peculiarity in E.C.'s visual perceptual processing. Therefore, his exceptional graphic performances cannot be easily explained through the models of object recognition put forward in neuropsychology.

However, these models do not, on their own, completely capture visual processing. Indeed, objects are often made of distinct parts which may be individually recognized as well as organized into whole meaningful objects. For example, the global shape of a table is made of local, distinct parts, a platform and four legs. Additionally, the analysis of visual scenes requires the perception of several individual objects and their grouping and organization into a coherent structure. Thus, a table can itself become part of a larger ensemble, like an office room. In order to achieve such representations, local and global properties of a visual array have to be detected and ordered into an adequate hierarchy (Robertson & Lamb, 1991). It is this particular ability that is assessed and described, in this second section, with respect to E.C.'s perceptual and constructional abilities. The interaction between features was assessed using three types of evidence: the performance in hierarchical stimuli, the stability of graphic recall order, and lastly the perception of impossible figures.

Experiment 8: Perception of hierarchical stimuli. One of the most widely used tasks for assessing the interaction of local and global form information consists of hierarchical stimuli. Hierarchical stimuli are made of a large unit (global level) composed of smaller parts (local level) (Navon, 1977). The two levels may be congruent (e.g., a large C made of smaller C's) or incongruent (e.g., a large C made of smaller O's). This paradigm was used in a wide range of studies in normal, developing, and brain-damaged subjects (for a review, Robertson & Lamb, 1991).

Two distinct phenomenon have been identified on the basis of these experiments. *Advantage* is the superiority in precision of one level over the other. Navon's first findings (Navon, 1977) was that in normal subjects the global level was quicker and more accurately detected than the local level (global advantage effect). Results from brain-damaged patients showed that the local and global levels actually corresponded to two independent processing channels. Indeed, it was shown that left temporal and parietal brain-injured patients respond faster to the global information, while patients with cortical lesions in the analogous region of the right hemisphere respond faster to local information (Delis, Robertson, & Efron, 1986; Lamb, Robertson, & Knight, 1990). Two subsystems were thus evidenced: one associated with the right hemisphere that performs global analysis more rapidly, while the other, associated with the left hemisphere, shows preferential processing of the local information.

Interference relates to the fact that the two levels, local and global, interact at some point in the pattern analysis, and this is evidenced by manipulating the congruence of the stimuli. It has been shown that when a pattern diverges with respect to its local and global elements, interference of one level over the other occurs (Lamb & Robertson, 1989). In most cases, it is the global level that interferes with the local level. This global interference effect is, however, independent from the global advantage effect. Indeed, Lamb and Robertson (1988) showed that patients with a lesion to the superior temporal gyrus present no interference effect, while exhibiting advantage effects. In normal subjects, Navon and Norman (1983) have also demonstrated that interference and advantage could vary independently. Thus, while the advantage effect reflects the faster or more accurate processing of one system compared to the other, the interference effect reflects the influence of a given system on the genuine capacity of the other. In normal individuals, advantage and interference effects usually favor the global level. This cooccurence of the two effects defines the *precedence effect.*

Hierarchical stimuli were used here in E.C., in order to assess local and global analysis as well as their interaction. For this purpose, congruent and incongruent hierarchical stimuli were generated (Navon & Norman, 1983). The stimuli were large letter C's or O's made of smaller C's or O's. These letters were chosen so that the discriminating information be at the same eccentricity or distance from the fixation point. In other combinations, for example large X's made of small T's, one of the two patterns (the X) could be identified by looking at the center and the other (the T) by looking at the upper portion.

To construct the stimuli, a series of O's made of 16 small O's and a series of C's made of 13 small C's were first produced with white letraset on black cardboard to prevent dazzling. The global stimuli were then obtained by the juxtaposition of letters from these series: 16 for the large O's and 13 for the large C's. The global stimuli were thus large replicas of the local level. The global stimuli were then photographically reduced. Congruent stimuli were those for which the global and local levels were made of identical letters, half of them being C's and half being O's. The incongruent stimuli were those for which the global and local levels differed: half were C's made of O's and half were O's made of C's. Half of the congruent and incongruent C's were reverse-oriented in order to avoid identification of the letter only by focusing to its opened right portion. The stimuli were displayed on a two-way tachistoscope at a 50-cm viewing distance. The large letters were 30-mm wide, which corresponds to about 5° of visual angle from the viewing distance used here. This is within the range of angles used in hierarchical stimuli (Delis et al., 1986).

