Object Recognition Difficulty in Visual Apperceptive Agnosia

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Two patients with visual apperceptive agnosia were examined on tasks assessing the appreciation of visual material. Elementary visual functioning was relatively preserved, but they had profound difficulty recognizing and naming line drawings. More detailed evaluation revealed accurate recognition of regular geometric shapes and colors, but performance deteriorated when the shapes were made more complex visually, when multiple-choice arrays contained larger numbers of simple targets and foils, and when a mental manipulation such as a rotation was required. The recognition of letters and words was similarly compromised. Naming, recognition, and anomaly judgments of colored pictures and real objects were more accurate than similar decisions involving black-and-white line drawings. Visual imagery for shapes, letters, and objects appeared to be more accurate than visual perception of the same materials. We hypothesize that object recognition difficulty in visual apperceptive agnosia is due to two related factors: the impaired appreciation of the visual perceptual features that constitute objects, and a limitation in the cognitive resources that are available for processing demanding material within the visual modality. © 1997 Academic Press

INTRODUCTION

Visual apperceptive agnosia, first described by Lissauer (1890), refers to difficulty recognizing an object where higher-level visual processes are impaired but elementary visual functioning is relatively intact. Cases of apperceptive agnosia, as narrowly defined by Farah (1990), have been reported infrequently (Warrington & James, 1988; Landis, Graves, Benson & Hebben, 1982; Gelb & Goldstein, 1918; Efron, 1968; Campion & Latto, 1985; Cam-
The purpose of this study is to describe two additional patients with apperceptive agnosia, focusing specifically on their perceptual processing difficulties.

In apperceptive agnosia, visual fields and visual acuity are typically normal. Most of these patients can maintain visual fixation and reach for a moving target. Despite the relative preservation of elementary visual functions, these patients have profound difficulty recognizing visually presented material. One agnosic patient described a circle as “lots of dots” (Campion, 1987). Another patient could not distinguish between “X” and “O” (Benson & Greenberg, 1969). Apperceptive agnosics are said to have difficulty copying geometric shapes and letters, and apparently cannot match a target geometric shape to one of several choices. Several investigators have observed that apperceptive agnosics use their hands in an attempt to help understand what they are seeing (Landis et al., 1982; Gelb & Goldstein, 1918; Efron, 1968). Thus, they might trace letters and shapes with their index finger; however, other patients derived little benefit from this strategy since they were unable to trace visual figures (Campion, 1987; Alexander & Albert, 1983). Object recognition may have been assisted in several patients when the object was moved (Efron, 1968; Benson & Greenberg, 1969; Alexander & Albert, 1983), but this did not help other patients (Landis et al., 1982). It is often stated that apperceptive agnosics can recognize real objects better than geometric shapes and pictures. For example, several of these patients were impaired on tasks measuring spatial, shape, and perspective appreciation, but were able to make accurate semantic judgments of visual stimuli (Warrington & James, 1988).

Hypotheses forwarded to account for visual apperceptive agnosia can be evaluated within the context of models such as Lissauer’s (1890) characterization of visual object recognition. He postulated that several dissociable components contribute to the appreciation of visually presented material. For the purpose of the present paper, a highly simplified description of an object recognition mechanism includes a visual sensory impression that is interpreted by special-purpose processors subserving the appreciation of specific perceptual features such as color and shape. These visual characteristics are assembled into a perceptual description of the object that allows it to be recognized from unusual perspectives. Semantic memory is the long-term mental representation of information about objects, and this contributes to understanding an object and relating it to other meaningful experiences. The processes associated with each of these components may be selectively compromised by a specific lesion locus. Moreover, these perceptual, integrative, and semantic processes require time for their execution and occupy some proportion of a limited-capacity short-term visual memory system. Working memory processes such as the selective distribution of attentional resources and the organized execution of multiple processes help overcome some limitations associated with these features of a visual processing device. Neverthe-
less, limitations are imposed on the ultimate capacity of the processing system such that more complex and demanding visual material requires greater processing resources than simpler visual material. These cognitive resources are thought to be a property of the flow of information within the entire processing system, analogous to a parallel distributed processing network, and thus may be compromised in proportion to the size of the defect.

Impairments in each of the perceptual, integrative, semantic, and attentional processing components have been proposed to account for apperceptive agnosia. For example, it has been hypothesized that the visual fields of apperceptive agnosics have many small scotomata that mask accurate visual perception, and that a sensory defect thus may account for their object recognition difficulty (Campion & Latto, 1985). Other investigators have proposed that the appreciation of an object’s perceptual features such as form and color may be compromised (Warrington, 1985; Warrington & James, 1986, 1988; Humphreys & Riddoch, 1984). Some have suggested that apperceptive agnosics are compromised at the level of integrating this perceptual information into a coherent whole that allows an object to be recognized (Warrington & Taylor, 1978; Warrington, 1985; Riddoch & Humphreys, 1987). Recognition difficulty in visual agnosia also has been attributed to the failure of visual sensory impressions to trigger the appropriate information in semantic memory (Damasio, 1985). Finally, poor regulation of attentional resources has been cited as a cause of apperceptive agnosia (Humphreys & Riddoch, 1987; Luria, 1966).

The studies described below attempted to examine the nature of the object recognition difficulty in visual apperceptive agnosia by assessing their ability to appreciate a variety of visual materials. Thus, we asked patients to judge geometric shapes, letters, and colors that were made increasingly complex visually, were rotated and subjected to other manipulations, and were administered in increasingly demanding contexts. We also assessed their appreciation of qualitatively different representations of materials such as line drawings, colored pictures and photographs, faces, and real objects. Finally, we evaluated their visual imagery of letters and objects. We hypothesized that object recognition difficulty in visual apperceptive agnosia is multifactorial in nature: Their deficit is due in part to a visual perceptual processing impairment and to a limitation in the cognitive resources available to their visual processing system. These deficits were thought to reflect at least two of the consequences of insult to an object recognition device: the particular locus of the lesion within the visual processing system, and the size of the defect in the system. From this perspective, moreover, visual agnosics have a central processing deficit that should limit the value of compensatory sensorimotor strategies such as finger tracing and object movement within the visual field. We hypothesized instead that they could use their relatively preserved semantic processing to optimize the object recognition capability of their residual visual processing system.
CLINICAL HISTORIES

Case SZ

SZ is a 54-year-old right-handed accountant and businessman who was well until a massive myocardial infarction resulted in his admission to hospital. When he awoke, he was found to be confused and speaking in a slurred manner, but these problems cleared rapidly. He was initially thought to be blind. General physical examination and neurological examination were largely normal. Neuroophthalmological evaluation at 1 and 6 months after his myocardial infarction revealed pupils that were 3 mm, round, and symmetrically responsive to light. He had a bilateral altitudinal defect on confrontation testing but was able to see in his superior hemifields. Visual acuity was difficult to test formally due to the patient’s impairment with letter targets, but he was able to identify colored blobs the size of a 20/40 letter on a near card (about 2 mm). He reached accurately for moving targets under visual guidance. There was no evidence for extinction of lateralized stimuli during double simultaneous stimulation. Assessment of ocular motility revealed full conjugate gaze in response to pursuit of a target and requests to look in a particular direction. Pursuit movements were performed smoothly, and saccadic eye movements were intact. The retina and optic nerve were normal.

Clinical mental status testing is summarized in Table 1. Reading and pic-

<table>
<thead>
<tr>
<th>Task</th>
<th>SZ</th>
<th>AP</th>
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<tbody>
<tr>
<td>Orientation</td>
<td>Intact</td>
<td>All but date of month</td>
</tr>
<tr>
<td>Auditory vigilance</td>
<td>100%</td>
<td>100%</td>
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<tr>
<td>Digit span (forward, backward)</td>
<td>9, 8</td>
<td>6, 4</td>
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<td>Rey Auditory Verbal Learning Test (trial 1, trial 5)</td>
<td>8, 12</td>
<td>3, 5</td>
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<td>Rey Auditory Verbal Learning Test recognition (30 min)</td>
<td>13</td>
<td>10</td>
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<tr>
<td>Spontaneous oral expression</td>
<td>Intact</td>
<td>occ. word-finding problems</td>
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<tr>
<td>Oral repetition</td>
<td>10/10</td>
<td>10/10</td>
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<tr>
<td>Oral lexical comprehension</td>
<td>30/30</td>
<td>28/30</td>
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<tr>
<td>Oral sentence comprehension</td>
<td>36/36</td>
<td>28/36</td>
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<tr>
<td>Naming to auditory or tactile confrontation</td>
<td>20/20</td>
<td>20/20</td>
</tr>
<tr>
<td>Gesturing use of visually presented objects</td>
<td>0/10</td>
<td>0/10</td>
</tr>
<tr>
<td>Gesturing use of objects presented auditorily or tactilely</td>
<td>20/20</td>
<td>19/20</td>
</tr>
<tr>
<td>Single-word reading</td>
<td>0/15</td>
<td>0/15</td>
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<tr>
<td>Letter writing to dictation</td>
<td>26/26</td>
<td>26/26</td>
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<tr>
<td>Writing single words to dictation</td>
<td>30/30</td>
<td>28/30</td>
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<tr>
<td>Oral spelling of single words</td>
<td>80/80</td>
<td>71/80</td>
</tr>
<tr>
<td>Oral naming of spelled words</td>
<td>30/30</td>
<td>28/30</td>
</tr>
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ture comprehension were severely compromised. He attempted to feel words and pictures on the paper with his fingers and often tried to trace a letter or a pictured object’s outline with his finger, but this rarely improved his performance. His visual object recognition difficulty did not improve by gently moving the object. His writing was intact. He was able to demonstrate an object’s use to tactile or auditory presentation, but not when presented visually.

