Color-to-Figure Matching in Alzheimer’s Disease

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Thirty-three patients with probable Alzheimer’s disease were examined on a standardized Color-to-Figure Matching Test (CFMT) for which patients select appropriate colors from a set of colored pencils to match outline pictures of common objects. Seven patients performing below the CFMT cut-off score were further assessed using other tests investigating the naming of these outline pictures of common objects as well as the naming and sorting of colors: One patient performed badly in all tests; three other patients could not be considered true cases of poor object-color retrieval because of their inability to name the objects; and in the remaining three patients with unimpaired object naming (although two of them had word-finding difficulties), their impaired object-color retrieval was found to dissociate from both color sorting and color naming. These findings support the notion of a separation of pure color processing from object-color knowledge. Thus for patients with Alzheimer’s disease, there is evidence in a few instances for a dissociation between object-color retrieval and both color sorting and color naming. © 2000 National Academy of Neuropsychology. Published by Elsevier Science Ltd

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Central color disturbances range from acquired achromatopsia (the loss of color vision), identifiable by failures on the standard tests of color vision, to the more subtle impairments such as color aphasia (and its subset, color anomia) and color agnosia for which patients can perform normally on such a test as the Ishihara Plates. This paper is concerned with central color disturbances in Alzheimer’s disease patients.

Any review of the recognition and retrieval of object colors has to refer to the classic study of Lewandowsky (1908). Lewandowsky devised a series of color tasks for his fifty-year-old male patient with a possible lesion in the posterior areas of the left hemisphere. The patient was unable to name colored wool probes shown to him or to point at those that were named by color, thus displaying the symptoms of color anomia. He could not

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name the colors of named objects familiar to him such as a lemon, nor could he pick out the
color of a lemon from the range of wool probes, thus also displaying the symptoms of color
aphasia. Another task asked the patient to select from a set of colored pencils the ones consid-
erated appropriate for coloring black-and-white line-drawings of familiar objects. Since his pa-
tient could not sort and name colors, nor recall or recognize object colors, Lewandowsky sug-
gested that there was a dissociation of object colors and shapes (Farbe-Form Abspaltung).

Lewandowsky’s (1908) patient had a profound color anomia (the inability to name
the color of a named object) and even in the following decades, only a few cases have
been reported of poor object-color retrieval with preserved color perception (Chiacchio,
Angelini, Orsini, & Grossi, 1987; Farah, Levine, & Calvanio, 1988; Schneider, Landis, Re-
gard, & Benson, 1992; these last authors also report a case in Germany by Engerth in
1934; see Davidoff, 1996 for a review). Actually, Luzzatti and Davidoff (1994) pointed
out that close inspection of the data from these cases revealed that two (Chiacchio et al.,
1987; Schneider et al., 1992) did not have perfect color naming and the other (Farah et al.,
1988) was not examined thoroughly for impairments to object-color knowledge. Even
the reverse dissociation of color anomia (the inability to name colors of papers or wools)
and intact retrieval of object-color knowledge is quite rare (Beauvois & Saillant, 1985;
Coslett & Saffran, 1989; Fukuzawa, Itoh, Sasanuma, Suzuki, & Fukusako, 1988; Gesch-
Therefore, some authors (Damasio, McKee, & Damasio, 1979; Kinsbourne & Warr-
ington, 1964) have attributed the impaired object-color retrieval from line-drawings
to interference from erroneously used color names even if they are not overtly required
for the task. To demonstrate such a verbal interference, Beauvois and Saillant (1985)
showed that their patient MP could improve performance on a task of object-color re-
trieval if a bandage was placed over the mouth to prevent subvocal verbalization.

The interpretation of impaired object-color retrieval as being due to color name interfer-
ence may not be universally correct. A number of group studies on aphasic patients (Assal &
Buttet, 1976; Basso, Faglioni, & Spinnler, 1976; Cohen, Engel, Kelter, List, & Strohner, 1976;
Cohen & Kelter, 1979; De Renzi, Faglioni, Scotti, & Spinnler, 1972; De Renzi & Spinnler,
1967; Varney, 1982) showed that linguistic abilities such as color naming and oral comprehen-
sion did not predict object-color retrieval. De Renzi and his coworkers, moving from the ob-servation that aphasics have similar difficulties in other nonverbal matching tasks (figure-to-
object, sound-to-object, pantomime-to-object; see Vignolo, 1989 for a review), concluded that
impairment on a color-to-figure matching test consists of a “general inability to recall peculiar
links between some perceptual data,” a view that is in line with Lewandowsky’s hypothesis of
an associative defect and, more generally speaking, with Marie’s conclusion about an impair-
ment of aphasics on ‘abstract thinking’ (Basso et al., 1976, p. 192). The concurrence of the
color-to-figure association impairment with aphasia was then interpreted in terms of anatom-
ical contiguity and broad overlapping between the central areas crucial for language and
those that process nonverbal conceptual information (see Vignolo, 1989 for a review).