The procedure was the following. Subjects were seated in front of the tachistoscope. A star was presented in the center of the display as a fixation point. The stimulus was then shown, followed by a mask made of vertical black and white stripes. Before the experimental session, a minimal exposure duration value (MED) was individually determined for each subject. MED corresponded to the exposure time for which a subject identifies correctly a target of the local level size on seven successive trials, using a staircase-type identification procedure. Presentation time was adjusted here for each subject because little information is available on the perception latencies of autistic subjects. By doing so, it was ensured that the stimuli were detected to an equivalent degree by E.C. and normal subjects. Six increasing exposure times were then determined (MED, MED + 3 ms, MED + 6 ms, MED + 9 ms, MED + 12 ms, MED + 15 ms) and used to control for eventual ceiling effects. The experimental session contained two blocks of 24 trials, each block separated by a 5-min rest. One block included six presentations of the four different stimuli. The presentation time and order for each stimulus type were randomly varied but remained fixed across subjects in order to allow direct comparison with E.C. Each trial was preceded by a verbal warning to fixate the star. Subjects were instructed to give a verbal report of the stimulus perceived (e.g., "a large . . . made of a small . . ."). This type of answer was chosen to unify a possible bias of the order of report on the respective detection of each level.

E.C.'s data was compared to that of 10 controls (6 untrained subjects, average age = 37.8; 4 gifted subjects, average age = 22). MED values were roughly similar across subjects and ranged from 5 to 13 ms. E.C.'s MED was 10 ms, no different from that of controls. A prior analysis of the data failed to show any pattern related to the six different exposure times. The data was thus pooled to allow an analysis of a larger number of trials.

The advantage effect was first assessed by comparing errors in accuracy at the local and global levels for stimuli that are congruent. Figure 3 shows that normal controls produce more local (81%) than global errors (19%). The same pattern of performance is observed in E.C. (Fig. 3): 86% of E.C.'s errors occur at the local level. Thus E.C. and normal subjects show a global advantage effect similar to that reported in the literature.

The interference effect was assessed by examining the influence of incongruency on the processing of one or the other level. When comparing congruent to incongruent stimuli there is no significant change in the number of global or local errors made by normals [$\chi^2(1) = 0.70$, NS] (Fig. 4a). Thus this paradigm does not reveal global or local interference effects in controls. In the case of E.C. the use of incongruent stimuli yields an increase in the number of global errors but not in the number of local errors [$\chi^2(1) = 7.63$, $p < .01$] (Fig. 4b). This suggests in his case an interference of local over global form level. Notably, the use of incongruent stimuli induces in E.C. a reversal of the global advantage found with congruent stimuli since all his errors now occur at the global level. This reversal is not observed in controls.

When using congruent stimuli the global level is processed better by

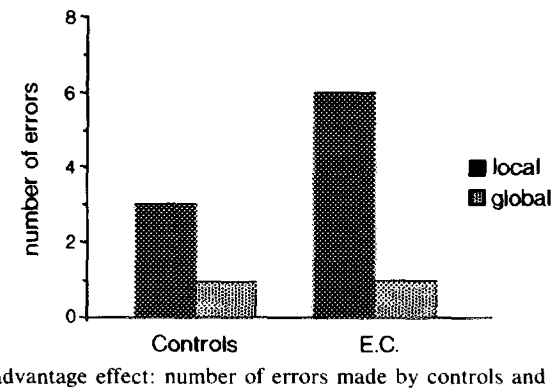

FIG. 3. The advantage effect: number of errors made by controls and E.C. at the local and global levels of congruent hierarchical stimuli.