Diagnostic evaluation revealed all blood studies to be negative, including tests for syphilis, thyroid function, vitamin B₁₂ and folate, serum electrolytes, glucose, and red and white blood cell counts. An EEG revealed occasional slowing that was most prominent posteriorly. An MRI scan 1 month after his accident was normal, and a SPECT scan at this time revealed extensive bilateral hypoperfusion in visual association cortices (Silverman, Galetta, Gray, Moster, Atlas, Maurer, & Alavi, 1993). A follow-up MRI scan 6 months later revealed a question of abnormal high signal intensity bilaterally in occipital association regions that was interpreted to be consistent with ischemia in a posterior watershed distribution, and a PET scan revealed extensive hypoperfusion bilaterally in middle and inferior temporooccipital cortices that spared primary visual cortex (Grossman, Galetta, Ding, Morrison, D’Esposito, Robinson, Jaggi, Alavi, & Reivich, 1996).

Case AP

AP is a 65-year-old, right-handed woman working as a substitute teacher who was well until 2 years prior to referral. Her family noticed that she was having difficulty managing her activities of daily living, and her neighbors expressed concern when she drove her car through the gardens in front of her house. Initial referrals to optometrists and ophthalmologists for correction of her visual acuity did not help. She had no exposure to toxins or carbon monoxide. Her mother had been blind from a very young age, but the etiology was unknown. General physical and neurological examinations were unremarkable. Clinical mental status testing, summarized in Table 1, revealed some memory difficulty. Reading and picture comprehension were profoundly compromised. She frequently felt printed words on the paper with her fingers and tried to trace the outlines of pictured objects. There were occasional perseverations that resulted in spelling errors (e.g., schools = “scchools”; was = “waaas”) and mechanical errors (e.g., three loops in writing a capital E), but her writing was otherwise easily interpreted. She was able to demonstrate an object’s use when presented auditorily or tactilely, but not when presented visually. Her recognition difficulty did not appear to improve following gentle movement of the object. Neuroophthalmological examination revealed pupils that were round and equally reactive to light. Visual acuity was performed slowly and with difficulty by the patient due to her ability to appreciate only letters presented individually. Under this
condition, she exhibited a best acuity of 20/25 right eye and 20/40 left eye. There was an intermittent left inferior quadrant visual neglect. The patient’s eye movements were slightly saccadic bilaterally. She was able to reach for a moving target under visual guidance. The retina and optic nerve were normal.

A diagnostic evaluation revealed normal blood studies for syphilis, thyroid function, vitamin B₁₂ and folate, serum electrolytes, glucose, heavy metals, and red and white blood cell counts. An MRI scan was interpreted to have some atrophy. A SPECT scan revealed extensive bilateral occipital association and temporal hypoperfusion (Silverman et al., 1993). A PET scan revealed a broad defect in bilateral middle and inferior temporoooccipital cortices that spared primary visual cortex (Grossman et al., 1996). A diagnosis of probable Alzheimer’s disease was made. This was confirmed histopathologically at 5 years following the evaluation described below.

EXPERIMENTAL METHODS AND RESULTS

Despite their ability to see in an elementary sense, it was clear that many visually mediated behaviors were compromised in these patients. We designed a series of studies to assess their appreciation of visual material in greater detail. Specifically, we performed five experiments to examine (1) the appreciation of black-and-white line drawings; (2) judgments of geometric shapes and colors, where we manipulated the complexity of these materials as well as the demands of the context in which these decisions were made; (3) the appreciation of letters and words, manipulated in a fashion similar to the geometric shapes; (4) the recognition of qualitatively different types of materials such as colored pictures, real objects, and faces; and (5) mental imagery of objects and letters.

Experiment 1: Line Drawings

We administered three visual tasks to SZ and AP to determine whether they had difficulty interpreting black-and-white line drawings.

*Boston Naming Test*

The patients were shown the black-and-white line drawings that are the stimuli from the Boston Naming Test (Kaplan, Goodglass, & Weintraub, 1983). They were asked to name spontaneously and to recognize the name of a stimulus if it was not named accurately. The choices, presented in random order, included the target, a semantically related foil, and a perceptually related foil. We contrasted visual confrontation naming with naming to tactile and auditory confrontation, administered during different sessions. The nonvisual items occurred with moderate levels of frequency. The 20 tactile stimuli, presented for unimanual palpation to either the right hand or the left hand, included items such as a pencil, a car key, a whistle, a flute, a telephone, and a coin. The 20 auditory stimuli, presented by tape recorder, in-
cluded many of the same items such as a tea kettle whistling, a car ignition starting, a flute sonata, and a telephone ringing.

During performance on the Boston Naming Test, SZ was accurate at naming only 5 (8%) of 60 pictures. His recognition naming was random (25% correct). He was very slow in his performance. At times he appeared to focus on a particular perceptual attribute of the stimulus and used this as the basis for the picture’s name. For example, scissors was described as “a circle, something coming down (gesturing), and a circle,” but was named “an ice cream cone.” A whistle was described as “a circle going back that way (gesturing) with a line,” and then was labeled “a key in a lock.” However, the perceptual features he described on other occasions were not in the target picture. At times, his accuracy improved when he perceived a distinct perceptual feature. Thus, he accurately named a comb, saying “I could see the teeth.” He also named an octopus and a mushroom correctly, referring to the appropriate diagnostic features.

We contrasted visual confrontation naming difficulty with the ability to name objects to tactile and auditory confrontation. SZ was 100% accurate on two occasions in briskly naming to auditory confrontation. He was specific in his responses, including “a kettle whistle” and “a car engine trying to start.” He was also 100% accurate in his detailed naming to tactile confrontation on two occasions, such as “pencil with an eraser” and “keys for a Volvo.”

When asked to name and recognize the stimuli from the Boston Naming Test, AP frequently commented “I don’t see it” or “It’s got alot of stuff—I’ll try to pick out one thing.” Her response latencies were very prolonged. She often felt the picture by rubbing it or attempting to trace some line contours with her fingertips; however, she was never accurate in naming a picture, and her recognition naming was random. At times she focused on a particular perceptual attribute and used this as the basis for her name. Thus, the finger holes of scissors became “wheels of a big car,” and the bristles of a brush resulted in the name “fence.” Typical responses, however, were random, and she often named and described perceptual features that were not a part of the target picture. Her attempts to trace line contours in the pictures with her finger often began appropriately, but her tracing then progressed to random finger movements along the paper surface that were unrelated to the lines constituting the picture.

The poor visual confrontation naming seen in AP contrasted with her 100% accuracy on two occasions in naming to auditory confrontation such as “keys” and “motor” and 100% accuracy in naming to tactile confrontation such as “pencil” and “key.” Her naming in these situations was brisk.

Anomaly Judgments of Black-and-White Line Drawings

To evaluate object recognition on a task requiring less than complete and exhaustively accurate visual perceptual analysis, we assessed the patients’
ability to judge the coherence of shape properties of visual material. Specifically, the patients were asked to judge the correctness of black-and-white line drawings depicting animals (Chertkow & Bub, 1990). Half of the pictures were anomalous since they were composites of two animals, such as the head and front legs of a pig attached to the torso and tail of a lion.

SZ performed randomly (57% correct) in judging whether a stimulus was truly a kind of animal. AP was also random (47% correct) in her judgments of the same pictures.

Description of the Cookie Theft Scene

The patients were asked to describe the Cookie Theft Scene from the Boston Diagnostic Aphasia Examination (Goodglass & Kaplan, 1983). This complex line drawing was developed to elicit a spontaneous speech sample from aphasic patients. We administered this to patients to determine whether an enriched, black-and-white line drawing context helped the patients interpret the sketched objects.