Recently, object-color impairment has been interpreted in the framework of modules
within visual cognition, with particular reference to its dissociation from other object
and color representations (Davidoff, 1991, 1996; Davidoff & De Bleser, 1993; Grüsser &
Landis, 1992). Flow-chart models of such a framework usually contain modules relating
to visual and aural inputs: The visual input is subdivided into object recognition based
on shape, surfaces and colors, and color recognition on its own (i.e., divorced from ob-
jects apart from the medium displaying the color such as wool probes or pencils); the au-
ral input is subdivided into names of objects and names of colors. Some models also in-
clude the reading of object and color names. It is then possible to identify the modules
that seem to be inoperative for patients with central color disturbances.
In the model of visual cognition proposed by Davidoff and De Bleser (1993; see also Davidoff, 1996), visual information is first held at a temporary register before passing on to specialized recognition systems for objects (referred to as entry-level stored structural description), for words (orthographic input lexicon), and for colors (internal color space). The object recognition system is subdivided into associative knowledge, function knowledge, and sensory knowledge.

In this model, the naming of a visually presented object involves four stages:

1. The recovery of shape boundaries containing surface (colored) information at the “temporary register.”
2. The match of the recovered shape information to visual object knowledge or pictogens.
3. The link to associated object knowledge including object-color knowledge (which includes sensory knowledge).
4. The activation of a phonological code for the name of the object.

Naming the color of a visually presented object has only three stages since information held at the temporary register accesses the “internal color space” and then reaches the phonological output lexicon for color names. Object-color knowledge is stored within sensory knowledge and its retrieval implies a route separate from other types of object knowledge. The separation of these pathways, and in particular, the separation between color naming and retrieval of object-color knowledge, is predicted by the model but, in fact, is of rare occurrence (Beauvois & Saillant, 1985; Chiacchio et al., 1987; Coslett & Saffran, 1989; Farah et al., 1988; Geschwind & Fusillo, 1966; Gil et al., 1985; Larrabee et al., 1985; Schnider et al., 1992). Luzzatti and Davidoff (1994) described two patients (GG and AV) affected by the sequelae of herpes simplex encephalitis who, despite their good color naming ability, had difficulty in the retrieval of object-color knowledge. However, the inability to name an object was not a sufficient condition for object-color impairment because this impairment was present for some objects that were correctly named.

Another important issue concerns the dissociation between the impairment for object-color knowledge and color agnosia, which in Sittig’s (1921) terminology, is an inability to sort colors (Farbenagnosie). Following the model of Davidoff (1996), the dissociation is predictable because color information is derived from the pictorial register without involving the retrieval of stored object-color knowledge. In fact, it has been confirmed in only a few cases (Beauvois & Saillant, 1985, Case MP; Kinsbourne & Warrington, 1964), probably because color sorting is rarely examined (Davidoff, 1996).

In this paper we focus on whether patients suffering from Alzheimer’s disease (AD) display a disturbance of object-color retrieval and, if so, whether such a disturbance is concomitant with other object and color deficits, namely object anomia, color anomia, and problems with sorting colors. The decision to test AD patients is based on the claim that a nonrandomly widespread pathological process of neuronal thinning out in the associative cortical areas, such as that produced by AD, rather than a massive localized lesion, is likely to cause patients to emerge with such a dissociation. In fact, heterogeneity characterizes the pathological, metabolic, and neuropsychological features of the degenerative process in AD (Boller, Forette, Khachaturian, Poncet, & Chrysten, 1992; Spinnler, 1999; Weinstein, Scheltens, Hijdra, & Van Rojen, 1993). From a neuropsychological point of view, AD can be conceived (in the lines of Pick, 1908) as a progressive assembly of incomplete defects affecting several psychological domains and cognitive processings (Martin et al., 1986). The incomplete encroachment by the AD process on regional neuronal networks might facilitate the emergence of fine-grained dissociations (Baddeley, Della Sala, & Spinnler, 1991; Becker, 1988; Della Sala, Muggia, Spinnler, & Zuffi, 1995; Thaiss & De Bleser, 1992).
AIMS

The aim of the present investigation was twofold, namely:

1. To assess the prevalence, in a sample of thirty-three patients with Alzheimer’s disease (AD), of impaired performance in a Color-to-Figure Matching Test (CFMT)—a test of object-color association.
2. To investigate whether any object-color impairments might be dissociated from other deficits relating to color alone. To this end, patients failing the CFMT were further assessed using other tests investigating the naming of the CFMT outline pictures of common objects, as well as the naming and sorting of colors. The procedure adopted here does not allow the verification of the opposite dissociation, that is, cases with preserved object-color retrieval, but impaired object knowledge, color knowledge, or both.