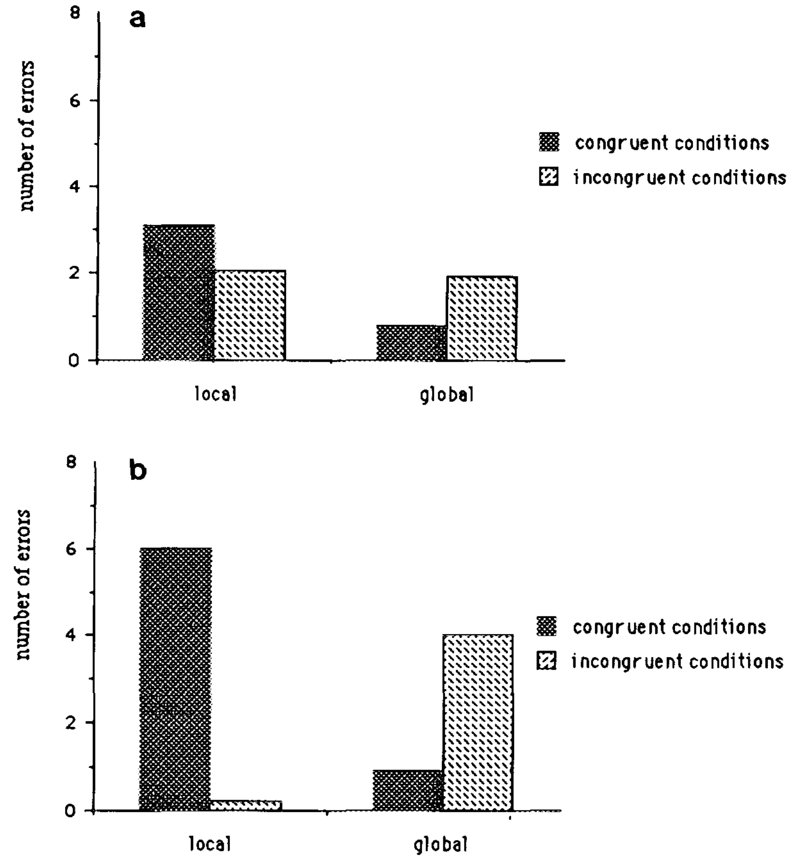

FIG. 4. The interference effect: comparison of the number of errors for congruent and incongruent stimuli at both the local and global levels in (a) normal controls and in (b) E.C.

both E.C. and the controls—this represents a global advantage. There are also indications for a local interference effect. Thus, there is an absence of global precedence in E.C. since advantage and interference act in opposite directions. These effects suggest that the global level is processed in a normal way (global advantage) but has no special status in E.C.'s perception (local interference). This hypothesis was tested using two other types of paradigms: the order of graphic recall and the perception of impossible figures.

Experiment 9: Order of graphic recall. The results from the previous experiment suggest that in E.C., there is a disturbance of the hierarchical organization upon which perceptual processes are usually based. The goal of the present experiment was to strengthen this hypothesis and to extend it to graphic recall. Indeed, a perceptual organization of parts into a hierarchy should show in graphic productions. On the one hand, the drawing production should favor the global aspect of the figure, while on the other hand, a stability in the order of graphic feature recall should be observed on repeated recall. This would imply that the parts are grouped into a hierarchical representation and then used for memorization. If E.C. has no such hierarchical organization, order of recall should not be driven by global features and should vary across repeated trials.

During the observation of E.C.'s natural drawing behavior, it was frequently observed that he began his drawing by a secondary detail and then progressed by adding contiguous elements. This particular drawing strategy was first assessed by videotaping E.C.'s graphic recall of a complex object. The object used here was the final component of a flute, seen backwards. The object was thus made of a large part (the body of the flute) composed of smaller parts (the keys) themselves made of even smaller details. The flute was presented for 15 sec and graphic recall was assessed immediately. There was no time constraint on recall.

An extensive analysis of the video revealed that E.C.'s construction of the figure was based on a proximity rule. Each new line added to the production was in spatial contiguity with the preceeding one. Furthermore, E.C. did not respect the integrity of a smaller part when producing it. Instead of drawing complete parts one after the other, he generated contiguous lines irrespective of their positions in parts. This drawing strategy produced a characteristic "frame-on-the-window-pane" effect when the video was accelerated. E.C. drew the flute outline only when he came upon a component contiguous with the body of the flute. This tank thus shows no privileged status of the global form in E.C.'s production of the figure, but rather a construction by local progression. In contrast, a professional draftsman control started by constructing the outline of the flute and proceeded to the juxtaposition of various parts. Note that in both cases the final production was excellent except that the draftsman production was sketched while E.C.'s was a fine-line drawing.

Order of feature recall across trials was assessed in a task where E.C. was asked to successively copy and recall two different familiar objects (from Snodgrass & Vanderwart, 1980) five times. A feature in the original figure was defined as a line, straight or curvilinear, drawn in a single smooth gesture with no change in angle. Simple figures with few features (about 10) were chosen. Figures for which the number of features recalled were likely to produce ceiling effect were favored. This was done in order to focus on the order of recall and eliminate as a factor the number of features recalled. It also facilitated feature identification in the scoring phase. To allow the analysis of order recall, we adopted the procedure used in the Rey-Osterieth figure task and provided a new color pencil to the subject when the drawing of a feature was done.