SZ was allowed to comment over 10 minutes. He said: ‘‘I see a whole bunch of lines. Are there animals in this?’’ A minute later, he said: ‘‘Something tells me there are animals in this.’’ Approximately 2 minutes later, he noted: ‘‘I can see a white background and black lines . . . lines up here and lines down here.’’ Several minutes later, he observed: ‘‘But the Gestalt: I can’t make sense of it.’’ His performance was very slow and tedious. He tried to feel the picture and attempted to trace the contours with his index finger. This did not help him recognize any elements of the picture since his finger tracing corresponded to the black lines only occasionally.

AP was also given 10 minutes to describe the Cookie Theft Scene. More than 2 minutes after she began looking at the picture, she commented: ‘‘This looks like a face with hair around it (pointing to the mother’s face).’’ More than a minute later, after having explored other parts of the picture, she returned to the mother’s face and stated: ‘‘This looks like a lady up here, that’s her face and hair.’’ A minute later, she stated: ‘‘I really can’t see anything in it. I see alot of squiggly things but it doesn’t mean anything to me.’’ Pointing to the handles of the cabinets in the lower right corner of the picture several seconds later, she said: ‘‘These could be nails down here.’’ A minute later, she pointed to the handles on the cabinets to the left of the mother and stated: ‘‘These could be files, you know, a nail file. I just see little squiggly . . . these all look like nails.’’ A minute later she returned to the mother’s face and said: ‘‘I told you about the lady up here.’’ Then she pointed to the boy and stated: ‘‘There’s another lady.’’ Indicating the lower left quadrant of the picture, she then said: ‘‘I didn’t go down there. I don’t think there’s anything in here.’’ Several seconds later she pointed to the stool and said: ‘‘Looks like alot of hair.’’ Finally, she pointed to the plates on the counter at the left of the picture and said: ‘‘This over here looks like squiggles.’’
During her description, she continuously attempted to feel the black lines used to draw the picture. She also attempted to trace these lines with her finger, albeit inaccurately, and thus this motor feedback appeared to contribute little to her visual recognition performance.

Taken together, these findings demonstrated that SZ and AP have profound difficulty in their recognition of black-and-white line drawings. Thus, their naming and recognition performance on the Boston Naming Test was poor, although their accurate naming to auditory and tactile confrontation emphasized the visual nature of their impairment. Attempts to use motor feedback strategies such as finger tracing did not appear to compensate for their poor recognition performance. While they attempted at times to infer the object from a detail property, this strategy was used only intermittently and was rarely successful. They were also random on a task requiring judgments of visual anomaly, emphasizing their difficulty deriving even partial information from line drawings that would permit a judgment of object coherence. Their descriptions of the Cookie Theft Scene were impoverished and laboriously slow, suggesting that attempts to enrich the visual context with additional, linelike material was not helpful.

Experiment 2: Geometric Shapes and Colors

One possible explanation for the impaired performance of visual agnosics is that they are limited in their appreciation of the visual perceptual characteristics that constitute the objects that they cannot recognize. We sought to determine whether SZ and AP could appreciate very simple forms such as regular geometric shapes. These materials were then made more complex to determine whether a perceptual deficit for shape interfered with performance. We also assessed their appreciation of color. Finally, we manipulated the cognitive resource demands of the context in which these form and color judgments were made by requiring the detection of a simple target form or color in a more complex visual setting.

**Simple Geometric Shapes**

SZ and AP were first assessed in their ability to select one of three available choices that matched a target regular geometric shape. The shapes included designs such as circles, squares, rectangles, and triangles, and were about 3 cm in size. These were equally divided between outlines where the black lines were 4 points thick and filled shapes. All materials were drawn in black against a white background. The choices were arrayed horizontally, and the correct response was equally distributed across the left, middle, and right positions of the choice array. The patients were prevented from tracing the forms with their finger.

SZ performed with 80% accuracy on 20 trials. His errors were equally distributed in the left and right positions of the choice array, and included
both filled shapes and outlines. AP performed with 100% accuracy. These findings, summarized in Table 2, indicated that SZ and AP can appreciate simple, regular geometric forms presented visually, and thus that the interpretation of all black-and-white shape material is not compromised in these patients.

**Geometric Form Complexity**

The same match-to-sample paradigm was used to evaluate somewhat more complex visual forms. The stimuli for these judgments consisted of two partially overlapping regular geometric shapes that had previously been judged with good accuracy (e.g., a circle partially overlapping a square, a rectangle partially overlapping a triangle) drawn in black against a white background that were unfilled or filled.

SZ was accurate 31% of the time over 35 trials. AP was accurate on 70% of the 35 trials. It may be noted that errors were not regularly distributed in a lateralized fashion, as summarized in Table 2.

On some additional trials, SZ and AP were allowed to use their spontaneously developed strategy of tracing the outlines of the geometric shapes with their finger. They both adopted the strategy of following a line or edge until it intersected with another line or edge, then exploring the directions in which the intersecting lines traveled. At times, they would move their finger along

| Table 2 |
|---------------------|---------------------|---------------------|
| Match-to-sample task\(^a\) | Geometric shapes | Letters and words | Objects |
| | SZ | AP | SZ | AP | SZ | AP |
| Simple | 80% | 100% | — | — | — | — |
| Complex | 31% | 70% | 44% | 48% | 70% | 70% |
| | — | — | 53% | 50% | — | — |
| | — | — | 33% | 22% | — | — |
| | — | — | 33% | 35% | — | — |
| Left target | 64% | 57% | 40% | 70% | 30% | 30% |
| Right target | 47% | 83% | 52% | 40% | 40% | 40% |
| Manipulation \(\leq90^\circ\) target rotation\(^b\) | 43% | 55% | 40% | 56% | 50% | 50% |
| | 180\(^\circ\) target rotation | 50% | 40% | 33% | 27% | — | — |
| | case | — | — | 50% | 50% | — | — |
| | font | — | — | 40% | 48% | — | — |

\(^a\) See text for more detailed descriptions of these tasks and related studies.

\(^b\) Only two choices were available for decisions about objects.
a trajectory that continued a line or an edge, even though there was no line or edge to follow. This finger tracing strategy thus did not appear to improve performance. In sum, form appreciation deteriorated with the use of partially overlapping geometric designs that had previously been judged with reasonable accuracy, suggesting that difficulty perceiving more complex shapes contributes to object recognition difficulty in visual apperceptive agnosia.

**Manipulating Visual Forms in Space**

The appreciation of visual material is not static but may be quite dynamic, involving mental manipulations such as rotations that allow the recognition of objects from multiple perspectives. These manipulations require shape perception as well as the cognitive resources to retain the shape mentally while it is being manipulated. We assessed the ability of SZ and AP to appreciate simple geometric shapes rotated in space. Specifically, the patients were asked to make match-to-sample decisions of designs composed of simple geometric forms (e.g., a square with a line extending perpendicularly from the middle of one side). Under this condition, the patients were asked to select the one correct match of a target from among three available choices where the correct choice was rotated from the original orientation of the target. On half of the trials the rotation was $90^\circ$ or less, and on the remaining trials the rotation was $180^\circ$. The foils were perceptual violations of the target. Performance on the control condition where patients matched unrotated stimuli was comparable to their performance with other simple geometric shapes ($SZ = 80\%$ correct, $AP = 85\%$ correct).

$SZ$ was correct on $43\%$ of the items that were rotated $90^\circ$ or less, and erred on $50\%$ of the items that were rotated $180^\circ$. $AP$ was correct on $55\%$ of the items that were rotated $90^\circ$ or less, and was correct on $40\%$ of the items that were rotated $180^\circ$. As summarized in Table 2, match-to-sample performance for simple geometric forms appeared to deteriorate when the patients were required to make mental rotations.

**Manipulating the Context of Shape Judgments**

The perceptual abilities of these patients may have been adequate to appreciate the form characteristics of a regular geometric shape, but the complex array of forms contributing to a line drawing may have exceeded the limited processing resources of a visual system with a large amount of damage. To investigate this possibility, we administered match-to-sample tasks using simple, unrotated geometric forms as targets, but manipulated the number of choices and the number of foils in a trial.

$SZ$ and AP were asked to select from among six choices arrayed next to each other the three selections that matched a simple, regular geometric shape target. The foils differed from the targets by one feature. On average, $SZ$ and AP selected one target and two foils from each of the 10 arrays that
were presented, worse than their match-to-sample performance with more complex geometric forms when only three choices were available.