MATERIAL AND METHODS

Subjects

Thirty-three patients (14 males, 19 females) with a clinical and cognitive picture fitting the NINCDS-ADRDA (McKhann et al., 1984) formal criteria for probable AD were studied. Patients were all mild to moderate in severity of AD, as measured by their performance on the Milan Overall Dementia Assessment (MODA; Brazzelli, Capitani, Della Sala, Spinnler, & Zuffi, 1994), a neuropsychologically oriented test for cognitive deterioration for which the total score ranges from 0 to 100, with a normality threshold set at 89. The MODA is a paper and pencil test composed of three sections: a behavioral scale and two testing sections. The behavioral component (autonomy scale) accounts for 15% of the score and comprises a set of items that aim to assess everyday coping skills. The cognitive contribution in the MODA represents 85% of the score (orientation inquiry and neuropsychological testing, including memory, language, perception, and spatial skills as well as executive tasks, yielding respectively, 35% and 50% of the overall score). Patients with a MODA age–education adjusted score ranging from 50 to 70 were rated as moderate; those greater than 70 were rated as mild. Their mean age at the time of testing was 69.6 years (SD = 8.9; range 51–86) and their years of schooling ranged from 3 to 17, with a mean of 6.9 (SD = 3.8). The relatively low level of education is typical of an Italian sample of this age. The mean length of illness from the first recognized behavioral disorder to the time of testing was 35.9 months (SD = 25.7, range 10–120). The mean age at onset was 66.1 (SD = 9.3, range 47–84), and 21 of the 33 patients considered (63.64%) were older than 65 at the time of onset. The mean raw score on the MODA was 67.74 (SD = 8.90, ranging from a minimum of 48.30 to a maximum of 88.60).

All patients proved to be unimpaired on the Ishihara Test for color vision (in cases suffering from alexia, color discrimination was tested by means of a tracking strategy). The tests were conducted in Italian.

Tests

Color-to-Figure Matching Test (CFMT). This is a revised version of De Renzi and Spinnler’s (1967) original color-figure matching test. It provides nine line-drawings of common objects (cherries, artichoke, banana, rabbit, leaf of ivy, pear, ear of wheat, pipe, and priest) presented in canonical view (see Figure 1), chosen because they are not linked with a unique, prototypical color (Beauvois & Saillant, 1985). The first drawing
(the only item with a strong verbal characterization of its chromatic attribute—the cherries) is used as a practice trial.

The participant is presented with one line-drawing at a time and with thirty colored pencils “Caran d’Ache” randomly placed on the testing desk, and is requested to choose the pencil considered to be the most appropriate for each drawing. The set of pencils is

FIGURE 1. The nine line-drawings employed for the Color-to-Figure Matching Test (figures are reduced in size by 50%).
made up of five different shades of red, two of pink, three of violet, two of brown, four of orange-yellow, four of green, six of blue, two of gray, one black, and one white (the international code numbers of the pencils employed are reported in Table 1). There is no time constraint, and no special instruction is given to inhibit or to avoid verbalization.

In a previous investigation (Della Sala, Galante, Spinnler, Stangalino & Venneri, 1996b), thirty-three healthy subjects had been employed as controls to rate the appropriateness of each pencil for each drawing: A pencil was considered “correct” for a given drawing if accepted by at least one third of the controls (11 of 33); a pencil was considered “doubtful” for a given drawing if accepted by less than eleven, but by at least six controls; and a pencil was considered “wrong” for a given drawing if accepted by less than six controls (i.e., less than 20%). The complete list of correct and doubtful pencils for each drawing is reported in Table 2.

Two points were awarded for a correct answer and one for a doubtful answer. Thus the total test score ranged from 0 to 16. The raw scores were transformed into age–education adjusted scores according to the statistical procedure defined in Della Sala et al. (1996b). The external tolerance limit (score of 11) from the control sample was taken as a psychometric cut-off; scores of less than 11 are considered to be pathological. This procedure allows a multiple single case approach indicating whether each individual’s performance is abnormal or falls within the normal range.