The quotation was obtained by analyzing the rate of fixed, or identical transitions (RFT) between two features for the different recalls. The RFT score corresponded to the number of times that, in different drawings of the same figure, a given feature was followed by the same other feature. For five successive copies of a 10-features figure, the maximum RFT value was $5 \times 9 = 45$ identical transitions and its minimal value $0 \times 9 = 0$ identical transitions. As evidenced in Fig. 5, E.C. shows a randomized order of feature production on both copy and recall conditions. Only 20% of the transitions made were repeated. In contrast, normal controls, as was hypothesized, exhibited very rigid recall sequences. The same sequences were indeed repeated on 90% of the transitions. To assess the status of the global level in graphic production, we also computed for one of the figures the position of the outline in the sequence of features recalled from memory. In this condition, the outline is most often drawn first by normal subjects (average position for the five trials = 1.3) while it is not by E.C. (average position for the five trials = 3.4).

In conclusion, E.C.'s graphic strategies are compatible with a lack of hierarchical organization. The drawings are constructed by local progression and global information, for example outlines, do not occupy a primary position in the order of feature drawing. Finally, neither copy nor recall routines were observed.

Experiment 10: Figure decision task. The two previous experiments are consistent with a disturbance in the hierarchical ordering of local and global parts. Experiment 3 nevertheless shows that E.C. can accurately recover the three-dimensional properties of objects. It is difficult to conceive that this recovery can be made without processing local form information in relation to global form information, unless E.C. identifies ca-

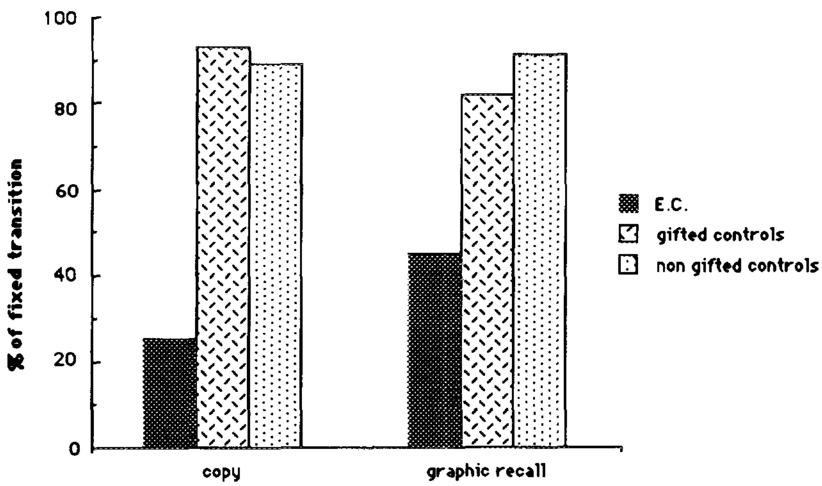

FIG. 5. Number of fixed transitions on five repetitive copies and recall of simple figures.

nonical and noncanonical views using only local cues. If this is the case, the subject should be impaired in the identification of geometrical three-dimensional figures whose parts are locally coherent, but globally incoherent. Instances of these are the well-known "impossible figures" such as the Devil's fork or Penrose triangle. In these figures, each local part or angle remains coherent with geometrical rules (see upper part of Fig. 7). It is only when the different parts are organized into a global percept that the geometrical impossibility arises.

A set of 12 line drawings of impossible figures as well as 12 individually matched possible counterparts (kindly provided by Bernadette Ska) were thus used. These 24 figures (12 possible and 12 impossible) were randomly presented to E.C. and the controls. Their task was to judge whether these drawings were geometrically possible or impossible. Each pattern was presented tachistoscopically with an increasing exposure duration (100, 300, 800 ms) to prevent ceiling or floor effects. A control condition at a duration of 15 sec was used at the end of the testing session to ensure that subjects understood the concept of geometrical possibility. They all performed perfectly on this control condition, including E.C. Finally, in a different testing session, E.C. was asked to draw from memory two of the impossible figures presented with the same four exposure durations.