SZ and AP were also asked to perform a match-to-sample task where 35 instances of a simple, filled target shape were arrayed on a 11 × 8.5-in. page among 140 foils. In contrast to his judgments of geometric shapes within simpler contexts, as summarized in Fig. 1, SZ was able to identify only one target over 10 minutes. To determine whether his poor performance was due to difficulty scanning the page or to the distracting effect of the foils, we also administered the scoring sheet to SZ. This showed only the targets in their locations on the sheet, but not the foils. He was able to identify 28 (80%) of 35 targets in about 5 min. His omissions were not preferentially distributed in the left or right visual hemifields. While still impaired, this was clearly better than his performance when the foils were present. Figure 1 summarizes AP’s judgments of simple geometric shapes within simpler contexts in contrast to her judgments within more complex contexts. As can be seen, she was able to identify only 11 (31%) of the targets from among the 140 foils in 10 min. There were 8 false-positive responses that AP thought were targets. When asked to detect the targets alone on the answer sheet, AP was able to identify 24 (69%) of 35 targets in 5 min. Her performance was slow and far from perfect, but she was able to identify many more targets when the foils were not present.

Fig. 1. Match-to-sample judgments of simple shape and color materials in visual apperceptive agnosia.
These findings suggested that the complexity of the context for shape recognition, not just the perceptual complexity of the target shape itself, played a role in their appreciation of black-and-white line drawings. The increased amount of time needed to explore a complex array and the poorer performance as the array size increased suggested that SZ and AP may have been restricted in the processing resources of their visual systems.

Simple and More Complex Color Judgments

We sought to determine whether the visual perceptual deficits of these patients were limited to shape or involved other visual perceptual attributes such as color as well. We administered a confrontation name task for swatches of the cardinal colors. We then administered three-choice, match-to-sample color judgment tasks to the patients that were analogous to the geometric shape judgments described above. The color stimuli consisted of 3 × 5-in. color swatches. One foil was from a closely related portion of the color spectrum and the second foil was from an unrelated portion of the color spectrum. We also asked SZ and AP to detect the presence of a target color (brown) in 80 more complex, color line drawings. The target color was present in half of the stimuli, and occupied approximately 5–10% of the stimulus area when the target color was present.

SZ was able to name the cardinal colors with 100% accuracy (although he called yellow “gold”). He performed with 88% accuracy on 25 match-to-sample trials of colors. His errors always consisted of related foils. SZ was able to detect the presence of the target color in a complex scene on 66% of trials.

AP was also able to name the cardinal colors using basic color terms with 100% accuracy. She performed with 100% accuracy on 25 match-to-sample trials for color material. AP was able to detect the presence of the target color in a complex scene on 59% of trials.

Thus, as summarized in Fig. 1, recognition of simple color proved reasonably easy for SZ and AP. Paralleling their judgments of shape, color judgments proved more difficult when set in a somewhat more demanding context consisting of other color elements.

Short-Term Memory during Geometric Shape and Color Judgments

AP had memory difficulty at the time of testing, although memory functioning was normal in SZ. We sought to determine whether memory limitations could account in part for the visual processing difficulties of these patients. To assess the role of visual short-term memory (STM) in recognizing simple geometric forms and colors, we repeated the match-to-sample tests for simple geometric forms and colors described above but with a 5-sec exposure period and a 10-sec unfilled delay before choosing from among the three available alternatives. SZ was accurate on 84% of 25 trials for geometric
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forms, and performed with 88% accuracy on 25 delayed match-to-sample trials for colors. The delay resulted in a decrement in AP’s performance with geometric forms (30% correct), but she performed with 80% accuracy on 25 delayed match-to-sample trials for colors. The baseline STM difficulties of AP thus were manifested on a delayed match-to-sample task using simple geometric forms, but were not evident in her performance with colors. This suggested that limited STM by itself may not be an adequate explanation for the object recognition difficulties of apperceptive agnosics.

In sum, SZ and AP performed adequately on a match-to-sample task involving simple, regular geometric shapes, emphasizing the relative preservation of their elementary visual functioning. Performance appeared to deteriorate when the shapes were made more complex visually or when a mental manipulation was required for appreciating the shapes. Moreover, their performance deteriorated when the context for the shape or color judgment task was made more demanding visually by including multiple targets and foils. These findings suggested that the compromised appreciation of perceptual features and a limitation in the processing resources of the visual perceptual system together may have contributed to the object recognition difficulty of the apperceptive agnosics.

Experiment 3: Letters and Words

A printed letter is arguably as familiar and frequent as a simple, regular geometric shape, although it is somewhat more complex than a regular geometric shape. We sought below to determine whether visual agnosics encounter the same difficulty with letters as they do with geometric shapes. Specifically, the patients were asked to perform match-to-sample judgments of physically identical letters and letters that have been manipulated. In addition, because of the special status that combinations of these particular geometric shapes may have with regard to being read as a unit, we examined match-to-sample judgments couched in the specific context of words. We evaluated the role of cognitive resource limitations in letter appreciation as well by manipulating the perceptual context in which letter judgments were made, paralleling our assessment of geometric shapes.

Written Letter Naming and Recognition

SZ and AP were asked to name uppercase block letters presented twice in random order. They were informed beforehand that the stimuli would be letters.

SZ was correct at naming 67% of the letters. He spontaneously adopted the strategies of attempting to name letters by feeling the surface of the page or attempting to trace the letters with his fingers. SZ was prevented from using these motor-based strategies in naming letters when reexamined in a different session, but letter naming accuracy did not change in comparison.
to naming with the aid of these extravisual strategies. AP was correct on 50% of the letters she named. On two occasions she accurately described what she saw (e.g., a “T” was “just a line across the top”) and then named the letter correctly. She also adopted spontaneously the strategies of naming letters by feeling the surface of the page or using her index finger to trace what she thought she saw. She was prevented from using these strategies for naming letters when retested in a different session, and was again correct in her naming 50% of the time. For both SZ and AP, this was less accurate than their confrontation naming of regular geometric shapes.

We administered a match-to-sample procedure for uppercase block letter recognition identical to the task used to assess geometric form recognition. The patients were not informed that the stimulus materials were letters. SZ was correct at selecting the matching letter on 22 (44%) of 50 trials. AP was correct at selecting the matching letter on 24 (48%) of 50 trials. As summarized in Table 2, match-to-sample performance for letters was less accurate than their performance with equally familiar, regular geometric shapes, but largely paralleled their recognition of more complex but less familiar geometric shapes. Table 2 also indicates that there was no regular relation between accuracy and the lateralized distribution of the choices. Thus, familiarity with letters did not improve recognition for visual shape material.

**Mental Manipulations of Written Letters**

We assessed performance on a match-to-sample task where the single target letters were rotated in space ±90° or 180° comparison to the orientation of the target. We also sought to determine whether the spatial nature of the manipulation was the basis for the patients’ difficulty. Thus, we asked SZ and AP to match letters following other, nonspatial manipulations.

SZ was correct on 18 (36%) of 50 items (40% correct for choices rotated ±90° and 33% correct for choices rotated 180°). AP was correct on 23 (46%) of 50 items (56% correct for choices rotated ±90° and 27% correct for choices rotated 180°). These findings are summarized in Table 2, where it can be seen that these results are quite comparable to the findings with more complex geometric shapes.

Other forms of mental manipulation of letters that are less determined by relative spatial properties involve uppercase–lowercase matches and the use of different fonts. SZ and AP were asked to match uppercase letters to lowercase letters. There were three alternatives, including the correct response, one of the foils perceptually related to the target, and one perceptually unrelated. They were each correct on 10 (50%) of 20 trials, as summarized in Table 2. Errors consisted disproportionately of perceptually related foils such as matching “Q” with “g” instead of “q” and “B” with “d” instead of “b”. We also administered a match-to-sample task with the letter choices printed in a font (i.e., italics) that differed from the font of the target. The
pattern of performance largely replicated our findings with a regular font. Thus, SZ was accurate at selecting the matching letter on 10 (40%) of 25 trials, and AP was accurate at selecting the matching letter on 12 (48%) of 25 trials. Perceptually related foils were no more likely to be selected than unrelated foils.

These findings suggested that difficulty appreciating mental manipulations is quite apparent for moderately complex geometric material, regardless of its familiarity and regardless of the type of mental manipulation that is required. These observations have implications for the broader issue of the recognition of real-world visual material such as objects viewed from an atypical perspective.

**Word Recognition**

Geometric forms were made more complex visually on a match-to-sample task by presenting pairs of partially overlapping shapes. We asked SZ and AP to match two-letter and three-letter pseudowords to a target using letters that could also be simpler geometric forms (e.g., ‘lo’, ‘olo’). These findings revealed that pseudowords are not treated differently from letters or more complex geometric forms.

To make letters more complex visually while minimizing the decrement in familiarity, AP and SZ were asked to match one of three words to a target word. The words were high-frequency tokens in the English vocabulary (e.g., ‘to’) that were two, three, or four letters long. SZ was 53% correct in his ability to match two-letter words, 33% correct for three-letter words, and 33% correct for four-letter words. AP was correct in 50% of her attempts to match two-letter words, 22% correct for three-letter words, and 35% correct for four-letter words.