**Additional Tests That Tap Into the Demands of the CFMT**

**Object naming.** The patients were presented with the nine line-drawings from the CFMT (Figure 1), shown one at a time, and asked to name them. In this test, the item “cherries” was included among the test items. Appropriateness of the answers was derived from a study (Della Sala, Galante, Spinnler, Stangalino, & Venneri, 1996a) conducted on one hundred normal adult subjects (mean age 45.33, \( SD = 14.74 \), range 20–70; mean education 6.7 ± 3.25 years, range 3–17). Subjects’ answers were recorded and then submitted to five independent judges (three males, two females; mean age 36.2; mean years of schooling 17). For each item, answers accepted by at least four judges were considered correct. One point was given for each appropriate answer, the total score ranging from 0 to 9. Fifteen healthy participants age-matched with the AD patients served as controls for this task. Their mean score was 8.86 with a worst performance of 8, which was used as the cut-off for the purpose of this study.

**TABLE 1**

*International Code Numbers of the 30 Pencils Caran d’Ache (Series 0999.330) Employed for the Color-to-Figure Matching Test*

<table>
<thead>
<tr>
<th>Color Domain</th>
<th>Code Numbers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red</td>
<td>60, 65, 70, 80, 90</td>
</tr>
<tr>
<td>Pink</td>
<td>51, 81</td>
</tr>
<tr>
<td>Violet</td>
<td>110, 120, 131</td>
</tr>
<tr>
<td>Brown</td>
<td>49, 59</td>
</tr>
<tr>
<td>Orange-yellow</td>
<td>10, 30, 35, 240</td>
</tr>
<tr>
<td>Green</td>
<td>210, 230, 245, 249</td>
</tr>
<tr>
<td>Blue</td>
<td>140, 159, 160, 161, 171, 180</td>
</tr>
<tr>
<td>Gray</td>
<td>3, 5</td>
</tr>
<tr>
<td>Black</td>
<td>9</td>
</tr>
<tr>
<td>White</td>
<td>1</td>
</tr>
</tbody>
</table>
Color naming. The patients were shown ten colored pencils, one at a time, and asked to name their color. The pencils were red, pink, violet, brown, orange-yellow, green, blue, gray, black, and white, sorted from the set of pencils Caran d’Ache employed in the CFMT (pencil code numbers were 70, 81, 110, 49, 240, 210, 160, 5, 9, 1, respectively). Appropriateness of the answers was derived from a study (Della Sala et al., 1996a) on the same one hundred normal adult subjects described for the object naming test. One point was given for each appropriate answer, the total score ranging from 0 to 10. The same fifteen healthy participants were used as controls for this task. Their mean score was 9.60 with a worst performance of 8, which was used as the cut-off for the purpose of this study.

Color sorting. The patients were presented with the set of thirty color pencils Caran d’Ache employed in the CFMT randomly placed on the testing table, and asked to select all the reds (five pencils), all the blues (six pencils), all the greens (four pencils), all the browns (two pencils) and all the orange-yellows (four pencils). Appropriate pencils for each color category were derived from a previous normative study (Della Sala et al., 1996a). One point was given to the patients for each pencil correctly categorized, the total score ranging from 0 to 21. The age-matched controls had a mean score of 20.2, the worst had a score of 18.

Figure 2 shows the visual and cognitive aspects of the CFMT in relation to the extra tests.

RESULTS

The mean raw score of the AD patients on the CFMT was 13.18 ($SD = 2.66$, ranging from a minimum of 7 to a maximum of 16). Seven of them (21.2%; Cases 4, 15, 16, 20, 22, 25, 29) performed below the age–education adjusted cut-off score and, therefore, were rated as CFMT impaired.

The overall correlation of CFMT performance with severity of disease (based on the MODA raw performance) was statistically significant ($r = .59$, $df = 31$, $p < .001$) but accounted for only 35% ($r^2$) of the variance. Furthermore, contrasting mild patients with moderate patients, the outcome was straightforward: All seven patients performing below the CFMT cut-off were at a moderate stage of severity, thus suggesting that object-color impairment is not an early deficit in AD.
The seven patients with impaired CFMT scores were further assessed using other tests investigating the naming of the CFMT outline pictures of common objects as well as the naming and sorting of colors.