The number of errors on possible and impossible figures was examined separately. If E.C. fails to integrate the different parts of a figure to attain a global percept, he should show a tendency to judge impossible figures as possible. Possible figures on the other hand should be accurately processed. As can be seen in Fig. 6 (upper part), E.C. was comparable to normal controls in his ability to recognize possible figures at all exposure durations. In contrast, E.C. made more errors than controls (lower part of Fig. 6) on judging impossible figures when the task was made more difficult (for short-exposure durations). A response bias in favor of the "possible" answers can be discarded, since at long exposure durations E.C. does not favor the "possible" answer. Furthermore, E.C.'s immediate graphic recall of impossible figures parallels his performance in the choice task (Fig. 7). At brief exposure durations (100 to 800 ms), E.C. reconstructs a globally coherent pattern and misses the geometric impossibility. At a longer time (15 sec), he reproduces an impossible figure. Note that while the globally impossible aspect of the figure (its impossibility) is not reproduced by E.C. at 300- to 800-ms exposure durations, its outline is. This implies that global level and outline may be distinct even though most paradigms (e.g., the hierarchical stimuli) do not allow their differentiation.

The present finding confirms that the extraction of local parts is correct in E.C. However, since an interaction between the different levels of the figure is necessary for a correct judgment of impossibility, this data also suggests an impairment in the relations between these different parts.

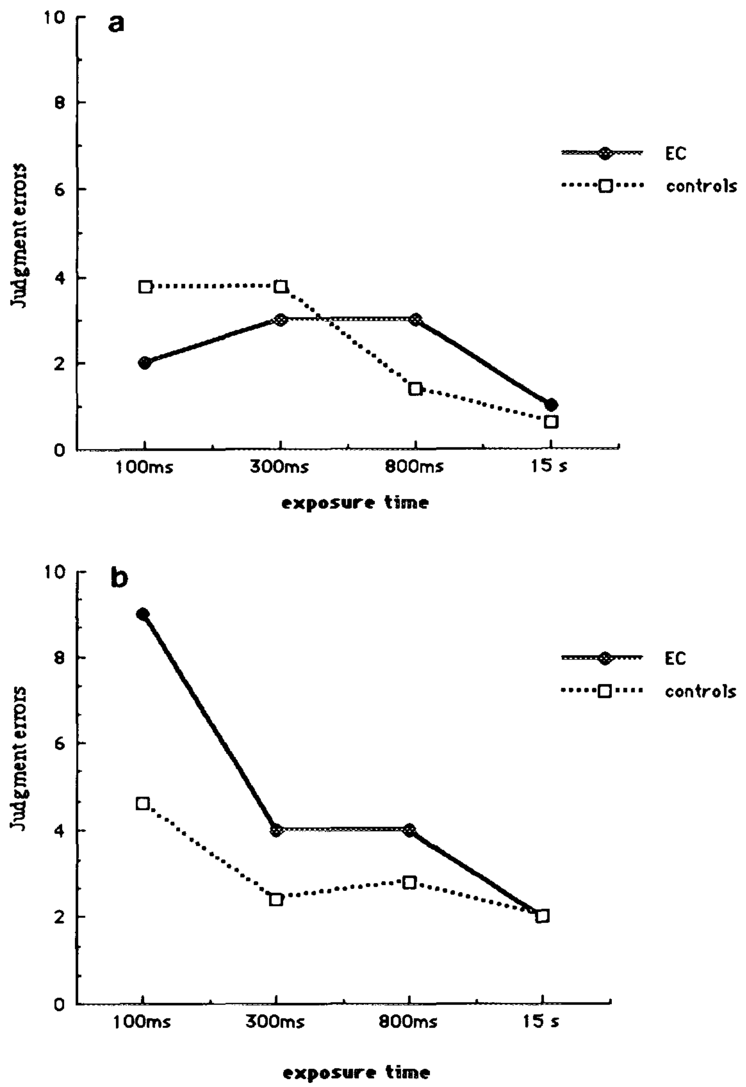

FIG. 6. Performance on the figure decision task by E.C. and a group of controls on (a) possible and on (b) impossible figures.

GENERAL DISCUSSION

The aim of the present study was to assess if a thorough analysis of E.C.'s perceptual behavior and performance could unveil qualitative differences in his perceptual processing. At the initial representation level, the analysis of contour is normal (Experiments 1 and 2): he is able to extract most features or discontinuities from a sensory input. However,