These findings again paralleled the results with less familiar but equally complex geometric forms, suggesting that the visual complexity of the material is the most important determinant of recognizability. The increased familiarity of letters and words was not sufficient to overcome the perceptual processing deficit in apperceptive agnosia. We also observed that any manipulation of shape material, not merely a spatial rotation, can interfere with recognizability.

**Manipulating the Cognitive Resource Demands of Letter Judgments**

SZ and AP were asked to make match-to-sample decisions for letters under conditions where we manipulated the number of choices that were available. They were shown the target, a block capital letter, and then asked to select the matching letters from among six available choices. Three of the choices were targets, and the three foils were perceptually related nontargets such as a left–right mirrored representation of the letter, a 180° rotation of the letter, and a geometric manipulation of the letter.
SZ missed one or two targets on each of the trials for the 26 letters (0% correct trials). False-positive selections included mirrored and rotated items (for 5 letters), subtle omissions of a component of the letter (for 4 letters), and other perceptual changes that transformed the letter more radically (for 10 letters). AP missed one or two targets on all but eight (A, I, M, P, S, T, V, and W) of the 26 letters constituting the alphabet (31% correct trials). False-positive foils included mirrored and rotated items (for 7 letters), subtle omissions of a component of the letter (for 7 letters), and more radical changes that transformed the letter into a geometric shape (for 7 letters). Both patients took much longer to respond on this task than the match-to-sample tasks with fewer choices. Thus, as we observed with geometric forms, a limitation in the perceptual appreciation of letters and words in these patients may have been exacerbated by the inclusion of additional targets and distractors in the choice array.

Taken together, these observations demonstrated the compromised appreciation of letters in visual apperceptive agnosia. Specifically, naming and match-to-sample performance with letters was far from accurate. Performance was poorer when the target material was made more complex visually by requiring the judgment of letter strings and when the patients were required to make mental rotations and other nonspatial mental manipulations (case, font) of the target letters. Familiarity with letters and words thus did not improve performance in comparison to other geometric shapes. Moreover, performance was compromised when the number of targets and foils in the visual array increased, indicating that cognitive resource limitations also may contribute to compromised object recognition performance.

Experiment 4: Colored Pictures, Objects, and Faces

We demonstrated above that SZ and AP can make accurate judgments of simple geometric shapes and colors, but that recognition judgments deteriorated when the target materials are made more complex perceptually and when cognitive resource demands are increased. Colored pictures and real-world objects incorporate both color and shape attributes and require some appreciation of the convergence of different perceptual properties in a single mental description of an object and meaningful interpretation. In addition to the increased perceptual complexity, object recognition from this perspective also turns in part on the ability to integrate diverse perceptual characteristics, and such an integrative function has been hypothesized to be compromised in some apperceptive agnosics (Warrington & Taylor, 1978; Warrington, 1985; Riddoch & Humphreys, 1987). The increased perceptual and integrative processing required by these materials should make them even more difficult to interpret meaningfully when compared with black-and-white line drawings; however, reports of apperceptive agnosics have observed almost universally that real-world objects are recognized more accurately than the apparently simpler line drawings (Warrington & James, 1988). We demon-
strated above that familiarity alone is insufficient to support accurate visual interpretation. Thus, it is unlikely that a frequency-sensitive mental vocabulary of object representations supports object recognition. We hypothesize that apperceptive agnosics are more accurate in their appreciation of real objects and colored pictures because of the additive and complementary nature of their perceptual features, and the meaningful and nonarbitrary manner in which the perceptual features combine may reduce the cognitive resource demands that would otherwise be associated with such a complex visual stimulus. We tested this hypothesis below.

Comprehension of Photographs

We asked SZ and AP to name color photographs of objects viewed from a prototypical perspective. SZ typically focused on the colors in a picture first. For example, he looked at a picture of a room and said: ‘‘I can see orange, I can see black: it must be a Hallowe’en picture.’’ The colors were correct but the picture was not a Hallowe’en scene. When looking at a car, he said (correctly): ‘‘That’s bluish or green.’’ All of the named objects he subsequently provided could have been green or blue in color, but were related to the shape less often. SZ was never accurate in naming the object depicted in a color photograph on 50 trials.

When AP looked at color photographs of objects, her names were frequently constrained by the possible color of an object. She would often focus on a single shape characteristic as well, and label the picture as an object of that shape and color. For example, a round object was more likely to be named ‘‘lemon’’ or ‘‘sun’’ if it was yellow, but ‘‘ball’’ if it was striped. She noted a round, blue-gray colored object in a picture, stated that it must be a wheel, and then named the entire picture ‘‘a car.’’ She identified a long, dark-colored, tubular item in a picture and called it ‘‘a pencil or a pen.’’ Despite these apparent form and color constraints and the ability to integrate these impressions appropriately, she was accurate only once in naming the object depicted in the color photograph on 50 trials.

As summarized in Fig. 2, their naming of color photographs was no better than their naming of black-and-white line drawings. Aspects of their performance nevertheless suggested that they were able to bring form and color properties together in evaluating a picture, and were able to use these visual perceptual cues to develop a reasonable, semantically based hypothesis about the name of the picture.

Anomaly Judgments of Color Pictures

If these patients are able to perform limited perceptual processing and to use information from semantic memory to constrain the possible meaning of these perceptual impressions, then their judgments of color pictures with anomalous perceptual features ought to be significantly better than their nam-
Fig. 2. Visual confrontation naming of black-and-white line drawings, color photographs, and real objects in visual apperceptive agnosia.

Grossman and Mickanin (1994) created a category membership judgment task consisting of a set of 64 colored line drawings where patients are asked to identify the 40% of the stimuli that are vegetables. Half of the foils are anomalous since they violate a single perceptual characteristic (e.g., a square lettuce or a striped carrot) and half of the foils depict coherent objects but violate a semantic feature (e.g., a picture of a strawberry or a couch for the category “vegetable”).

Figure 3 summarizes the performance of SZ and AP in judging anomalous colored pictures, and includes for reference the patients’ judgments of line drawings. While the two tasks were not exactly matched, it can be seen that judgments of colored anomalous pictures were more accurate than judgments of anomalous animals that were black-and-white line drawings. The patients’ comments during this test indicated that their better performance was due in part to their ability to reject with some accuracy picture foils that include particular color patterns (e.g., pink) and contours (e.g., straight lines) that were likely to disqualify an item from being an instance of a target concept like “vegetable.” Thus, their judgments were likely to be based on feedback information from semantic memory and the incoherence of two conjoined perceptual features. Even if the patients could not fully recognize a picture, then, they appeared to be able to identify the presence of an incongruous perceptual feature that disqualifies an item from being an exemplar of a semantic category.
Recognition and Naming of Real Objects

Objects in the real world exhibit form and color features, but differ from color pictures since they display additional perceptual features such as relative size. Objects also can be viewed from a prototypical perspective that is most favorable for recognition or from a less ideal perspective that may require a mental manipulation for optimal recognition (Warrington & Taylor, 1978). SZ and AP were asked to perform match-to-sample tasks and to name real-world objects presented visually from a prototypical perspective and a less ideal perspective.

It may be recalled that the patients were accurate in their naming and gesturing the use of an object to auditory and tactile confrontation (Table 1). When presented from a prototypical perspective, SZ named 4 (20%) of 20 objects accurately. While far from normal, Fig. 2 indicates that this was better than his naming of line drawings and color photographs. In another session, SZ was able to match one of two dissimilar objects (e.g., a pencil and a coin) presented in prototypical orientations to a target on 7 (70%) of 10 trials. As summarized in Table 2, this was superior to his match-to-sample performance with geometric shapes and letters.
When asked to name the same objects during a different session but presented from an atypical perspective, SZ was able to name only 1 (5%) of the 20 objects. A bronze-colored key presented at a 20° tilt from the horizontal evoked the comment ‘‘gold—it must be a tie clasp or a watch.’’ In response to a quarter presented at a similar angle, he said: ‘‘triangle—a piece of folded paper.’’ SZ was also asked to judge whether pairs of identical objects presented in different visual orientations were the same or different. He was accurate on 50% of 10 trials.

AP named 10 (50%) of 20 objects accurately when presented from a prototypical perspective. Figure 2 illustrates that this was better than her naming of line drawings and color photographs. We also asked AP in a different session to match one of two dissimilar objects to a target presented in the same, prototypical orientation, and she was accurate on 7 (70%) of 10 trials.

AP was also asked to name the same objects during a different session when they were presented from an atypical perspective. She was unable to name any of the objects. A pen presented at about a 20° tilt above the horizontal from a direct view down the barrel was labeled ‘‘a ring’’; a key presented from a similar, longitudinal perspective was called ‘‘a pencil.’’ She was asked to judge whether two objects presented in different visual orientations were the same or different. She too was random, demonstrating 50% accuracy on 10 trials.