Performances of Cases 4, 15, 16, 20, 22, 25, and 29 on the CFMT and the three additional tests are tabulated in Table 3. Their general psychometric profiles are tabulated in Table 4. Each case was then considered separately, with reference to the qualitative patterns of performances.

**TABLE 3**

<table>
<thead>
<tr>
<th>Case</th>
<th>CFMT* (Range 0–16)</th>
<th>Color Sorting (Range 0–21)</th>
<th>Object Naming (Range 0–9)</th>
<th>Color Naming (Range 0–10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>10</td>
<td>21</td>
<td>5&lt;sup&gt;b&lt;/sup&gt;</td>
<td>10</td>
</tr>
<tr>
<td>15</td>
<td>9</td>
<td>21</td>
<td>5&lt;sup&gt;b&lt;/sup&gt;</td>
<td>10</td>
</tr>
<tr>
<td>16</td>
<td>10</td>
<td>21</td>
<td>6&lt;sup&gt;b&lt;/sup&gt;</td>
<td>7&lt;sup&gt;b&lt;/sup&gt;</td>
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<tr>
<td>20</td>
<td>10</td>
<td>17&lt;sup&gt;b&lt;/sup&gt;</td>
<td>3&lt;sup&gt;b&lt;/sup&gt;</td>
<td>5&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>22</td>
<td>8</td>
<td>21</td>
<td>9</td>
<td>10</td>
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<td>25</td>
<td>7</td>
<td>21</td>
<td>9</td>
<td>10</td>
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<td>29</td>
<td>10</td>
<td>21</td>
<td>9</td>
<td>10</td>
</tr>
</tbody>
</table>

*CFMT performances are expressed as age–education adjusted scores and are all within the pathological range.

<sup>b</sup>Within the pathological range.
Case 4

The patient had, in general, no word-finding difficulties; however, he could name only 19 of 32 black-and-white photographs of common objects (Della Sala et al., 1996b). Most of the errors seemed to result from visual confusion, but almost all of them bore a semantic relationship with the stimuli; other errors were no responses (“I do not know,” “I cannot understand what this could be”).

On the CFMT, the patient made four errors (wrong answers were a white banana and a gray priest; doubtful answers were a red pear and a white pipe). On object naming, he scored 5 out of 9 correct: Errors were (in Italian) “apples” for cherries, “pear” for artichoke, “lettuce” for the leaf of ivy, and “soldier” for priest. These errors seemed to result from a visual recognition defect rather than anomia, as (a) the patient appeared very uncertain about the identity of the pictures misnamed, and spontaneously complained about the difficulty of understanding their meaning; and (b) for the items misnamed, he was unable to give appropriate definitions of category and function. Color naming and color sorting were both preserved (100% correct).

Case 15

On the CFMT, the patient made four errors (wrong answers were a blue rabbit and a blue priest; doubtful answers were a green ear of wheat and a red pear). On object naming, she scored 5 out of 9 correct: For the items artichoke, rabbit, ear of wheat, and priest, she complained about her inability to find the exact names, but gave precise circumlocutions that demonstrated spared object recognition. Although there was a tendency for her to make more errors for items to which she could not give the precise name (three of the four items unnamed were also failed on the CFMT), the inability to