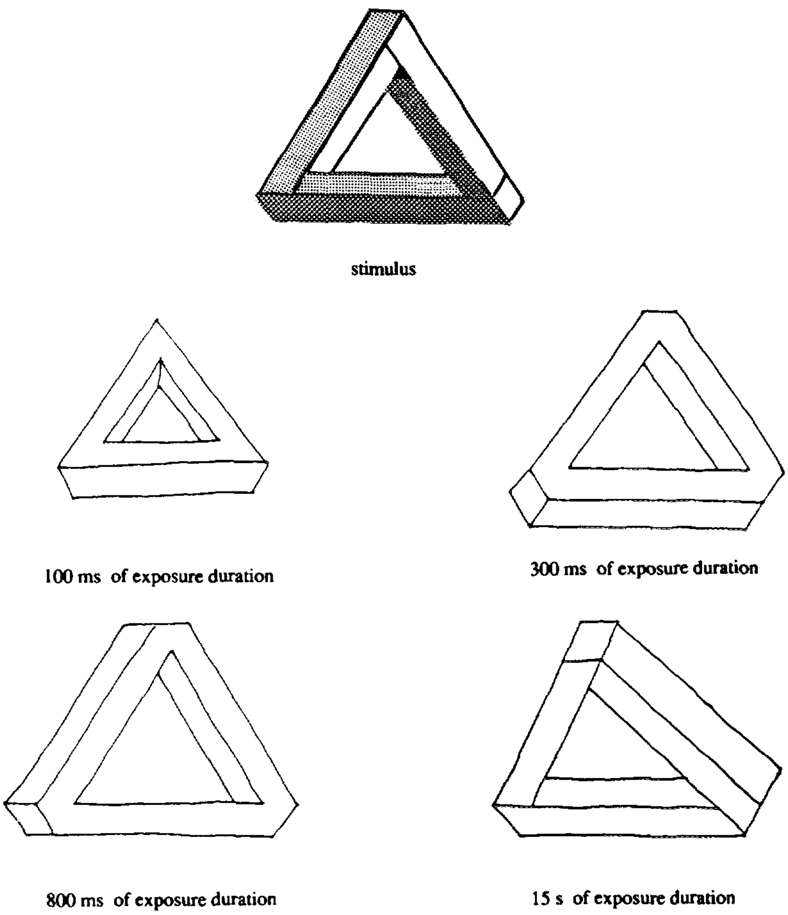

FIG. 7. One example of E.C.'s graphic recall of an impossible figure at increasing exposure duration.

his use of colors is inadequate (Experiment 3). At the level of object construction, E.C. succeeds in elaborating 3-D representations (Experiment 4) from viewer-centered ones. The matching of the 3-D model with a representation in a form lexicon is possible (Experiment 5 and 7), as well as the access from this lexicon to the name of objects (Experiment 6).

In contrast, an anomaly in the hierarchical organization of figure parts was observed using a series of different tasks. In hierarchical stimuli, E.C. has a normal global advantage but shows a local interference effect (Experiment 8). He fails to show global organization in copying and recalling from memory the features composing objects (Experiment 9). Finally, he is less efficient than controls in the detection of the geometrical impossibility in figures that are locally possible but globally impossible (Experiment 10).

The Hierarchy Anomalies in E.C.'s Pattern Analysis

E.C.'s impairment in hierarchical ordering cannot be related to a disorder at the local or global levels as such, since both are accurately processed in different conditions (see Experiment 8). Furthermore, in the perception of usual objects or in simple pattern recognition, E.C. is unimpaired. If either level was clearly defective, this should somehow affect E.C.'s perception of objects.

The hierarchical organization defect may rest on the alteration of at least two conditions. In order to fulfill a hierarchical ordering of parts and wholes after their respective processing first, the global level should possess a special status and second, the different parts of the figure should be interconnected. Each of these two possible explanations for E.C.'s hierarchical deficit will thus be assessed hereafter.

The local interference effect observed in E.C.'s perception of hierarchical stimuli reflects the fact that the interaction between levels favors the local one. This local interference effect is unlikely to reflect an attentional (Kinchla, Solis-Macias, & Hoffman, 1983) bias toward the local level, since it is not observed with congruent stimuli. A possible explanation for such a local interference effect is that the global level (or the outline) does not possess any special status. As was said earlier, the global advantage observed in E.C. for congruent stimuli reflects the fact that global features receive a faster processing and may be dissociated from the interference effect, which in turn reflects a true hierarchical organization. The global interference effect usually observed in normals when the two levels contradict is caused by the global level having a privileged status in perception. In the case of E.C., the speed advantage of the global level disappears when the two levels contradict to allow a local interference effect to show. We suggest that this local interference effect is observed with incongruent stimuli not because the local level has a special status, but because the global level has no particular status in E.C. Since the elements composing the local level are much more numerous (13 and 16) than those composing the global level (1), the former just outweigh the latter in the response selection. According to a similar hypothesis, an outline, which may be considered a global level, should never be ordered in a pole position by E.C. This is indeed observed in E.C.'s graphic production where the outline appears in any position in feature recall. The hypothesis of an unprivileged status of the global level is therefore also consistent with E.C.'s graphic performance.