These observations suggested that naming and recognition accuracy for real objects improves because of the complementary, albeit partial, perceptual information that can be derived from these rich and meaningful visual materials. Nevertheless, there are important constraints on real-world object recognition. Among these is the dependence on a particular view of an object that avoids the need for a mental manipulation to reorient it into a more informative perspective.

Comprehension of Faces

An entailment of the patients’ relatively accurate judgments of anomalous color pictures is that they are able to integrate different perceptual features of a visual presentation. This impression received some support from the patients’ comments during color photograph naming. We sought to test the integrative capacity of these patients more explicitly by examining face recognition. Unlike objects and words, the recognition of a face may be less dependent on the integration of multiple smaller components into a larger whole (Koenig, Kosslyn, & Wolff, 1991; Farah, 1991). Thus, face appreciation may be relatively accurate if object recognition difficulty is at the level of integrating components into a whole. Benton’s (Benton, Hamsher, Varney, & Spreen, 1983) face matching test was administered to SZ and AP. This requires a subject to match a black-and-white photograph of a face,
stripped of peripheral characteristics such as hair and glasses, with one of six choices. The amount of visual material in a face may be too large for a limited-capacity visual processing system, so we also asked the patients to make face judgments that require the appreciation of a limited set of face attributes. Specifically, they were asked to judge the sex of the faces on Benton’s task. The experimenter also mimed five facial expressions, and the patients were asked to name these and judge whether the expression matched a name (e.g., “smile”, “frown”).

SZ stated that he could not recognize the faces of his family members, but that he recognized family members immediately by their voice. Correspondingly, SZ was quite compromised even on the simpler training items of the face matching task. He was correct on only one trial overall. He was random when he judged the sex of the target faces. SZ was unable to name facial expressions spontaneously, and performed randomly on the multiple-choice facial recognition task.

AP appeared to identify a line drawing of a face in her description of the Cookie Theft Scene. When AP was asked whether she recognized the faces of her family members, however, she replied that she recognized her daughters and grandchildren only by their voices. On Benton’s face matching task, AP was compromised on the simpler training items, and she was never able to select the face matching the target on any trials of the test. She commented: “They all look the same.” She was random in her judgments of the sex of the target faces. She also had difficulty naming and recognizing facial expressions mimed by the examiner.

In sum, these patients appeared to be more successful at recognizing real objects when presented from a prototypical perspective than naming colored pictures or black-and-white line drawings. The additional, complementary information associated with a meaningful visual representation may have constrained the set of possible interpretations of the stimulus. Regardless of the specific explanation for their relatively successful naming of real objects, their relative accuracy judging anomalous color pictures and their failure to improve with faces suggest that SZ and AP are able to integrate multiple types of perceptual attributes to develop at least a primitive mental description of an object and to use their semantic memory to help interpret some visual material.

**Experiment 5: Visual Imagery**

Visual imagery involves processing mental representations of visual information from a memory source rather than processing visual sensory representations. Thus far we have inferred that the processing of visual material in semantic memory is relatively preserved. We assessed imagery in SZ and AP to test the hypothesis that their improved recognition of real-world objects is related in part to the relatively preserved representation of visual
Writing requires a component of visual imagery to specify the overall shape constituting a letter. The visual perceptual system is also needed to provide feedback that guides the fine-grained accuracy of the motor system during written production. We asked patients to write spontaneously. For comparison, the patients were also asked to copy and trace letters, tasks that are less dependent on visual imagery but more dependent on visual perception.

Spontaneous writing of the alphabet by SZ was fairly accurate (Fig. 4). Tracings of letters were much less accurate, particularly when he did not recognize the letter he was attempting to trace. His freehand written sentence production was faulty in that the words were not written in a row that was perpendicular to the side of the paper. Nevertheless, his writing was easily interpretable (Fig. 4).

AP’s alphabet was also fairly recognizable (Fig. 4). There were some misalignments of components (the horizontal component of the ‘‘A’’ was at the base of the diagonal arms so that it looked like a triangle, and the semicircle of the ‘‘P’’ was several centimeters above the uppermost portion of the vertical line, for example) and some perseverations (the B, M, and W each had several humps instead of 2). Freehand letter production was better than her letter tracings. Her spontaneous sentence writing consisted of letters that
looked similar to those in her alphabet (Fig. 4). Spontaneous grapheme production based on mentally generated letter shapes thus appears to be better than the visual perception of letters in these patients.

**Visual Imagery for Letters**

The patients performed a visual imagery task for letters that did not require motor production and thus was less dependent on feedback from the visual perceptual system during the process of writing. Thus, SZ and AP were asked to judge whether each lowercase printed letter in the alphabet was only ‘on the line,’ had a neck extending above the line, or had a tail extending below the line. They were also asked to judge whether an uppercase printed letter was composed only of straight lines or also had a curved component. The patients were discouraged from using their hands during these tasks.

While SZ was quite compromised at match-to-sample decisions about letters presented visually, assessment of visual imagery capacity in SZ indicated that he was quite accurate at making decisions about the shapes of letters. Thus, he was accurate in his form judgments of lowercase letters on 100% of trials. He was also able to state whether uppercase printed block letters included a curved contour on 100% of trials.

Assessment of imagery capacity in AP similarly found that she was able to state whether a lowercase letter extended above or below the line on 81% of trials. She was able to state whether uppercase printed block letters included a curved contour on 88% of trials. Although the tasks are not exactly comparable, we provide a summary for illustrative purposes in Fig. 5 indicating
ing their apparently superior visual imagery for letters compared with their match-to-sample recognition of visually presented letters.

Visual Imagery for Objects

We asked SZ and AP to describe familiar objects. Since this was performed without the benefit of an available picture or object model, the patients’ description could have come only from their mental representation of the object.

The patients’ descriptions of objects contained much visual information. When asked to describe the American flag, for example, SZ was able to state that “The flag is red, white, and blue. It has a red outline, blue stars, and a flag pole. There are 25 stripes and 25 stars—five rows of five.” He stated that an “apple has a stem and highlights . . . it’s red.” A banana was “yellow with a stem . . . may be a little brownish.”

When asked to describe the American flag, AP stated “It’s red, white, and blue.” She continued: “It’s usually put on a pole so you can see it and it can wave.” When specifically asked about the colors of the stripes and the color of the stars, AP responded “red, white, and blue,” but was unable to match particular color to a specific part of the flag. Her description of an apple was “It’s usually round, usually red when it’s ripe. It has seeds and it’s good for you.” Her description of an elephant was “He has a big trunk and a hump on his back. He’s a big animal. He has a nice big trunk and he’s usually huge.” Her description of a canary was “They’re small and they chatter . . . nice to play with . . . looks like a little bird. I don’t know if they have a large beak or not. They’re small, they chatter and chatter.”

Their verbal descriptions of mental images thus were reasonable. They provided shape, color, and relative size attributes in their spontaneous descriptions of objects; however, much of this information could have been encoded propositionally in language rather than being true descriptions of visual mental images.

Geometric Shape and Picture Production

We assessed visual imagery further by asking SZ and AP to draw pictures in a freehand fashion. While some attributes of objects may be verbally encoded, freehand drawing production of shapes and pictures turns on the appreciation of a visual mental image used as a model to an extent that is typically too detailed to be encoded verbally (Grossman, 1988, 1993; Grossman, Mickanin, Onishi, D’Esposito, & Robinson, 1996). However, freehand drawing does require some visual perceptual feedback during the drawing process to guide the motor system to produce a recognizable visual image that is a fair representation of the mental image. We contrasted freehand drawing performance with shapes and pictures drawn under visual guidance,
SZ had difficulty copying and tracing models of regular geometric shapes, drawing tasks that are relatively dependent on the visual perceptual component of drawing. While copying a circle, the radius became increasingly wider in his search for the beginning point of the circle’s circumference, so that he produced more than the $360^\circ$ turn of a circle before stopping. Figure 6 demonstrates his attempt to trace a circle, emphasizing his difficulty using visual perceptual features to guide his drawing. By comparison, SZ was able to draw simple, regular geometric shapes such as a circle, a square, and a triangle to command (Fig. 6). It can be seen that he had some minor difficulty closing the geometric shapes smoothly, although this component of freehand drawing can be attributed to limited visual perceptual feedback.

When asked to draw 10, more complex, real-world objects in a freehand fashion and without the benefit of a model, SZ typically produced the correct basic color (e.g., a banana was drawn with a yellow pen, an apple was drawn with a red pen) and many of the correct shape features (the banana was crescent-shaped, the apple was heart-shaped). Importantly, pictures drawn to command were more accurate and contained more details than pictures
produced under visual guidance, particularly when he did not recognize the object he was copying (Fig. 7).