### TABLE 4

General Neuropsychological Testing of Cases 4, 15, 16, 20, 22, 25, and 29

<table>
<thead>
<tr>
<th>Test</th>
<th>Score</th>
<th>Range</th>
<th>Case 4</th>
<th>Case 15</th>
<th>Case 16</th>
<th>Case 20</th>
<th>Case 22</th>
<th>Case 25</th>
<th>Case 29</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attention</td>
<td></td>
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<tr>
<td>Digit Cancellation Test</td>
<td>0–60</td>
<td>31</td>
<td>32.25</td>
<td>40.75</td>
<td>5.25b</td>
<td>0b</td>
<td>13.5b</td>
<td>15b</td>
<td>29.5b</td>
</tr>
<tr>
<td>Intellectual Efficiency</td>
<td></td>
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<tr>
<td>Raven Progressive Matrices 1938</td>
<td>0–48</td>
<td>15</td>
<td>21</td>
<td>17.75</td>
<td>12b</td>
<td>0b</td>
<td>n.a.</td>
<td>13.5b</td>
<td>n.a.</td>
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<tr>
<td>Weigl’s Sorting Test</td>
<td>0–15</td>
<td>4.5</td>
<td>8.5</td>
<td>6.75</td>
<td>3.5b</td>
<td>n.a.</td>
<td>7.25</td>
<td>0</td>
<td>7.5</td>
</tr>
<tr>
<td>Memory</td>
<td></td>
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<tr>
<td>Span for bisyllabic words</td>
<td>0–10</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>2b</td>
<td>3</td>
<td>3.25</td>
<td>3.5</td>
<td>2.75</td>
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<tr>
<td>Paired Associate Learning Test</td>
<td>0–22.5</td>
<td>6.5</td>
<td>6</td>
<td>3b</td>
<td>5b</td>
<td>1.5b</td>
<td>6</td>
<td>0b</td>
<td>8</td>
</tr>
<tr>
<td>Buschke-Fuld’s Test (total recall)</td>
<td>0–170</td>
<td>37</td>
<td>40</td>
<td>34b</td>
<td>n.a.</td>
<td>n.a.</td>
<td>37</td>
<td>25b</td>
<td>14b</td>
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<td>Prose Memory Test</td>
<td>0–151</td>
<td>25</td>
<td>23b</td>
<td>8b</td>
<td>13b</td>
<td>10.5b</td>
<td>31.5</td>
<td>0b</td>
<td>17b</td>
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<tr>
<td>Memory for autobiographical events (MAB)</td>
<td>0–45</td>
<td>19.5</td>
<td>7.5b</td>
<td>14b</td>
<td>22.5</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
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<tr>
<td>Semantic Fluency</td>
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<tr>
<td>Semantically cued word generation</td>
<td>0–∞</td>
<td>7.25</td>
<td>8</td>
<td>6b</td>
<td>6b</td>
<td>5b</td>
<td>7.25</td>
<td>7b</td>
<td>10.75</td>
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<tr>
<td>Generative associative naming</td>
<td>0–∞</td>
<td>4</td>
<td>2.5b</td>
<td>3.25b</td>
<td>2b</td>
<td>n.a.</td>
<td>5.75</td>
<td>n.a.</td>
<td>n.a.</td>
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<td>Language</td>
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<tr>
<td>Token Test</td>
<td>0–36</td>
<td>26.5</td>
<td>31.25</td>
<td>30.5</td>
<td>25.75b</td>
<td>18b</td>
<td>29.5</td>
<td>22.5b</td>
<td>27.25</td>
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<td>Spatial Abilities and Visual Perception</td>
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<tr>
<td>Test for constructional apraxia</td>
<td>0–14</td>
<td>8</td>
<td>8</td>
<td>14</td>
<td>0b</td>
<td>n.a.</td>
<td>n.a.</td>
<td>2.75b</td>
<td>11.25</td>
</tr>
<tr>
<td>Lines’ length judgement</td>
<td>0–32</td>
<td>18</td>
<td>27</td>
<td>28</td>
<td>24b</td>
<td>n.a.</td>
<td>n.a.</td>
<td>18b</td>
<td>25</td>
</tr>
</tbody>
</table>

Note. n.a. = not administered.

*Spinnler and Tognoni (1987).

*Pathological performance.

*Novelli et al. (1986).

*Barigazzi, Della Sala, Laiacona, Spinnler, and Valenti (1987).

*Borrini, Dall’Ora, Della Sala, and Spinnler (1989).
name an object was not a necessary condition for the impairment to emerge, as it was present even for the item priest, correctly named; moreover, the reverse situation of spared object-color retrieval for an item not correctly named was observed (the artichoke was associated with the appropriate color even though not correctly named). Color naming and color sorting were both spared (100% correct).

**Case 16**

On the CFMT, the patient made four errors (wrong answers were a blue pipe and a brown priest; doubtful answers were a green banana and a green ear of wheat). On object naming, she scored 6 out of 9 correct: Errors were “jewel” for ear of wheat, “scissors” for pipe, and “friar” for priest. A visual object recognition defect seemed to contribute to errors since the patient was also unable to give appropriate alternative verbal definitions. On color naming, she scored 7 out of 10: Errors consisted of no responses and semantic paraphasias, but with correct alternative circumlocutions. Color sorting was preserved (100% correct).

**Case 20**

On the CFMT, the patient made three errors (a green rabbit, a yellow pipe, and a blue priest). On object naming, he scored 3 out of 9 correct: Errors were “geometrical figure” for artichoke, “melon” for banana, “Alpine flower” for the leaf of ivy, “violin” for pear, “hair” for ear of wheat, and “balloon” for pipe. A visual agnosic disorder seemed to contribute significantly to these errors, as the patient was unable to give verbally the functional and physical attributes of the items misnamed. On object naming, a visual agnosic disorder contributed to the failing, as the patient always appeared uncertain about the identity of the colors seen, and gave inappropriate alternative circumlocutions. On color naming, the patient scored 5 out of 10: Errors were no responses (“I do not know”), anomias, phonemic paraphasias, and semantic paraphasias (e.g., “light blue” for red, and “gray” for green). On color sorting, he made errors in two color categories (two blue pencils were categorized as red, and two green pencils were unsorted), thus scoring 17 out of 21 (80.95%).