The hierarchical organization defect is also evidenced by a lack of interconnection between parts. This is supported by the absence of rigid sequences in graphic copy and recall (Experiment 9). Indeed, to make a sequence between two elements, these have to be connected in some way. The absence of such connections in recall and memory is thus compatible with the fact that each feature in the figure is independent from the other. The same anomaly may account for E.C.'s difficulty to judge impossible figures in Experiment 10. In effect, the perception of the geometrical impossibility requires the integration of various local parts into a global form as well as an interaction between the local and global aspects of the pattern. The fact that this difficulty arises only with short exposure durations is further evidence in favor of a weakened integration hypothesis, because in this case, the analysis cannot depend on alternative strategies.

There is thus evidence for an impairment of hierarchical organization in E.C.'s perceptual analysis which is robust enough to resist a change in the semantic value of the material used (from meaningful, in Experiments 8 and 9, to meaningless, in Experiment 10) and in conditions of testing. Two hypotheses are compatible with this impairment, an absence of interconnection between global and local information, and between parts, and an absence of a special status for the global level. These two hypotheses are not mutually exclusive and may be causally or developmentally related. For example, in parallel models of pattern identification (Rummelhart & McClelland, 1987) the interconnection between parts is necessary to ensure a special status of the outline during the normal development. The interaction between units yields a gradual modification of their respective "weight." The relative status of the different parts of a pattern is confirmed by each new identification. As a result, there is a trend for the differential status of parts and wholes to gradually separate from one another. According to this model, an alteration of the interaction between parts would occur first. This self-perpetuating anomaly would secondarily prevent the developmental elaboration of the different status between whole and parts.

Implications for E.C.'s Graphic and Recognition Performance

How can the lack of hierarchical organization observed here in E.C.'s perception relate to his special graphic abilities? In normal subjects, the hierarchization in favor of the global level probably brings a gain in graphic organization but in turn, a loss of local precision. The absence of hierarchization in E.C. should free local levels from global interference, yielding a benefit in local precision. Such a benefit is indeed observed in E.C. and is exemplified by the extreme precision he shows for graphic details such as angles, curves, and lines. Impoverishment of the relationships between levels may also relate to E.C.'s absence of corrections in drawings. Indeed, in the video analysis of the flute drawing reported in

Experiment 9, the control draftsman returned frequently backward to modify the global outline each time a new local component was added. This modification of an already drawn feature under the influence of a newly drawn one was never observed in E.C. and this may be due to the lack of interconnections between the various features.

A lack of hierarchical organization is also likely to bear costs. At the perceptual level, it is quite surprising that the hierarchical organization defect observed in E.C. has no obvious detrimental effect on his perceptual analysis of objects and shapes. Indeed, Experiments 1 to 7 showed that E.C. is not agnosic and performs like normals on various perceptual judgement tasks. In that respect, E.C. differs from patients with integrative agnosia (Grailet, Seron, Bruyer, Coyette, & Frederix, 1990; Humphrey & Riddoch, 1987a, 1987b; Riddoch & Humphrey, 1987) who, following brain-damage at adult age, fail to recognize objects due to an incapacity to integrate their various parts. This may be related to the fact that the lesion suspected in autistic subjects arises early in life when cerebral plasticity allows alternative processes to be engaged in cognitive functions for which they are not wired for. At the level of graphic productions, the cost that may arise from a hierarchical defect is not evident. Interestingly though, E.C.'s graphic abilities for mechanical objects and living creatures are strikingly different. Indeed, while E.C. is exceptionally skilled in drawing artifacts, he is not particularly good at drawing human or animal faces. This could arise from an intrinsic difference in the part–whole organization of biological and nonbiological objects. Mechanical objects are distinguished among each other by the presence or absence of particular morphological parts. By contrast, living creatures are differentiated by the proportion of their different components. A similar explanation of category-specific impairment has already been proposed to explain one case of category-specific agnosia (Decter, Bub, & Chertkow, 1989).