The tracings of geometric shapes produced by AP included lines that did not correspond to the model, resembling the patterns of finger tracings that she used to explore other line drawings (Fig. 6). AP was able to draw simple, regular geometric shapes such as a circle, a square, and a triangle to command (Fig. 6), although she could not reliably close her shapes. While draw-
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ing a square, for example, she produced three sides of slightly different lengths, so her fourth side did not end near the beginning of her first side. This can be attributed to the visual perceptual feedback component of spontaneous shape production.

When AP was asked to draw objects in a freehand fashion, the shape and color characteristics of the target often were approximately accurate. Her freehand pictures were reasonably recognizable (Fig. 7). Her line drawings of objects under the guidance of a visual model, by comparison, were compromised (Fig. 7). She often did not recognize the object she was attempting to copy. Their relatively accurate freehand drawings thus suggested that SZ and AP knew a great deal about the visual properties of objects, even if they could not recognize the same objects when presented visually.

In sum, SZ and AP both appeared to be better in their mental imagery of letters, geometric shapes, and objects than their copying or tracing, dissociating visual imagery from visual perception. This emphasizes the ability of apperceptive agnosics to access and use relatively preserved visual information represented in memory that can act as a basis for recognition of real-world objects.

DISCUSSION

We assessed two patients with visual apperceptive agnosia. We found that their elementary visual functioning is relatively preserved. They appeared to be able to integrate perceptual characteristics into a coherent whole and to process information in memory based on input from visual and mental imagery sources. Their recognition and naming of auditory and tactile representations of objects were relatively preserved. Despite reasonable sensory and semantic memory functioning in the visual domain, they had profound difficulty recognizing and naming line drawings. We administered several tasks in an attempt to understand the basis for this visual deficit. Their performance deteriorated under two conditions: when the perceptual characteristics of the visual target itself were made more complex, and when the perceptual judgments were made in circumstances of increased resource demands. We hypothesize that the object recognition impairment in apperceptive agnosia is due in part to a combination of compromised perceptual appreciation and a limitation in visual processing resources.

Several accounts have been forwarded in an attempt to explain the object recognition difficulty seen in patients with visual apperceptive agnosia. One type of explanation focuses on difficulty appreciating the sensory attributes of visual material (Campion & Latto, 1985). While an altitudinal visual field defect was present in one patient, elementary visual functioning did not otherwise appear to be greatly impaired. Indeed, SZ and AP performed reasonably well at recognizing simple, regular geometric forms and colors. It has also been hypothesized that a sensory deficit together with a dementia can
result in a visual agnosia (Bender & Feldman, 1972). From this perspective, the memory impairment of AP, together with the low-level visual deficit that can be seen in patients with probable Alzheimer’s disease (Sadun, Borchert, DeVita, Hinton, & Bassi, 1987; Nissen, Corkin, Buonanno, Growdon, Wray, & Bauer, 1985; Bender & Feldman, 1972) could have interfered with her ability to recognize objects. AP’s memory deficit apparently interfered with her performance on a delayed match-to-sample task for simple geometric shapes, for example, but her reasonably good delayed match-to-sample performance with color swatches discounts this type of explanation for her impairment. Indeed, her successful naming to auditory and tactile confrontation suggests that other clinical aspects of Alzheimer’s disease such as naming difficulty are unlikely to have played a major role in her object recognition impairment. We cannot fully rule out that AP has a relative memory impairment specifically for shapes, although this must be constrained by her reasonably accurate freehand production of shapes and objects in her drawings. Memory difficulty does not appear to be a necessary feature of an agnosia, moreover, since a similar visual recognition deficit was seen in SZ, an agnosic whose performance clearly did not deteriorate under delayed match-to-sample conditions. Taken together, it is difficult to attribute the pattern of object recognition difficulty in these patients to some form of a visual sensory impairment.

It has also been hypothesized that some apperceptive agnosics are compromised in the ability to synthesize perceptual features into the coherent whole that is necessary for object recognition from multiple perspectives (Warrington, 1985; Riddoch & Humphreys, 1987). Several sources of evidence are not consistent with this explanation. For example, the patients appeared to use combined descriptions of shapes and colors in pictures to help interpret the nature of the depicted object in a coherent fashion, even if they were ultimately inaccurate in recognizing the object. They were also relatively successful at judging anomalous colored pictures where a shape attribute or color attribute was not consistent with the other features of the picture. These observations suggested that they are able to integrate different types of perceptual characteristics such as form and color during their attempts to interpret a visually presented object. Further, face recognition is thought to be less dependent on the ability to synthesize a single mental unit from diverse components (Koenig, Kosslyn, & Wolff, 1991; Farah, 1991), so difficulty at the level of integrating perceptual components into a whole may spare face recognition. However, face recognition appeared to be as compromised as object recognition and word recognition in SZ and AP. These patients could not even make decisions about faces that focused on a restricted subset of the visual information constituting a face such as the sex or the facial expression displayed by a face. We did not administer other facelike material to these patients to rule out a defect in the cortical representation of a face processing module. Additional observations are needed to establish the pre-
cise status of face recognition in apperceptive agnosia. Taken together with
the patients’ anomaly judgments and descriptions of color pictures, however,
there is meager evidence to support the hypothesis that the object recognition
deficit in apperceptive agnosia can be attributed entirely to an impairment
integrating perceptual information.

An alternative account of object recognition difficulty in visual appercep-
tive agnosia turns on a deficit appreciating semantic information in a visual
representation. For example, apperceptive agnosics may encounter difficulty
using visual information to access representations of meaning in semantic
memory (Damasio, 1985). However, the patients were able to describe objects
without a visual model, and the production of recognizable pictures
during freehand drawing measures of mental imagery suggested that the pa-
tients are able to access visual object meaning. These findings confirm earlier
observations of intact visual imagery in visual associative agnosia (Jankow-
ian, Kinsbourne, Shalev, & Bachman, 1992; Behrmann, Winocur, & Mos-
covich, 1992), and extend the finding of relatively preserved imagery to
some patients with apperceptive agnosia. We also found that the patients
we studied do not have difficulty understanding, recognizing, naming, or
gesturing the use of objects presented via auditory or tactile modalities.
Taken together, these data suggest that semantic memory is largely intact in
SZ and AP and that limited access to semantic memory is unlikely to be a
major source of their object recognition difficulty.

We believe that the most likely explanation for object recognition diffi-
culty, first proposed by Lissauer (1890), turns in part on the compromised
integrity of the visual perceptual apparatus used to recognize objects. Spe-
cifically, various perceptual attributes of an object such as color and shape
are appreciated by independent processors. These visual perceptual pro-
cessing devices have been dissociated in lesion studies and functional neuro-
imaging studies of healthy adults, demonstrating the independence of pro-
cesses for visual shape (Corbetta, Miezin, Dobmeyer, Shulman, & Petersen,
1990, 1991; Desimone, Schein, Moran, & Ungerleider, 1985) and color
(Martin, Haxby, Lalonde, Wiggs, & Ungerleider, 1995; Lueck, Zeki, Friston,
Deiber, Cope, Cunningham, Lammertsma, Kennard, & Frackowiak, 1989;
Zeki, 1973; Livingstone & Hubel, 1984; Pearlman, Birch, & Meadows, 1979;
Meadows, 1974). We hypothesize that the object recognition difficulty of
apperceptive agnosia is due in part to difficulty appreciating multiple percept-
ual characteristics that contribute to an object’s visual features, especially
difficulty processing shape (Warrington & James, 1986; 1988; Humphreys &
Riddoch, 1984). Our data do not investigate color appreciation in as much
detail as shape and letter appreciation, and in fact shape generally appeared
to be more difficult for these patients to appreciate than color. Additional
work is needed to assess color processing in more detail in visual agnosics.

By examining the effects of specific perceptual manipulations, we were
able to begin specifying some of the visual processing limitations that con-
tributed to the object recognition difficulties of SZ and AP. We observed
that an accumulation of visual shape features results in a decrement in visual
recognition. Evidence to support this view comes from the patients’ rela-
tively accurate recognition of simple regular geometric shapes compared
with their poorer recognition of partially overlapping pairs of the same
shapes. The relative familiarity of letters and words did not improve recogni-
tion accuracy, and SZ and AP were as compromised with letters as they were
for overlapping geometric forms. Reading and object recognition difficulties
thus appear to be due in part to similar sources of impairment, namely, a
deficit processing perceptual attributes such as the forms that constitute geo-
metric shapes, letters, and line drawings. We have argued elsewhere that
these patients have an object recognition deficit without a corresponding con-
structional apraxia that parallels their alexia without agraphia (Grossman et
al., 1996).