**Case 22**

On the CFMT, the patient made 5 errors (wrong answers were a yellow rabbit, a pink pear, a brown priest; doubtful answers were a brown artichoke and a yellow leaf of ivy). Object naming, color naming and color sorting were all preserved (100% correct).

**Case 25**

On the CFMT, the patient made 5 errors (wrong answers were a gray artichoke, a blue pear, a yellow pipe, and a brown priest; a doubtful answer was an orange-yellow banana). Object naming and color naming were 100% correct, however, with several anomic latencies. Color sorting was unimpaired (100% correct).

**Case 29**

On the CFMT, the patient made 4 errors (wrong answers were a gray pear and a gray ear of wheat; doubtful answers were an orange-yellow banana and a black leaf of ivy).
Object naming, color naming, and color sorting were all spared (100% correct). The patient was then given an oral version of the CFMT (i.e., “Tell me what color a banana is.”): She scored 7 out of 9 correct and failed the same items (with the only exception of the item “ear of wheat,” for which she correctly retrieved “yellow”).

Table 5 shows the results of the extra tests for those with an impaired CMFT test.

### DISCUSSION

Impaired performance on the CFMT was clear in seven of the thirty-three AD patients examined. Although the correlation of CFMT performance with severity of disease was significant, it only accounted for 35% of the variance; thus the CFMT performance cannot be traced back to the overall cognitive competence of the patients. It is also worth noticing that 79% of the patients in our sample performed well on the CFMT, a task that implies the matching of colored pencils to two-dimensional line-drawings.

The relative sparing of AD patients for the CFMT is interesting considering the performance on this task by patients affected by semantic dementia. In fact, patients with semantic dementia show a poor performance on several semantic tasks (Hodges, Graham, & Patterson, 1995) including the CMFT (Graham, 1995; Graham, Becker, Patterson, & Hodges, 1997). Therefore, as claimed by other authors, nonverbal semantic tasks such as CMFT could be used as a means of distinguishing between the two forms of dementia, one being centered on semantic deficits, the other on episodic memory disorders (e.g., Hodges & Patterson, 1995). This might reflect the anatomical location of the memory deficit, mainly the hippocampus and peri-hippocampus for AD, and the infero-lateral temporal cortex for semantic dementia (Hodges et al., 1999; Graham, Pratt, & Hodges, 1998).

The typical pathology of AD, characterized by heterogeneous microstructural changes in the cortical architecture (Boller et al., 1992), might facilitate the emergence of fine-grained dissociations (Della Sala et al., 1995; Della Sala & Spinell, 1999), so the question of interest is whether this object-color impairment dissociates from the other types of central color disturbances.

A disturbance of object naming could occur as the result of either not recognizing an object from its edges and surfaces, not associating an object with a function (i.e., not realizing cherries outlined as a bunch are cherries), not associating an outline with a typical color, or finally (assuming object recognition and object-color association have oc-

<table>
<thead>
<tr>
<th>Poor with the CMFT</th>
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<tbody>
<tr>
<td>7 (4, 15, 16, 20, 22, 25, 29)</td>
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</table>

<table>
<thead>
<tr>
<th>Good with Color Sorting</th>
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<tr>
<td>6 (4, 15, 16, 22, 25, 29)</td>
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</table>

<table>
<thead>
<tr>
<th>Poor with Color Sorting</th>
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</thead>
<tbody>
<tr>
<td>1 (20)</td>
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<table>
<thead>
<tr>
<th>Good with Object Naming</th>
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<tbody>
<tr>
<td>3 (22, 25, 29)</td>
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<table>
<thead>
<tr>
<th>Poor with Object Naming</th>
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<tr>
<td>3 (4, 15, 16)</td>
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<tr>
<th>Poor with Object Naming</th>
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<td>1 (20)</td>
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<tr>
<th>Good with Color Naming</th>
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<td>3 (22, 25, 29)</td>
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<tr>
<th>Poor with Color Naming</th>
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<td>0</td>
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<tr>
<th>Good with Color Naming</th>
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<tbody>
<tr>
<td>2 (4, 15)</td>
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<table>
<thead>
<tr>
<th>Poor with Color Naming</th>
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<tr>
<td>1 (16)</td>
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<table>
<thead>
<tr>
<th>Poor with Color Naming</th>
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<tr>
<td>1 (20)</td>
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curred successfully) not having access to the phonological output lexicon of object names (i.e., realizing an object is an orange-colored fruit but not being able to name it as an orange). A disturbance of color naming could occur if there is a breakdown between visual color detection and the color lexicon, or a breakdown in connecting the color lexicon with the phonological output lexicon of color names (i.e., recognizing a color but not being able to put a name to it).