Implications for E.C.'s Autistic Syndrome

Can a defect in hierarchical organization impair E.C.'s behavior in other domains of knowledge? Infantile autism is characterized by anomalies in numerous heterogeneous domains, extending from perception to social cognition. It is generally agreed that a common cognitive defect should underly these various behavioral symptoms (for example, see Frith, Morton & Leslie, 1991). Thus, an anomaly of pattern hierarchization may be a possible candidate for this common underlying cognitive factor. Indeed, "local" and "global" levels are concepts that are valuable across modalities. Studies of hemispheric lateralization in normal subjects and brain-damaged patients have suggested a specialization in global or local processing across domains (music, prosodic speech, language in context and visual patterns) for the right and left hemisphere respectively (e.g., Bradshaw & Nettleton, 1981; Joanette, Goulet, & Hannequin, 1990; Kosslyn, 1987; Peretz, 1990; Robertson & Delis, 1986). Although one must remain prudent in attempting to generalize these concepts to various domains of knowledge, there is evidence for their relevance with respect to the explanation of some of the autistic signs. On the one hand, the frequent occurrence of several special abilities in the same savant (calendar calculations in some hyperlexics, Aram & Healy 1988; and musical savant, Judd 1988) supports the notion of a single common impairment. On the other hand, random order of recall, one of the particularities from which we infer an impairment of pattern hierarchization, was observed in autistic subjects with other domains of competence (Goldberg & Rothermel, 1984; Howe & Smith, 1979). In the following section, the relationship between anomalous hierarchical organization that favors the local level, and some of the perceptual characteristics of E.C. and typical autistic subjects, will be speculatively examined.

Autistic subjects are known to detect minor modifications in their surroundings more rapidly than normals and to fixate on small morphological details (Rimland, 1971). The impossibility to remove one's attention from a local feature could be a behavioral correlate of a pathological modification of the local/global trade-off in favor of local features. Some of the data on the perceptual abilities of autistic subjects are also congruent with that hypothesis. Shah and Frith (1983) observed that even low-functioning autistics recognize hidden figures better than controls, a task which, in normal subjects, is slowed by the embedding of the target in a larger unit. The WAIS profile of autistic subjects may bear on similar perceptual grounds. Block Design and Object Assembly, the two subtests where E.C. and autistics performed above their IQ, rest on local-by-local matching. Additionally, autistic subjects are known to be excellent at jigsaw puzzles and observations have shown that, unlike controls, they do so by using the shape of the pieces rather than the image pattern figuring on the pieces (Frith & Hermelin, 1969). The local-by-local progression, constrained by the jigsaw task, violates the normal local/global interaction. Therefore, a subject pathologically limited in such an interaction should be advantaged. Secondly, building a jigsaw puzzle without the help of the image pattern constitutes another example of an absence of interaction between the local (the shape of the piece) and global (the scene to build) parts of a figure in natural settings. Our hypothesis could thus account both for autistics' general aptitude to be performant in jigsaw puzzles and for their not using the image pattern in building them.

At a more abstract level, the local/global hierarchical organization is a formal relationship in which the domain of validity surpasses perceptual objects. It may also apply to any mental representations which constitute a combination of events. An example of this is action planning. The achievement of a scheduled action requires the ordered planning of a number of partial steps leading to the general goal to be fulfilled. In normal individuals, a mismatch between the various steps that are parts of a planned program and those actually performed in reality will not block its actualization. In autistic patients though, like in E.C., the frequent and characteristic interruptions in programmed actions are often caused by small mismatches between what occurs and what was planned. If it is possible to extend in the same way a perceptual relationship to more abstract counterparts, several seemingly different autistic symptoms of E.C. could be linked to the same explanation: E.C.'s weakness in logical reasoning, his misunderstanding of contextual variation in semantic content, and his inability to understand humor. The pattern of performance observed here may thus have a generalization power with respect to the autistic pathological behavior. Of course, at this point, such a relation remains speculative.

In conclusion, the extensive analysis of an autistic subject with outstanding graphic abilities indicated a selective defect in the part/whole hierarchization of visual stimuli. This anomaly has repercussions on his visuo-graphic strategies and on perceptual tasks, which require the integration of parts and wholes. It is also hypothesized that this defect crosses domains in autistic subjects and underlies a larger range of pathological behaviors. Remarkably, E.C.'s drawing characteristics are comparable to those of other "savant" draftsmen presented in the literature (Hermelin & O'Connor, 1990; O'Connor & Hermelin, 1987a; O'Connor & Hermelin, 1990; Selfe, 1977, 1983): age and mode of beginning of drawing are common; they all showed a particular ability with perspective; they rarely use color or texture; they all exhibited the same idiosyncratic tendency to begin a figure by a peripheral detail. However, since E.C. is the first case to be explored using a cognitive theoretical model, the comparison between our subject and other exceptional autistic draftsmen is limited to these descriptive aspects. While they are likely to share the same cognitive anomaly, this will remain a hypothesis until more autistic savants are assessed using a cognitive approach.

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