If a perceptual impairment accounts in part for the object recognition dif-
ficulties of SZ and AP, it would be necessary to explain how they could
recognize simple shape and color features. One possibility is that these par-
ticular types of materials may be part of an “elementary visual vocabulary”
that is not necessarily compromised when the perceptual apparatus underly-
ing more demanding shape and color appreciation is impaired. The physio-
logical basis for this proposal may be the intact primary visual cortices that
presumably subserve elementary visual functioning in these patients. Alter-
atively, perceptual material such as simple geometric shapes and colors may
be represented redundantly in visual association cortices, consistent with a
parallel distributed processing-like network for visual perceptual processing,
and thus the appreciation of this elementary material may not be impaired
unless a very large portion of visual association cortex is compromised. Rest-
ing PET scans in these patients do not discriminate between these alterna-
tives: Primary visual cortex is relatively preserved in these patients, and some
proportion of the visual association cortices is preserved in these patients
(Grossman, et al., 1996). However, unpublished PET activation studies in
apperceptive agnosics during perceptual and semantic category membership
decisions about color pictures demonstrated some increased activity in resid-
ual visual association cortices but not primary visual cortex. This observation
lends support to the hypothesis that simple, regular geometric shapes and
colors are represented in a redundant and distributed fashion throughout vi-
sual association cortices. Clearly additional work is needed to investigate
alternative hypotheses such as these.

While there is considerable evidence to support the claim that a visual
perceptual impairment is a necessary deficit contributing to the visual recog-
nition difficulty of apperceptive agnosics, we do not believe that this is a
sufficient explanation. Thus, the patients’ recognition of shapes, letters, and
objects also varied depending on the context in which these decisions were
made. A triangle was more difficult to recognize when couched in the context
of many other shapes, for example, in comparison to its recognition in isolation. Similarly, a visually impaired patient with Alzheimer’s disease has been described who could reach for an object accurately when it was placed against a simple background but had difficulty when the background for the object was made more complex (Saffran, Fitzpatrick-DeSalme, & Coslett, 1990). Other visual agnosics have been reported who attempt to recognize line drawings in a “feature-by-feature” fashion (Luria, 1966), and some of these patients were never able to develop an integrated overview of the stimulus features (Thaiss & De Blesser, 1992; Humphreys & Riddoch, 1987). Similar phenomena have been observed in letter recognition, where patients may be limited as a function of the amount of similar but nontarget information that is made available during a trial (Shallice & Warrington, 1977). These alexics were able to read single letters, for example, but performance deteriorated when target letters were flanked by other letters.

In general, difficulties such as these have been attributed to an attentional limitation (Thaiss & De Blesser, 1992), but the precise nature of this deficit has been elusive. One explanation for these observations suggests that there is a reduced “attentional spotlight” that allows visual agnosics to attend to local features but not to the overall nature of the presented material (Thaiss & De Blesser, 1992). This kind of explanation, derived largely from difficulty interpreting line drawings, does not provide an explanation for the better recognition of real-world stimuli compared with line drawings in apperceptive agnosics. Another attention-based account has contrasted a “preattentive” level of visual processing that involves parallel processing of different channels of perceptual information with an “attentive” level of processing that is a limited-capacity, serially organized, mechanism linking together different types of perceptual information (Treisman & Gormican, 1988; Treisman & Gelade, 1980; Saffran et al., 1990). The poor recognition of simple targets couched in complex backgrounds seen in SZ and AP could be interpreted as difficulty with a serial processing system; however, other observations suggested that these patients are able to integrate information from multiple perceptual sources in a fashion that should also be dependent on a serial processing system, such as their relatively accurate judgments of anomalous color pictures.

We believe that a more reasonable account for poor judgments of visual material in more complex contexts is related to a cognitive resource limitation. The “working memory” account of Baddeley and his fellow investigators describes limitations in the distribution of selective attention and other features of the central executive component of working memory that can explain context-dependent recognition difficulty (Shallice, 1982; Baddeley, Grant, Wight, & Thomson, 1975; Baddeley, 1986). While SZ and AP may be able to make reasonably accurate judgments about regular geometric forms when presented in relative isolation, for example, there may not be sufficient capacity in the residual visual processing apparatus of these pa-
tients to support the recognition of a target object in a dichotomous recognition context and reject many other competing shapes that are present in the vicinity. This type of limitation may also explain the difficulty encountered by SZ and AP during their attempts to manipulate information mentally. For example, a mental rotation can be considered an example of a “dual task,” where information must be held in mind while it is being manipulated mentally. SZ and AP found it difficult to appreciate fairly simple geometric forms and letters presented from different perspectives, that is, following a mental rotation. Relatedly, SZ and AP exhibited increased difficulty recognizing and naming objects from atypical perspectives compared with prototypical perspectives, and they were random at judging the similarity of pairs of objects presented from different perspectives. It is noteworthy that these patients also were impaired with other types of mental manipulations such as uppercase–lowercase letter matches and plain text–italic matches of letters, suggesting that the spatial nature of a mental rotation cannot explain this difficulty. A parsimonious account for difficulty with shape manipulations and the appreciation of objects presented from atypical perspectives thus may be related to the dependence of mental manipulations on working memory resources that appear to be limited in these patients.

This account is compatible with our understanding of the physiological basis for visual apperceptive agnosia. Recent PET and functional MRI studies have demonstrated that visual association cortices support both the perception of a visual stimulus and its mental manipulation (Sergent, Zuck, Levesque, & MacDonald, 1992; Sergent, Ohta, & MacDonald, 1992; Haxby, Grady, Horwitz, Ungerleider, Mishkin, Carson, Herscovitch, Schapiro, & Rapoport, 1991). For example, an fMRI study using simple geometric shapes has shown that virtually the same cortical regions subserve both a visual match task and a visual rotation task. Differences between these tasks appear to be related to the amount of time and magnitude of activation needed to perform the requisite task by a particular cortical region, but not to a unique cortical substrate for each task (D’Esposito, Zarahn, Aguirre, Shin, Auerbach, Thompson, Alsop, & Detre, 1996). From this perspective, limitations in the visual perceptual processing of apperceptive agnosics may be related not only to the locus of disease, but also to the extent of dysfunction in the cortical regions subserving the visual perceptual apparatus. A cognitive resource limitation may emerge in this context simply by destroying a large enough mass of the corresponding perceptual apparatus, analogous to lesioning a large number of units in a parallel distributed processing-like model of an object recognition device. Resting PET scan studies in SZ and AP in fact have revealed widespread defects in ventral and mesial temporooccipital cortices that are important for appreciating perceptual features such as form and color (Grossman, et al., 1996).

It is important to consider how SZ and AP may have been able to recognize a real-world object in the face of their poor perceptual processing and limited
cognitive resources. According to one view, relatively preserved recognition of real objects in visual apperceptive agnosia is explained by modifying the traditional serial model that processes visual information through a sensory device, a perceptual device, and a semantic device (Warrington & James, 1988). Instead, these investigators postulate parallel access to meaning from a visual–sensory system through perceptual categorization or semantic categorization systems. In this context, apperceptive agnosia is thought to be due to a limitation in the perceptual categorization route to object recognition. It is problematic to invoke such a parallel model because meaningful line drawings presumably could be appreciated by semantic categorization, but in fact the patients have profound difficulty recognizing such line drawings. Alternatively, several different types of perceptual information are made available during recognition of a real object. A limited amount of information from several perceptual domains could allow an apperceptive agnostic to constrain the possible set of objects that the stimulus could represent in a relatively preserved semantic memory. We assume that small amounts of many different types of visual information do not overwhelm the limited processing resources of the apperceptive agnostic’s visual system since the integrated meaningfulness of the stimulus reduces processing resource demands. This explanation for real-world object recognition in patients like SZ and AP is not inconsistent with the top-down component of some object recognition models, that is, the use of information in relatively intact semantic memory to guide and constrain perceptual functioning (Kosslyn, Flynn, Amsterdam, & Wang, 1990).

Several caveats must be kept in mind when considering these data. Visual apperceptive agnosia is a heterogeneous entity with several clinical manifestations. Additional observations of this rare syndrome are needed to appreciate the full spectrum of impairments that can interfere with object recognition difficulty in these patients. It is clear that this study did not assess the full spectrum of perceptual attributes that should be studied in patients such as SZ and AP, including more detailed examinations of color appreciation and evaluations of unexplored domains such as object motion. Moreover, the precise role of resource limitations in the object recognition difficulties of these patients remains to be established. With these shortcomings in mind, we hypothesize that the object recognition deficit of visual apperceptive agnosics like SZ and AP is associated with a dual impairment in appreciating the perceptual attributes of an object and in recruiting adequate cognitive resources to support the perceptual processes needed for object recognition.

REFERENCES