A failure to sort colors could also be due to a breakdown between visual color detection and the color lexicon, or to a breakdown in organizing the colors in the color lexicon leading to color sorting failures.

All the cases except Case 20 were able to correctly sort colors. Case 20 had a severe disorder for both colors and object shapes, and therefore performed badly on all the tests (color sorting, object naming, and color naming). Thus this patient could not show any dissociated performances since there were problems with both object recognition and color processing.

Cases 4, 15, and 16 had problems with object naming and so their object-color retrieval problems could simply be due to their object aphasia rather than to any color disturbance. This is borne out by Cases 4 and 15, who have normal color naming and color sorting performances. Case 15 substantially reproduces Luzzatti and Davidoff’s (1994) findings on two patients (GG and AV), as her impaired object-color knowledge was related to the ability to name the objects; nevertheless, as for GG and AV, the inability to name an object was not a sufficient condition for the impairment to be shown because it was present for items that were correctly named. Case 16 showed some difficulty with color naming, suggesting that her object-color impairment may not simply be an object naming one.

The other three patients (Cases 22, 25, and 29) are the most relevant to our discussion because although they failed the CMFT, they had perfect performances on the other three tests. Thus, their failures in object-color retrieval do not extend to problems with color naming and sorting. Their problem is located strictly within the object-color knowledge area; their internal color space and color naming capacities are largely unaffected. Whereas the naming ability of Case 25 was not perfect (as demonstrated by the presence of word-finding difficulties in daily life and the frequent anomic latencies in the experimental tasks), it is worth noting that Cases 22 and 29 had no word-finding difficulties.

Finally, the preservation of reading in two cases (Cases 22 and 25) is noteworthy since the dissociation between object-color knowledge and reading has been rarely observed (see Luzzatti & Davidoff, 1994, for a recent report and Davidoff, 1996, for a review).

Our data, however, do not allow us to distinguish a difficulty in access to, or degradation of, a store of object-color knowledge, as no information was available on the patients’ ability to recognize, in a forced-choice condition, correctly colored-in drawings of the same objects, and no data from repeated testing were available to provide evidence for the consistency of errors.

Luzzatti and Davidoff (1994) have suggested that incorrect responses of dark or basic colors such as black and white could imply a degraded store rather than a disorder of access. This is indirectly confirmed by patients with a true CFMT impairment: We found the tendency to give dark, less vivid, or black and white responses in almost all cases (Case 15: dark green ear of wheat, dark blue rabbit, dark blue priest; Case 22: brown artichoke, pink pear, brown priest; Case 25: gray artichoke, dark blue pear, brown priest; Case 29: gray pear, black leaf of ivy, gray ear of wheat). The present data also do not allow us to derive reliable information on the object-color knowledge coding, whether unidimensional (only visual) or bidimensional (visual and verbal). Some authors have
hypothesized that the store for object-color knowledge has both visual and verbal components (Beauvois & Saillant, 1985; Davidoff & De Bleser, 1993), whereas others have suggested the existence of a unitary store (Riddoch & Humphreys, 1987). In our study, only Case 29 was presented with a verbal test of object-color retrieval (e.g., “Tell me what color are bananas”) and was found to be impaired on the same items as on the CMFT (with one exception). In this case, there was no evidence of differential impairment for responses to verbal and visual tasks. This finding seems to support the view of a unitary store or, alternatively, that a verbal input tapping perceptual information requires the interplay of the visual semantic system, perhaps by means of a visual imaginative strategy for a full specification of the answer (McKenna & Warrington, 1993). It is noteworthy that in Cases 22 and 29 impaired object-color retrieval did not seem to be associated with impairment of other types of object knowledge or with a semantic-lexical deficit: Both patients had no difficulties in describing the properties and uses of the items for which they could not retrieve the appropriate color (in Case 29, this was true either on a visual modality or on an oral modality) and performed normally in the semantic fluency tests; on informal conversation, no difficulties in word-finding and in word comprehension were evident.

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