10 | Perception

The tests considered in this chapter are essentially perceptual, requiring little or no physical manipulation of the test material. Most of them test other functions as well, such as attention, spatial orientation, or memory, for the complexities of brain function make such overlap both inevitable and desirable. Only by testing each function in different modalities, in combination with different functions, and under different conditions can the examiner gain an understanding of which functions are impaired and how that impairment is manifested.

VISUAL PERCEPTION

Many aspects of visual perception may be impaired by brain disease. Typically brain impairment involving one visual function will affect a cluster of functions (Zihl, 1989); infrequently the visuoperceptual disorder will be confined to a single or small-set dysfunction (Riddoch and Humphreys, 2001). These latter instances of defective visuoperception provide the substance for theorizing on the nature of visuoperception. Some of the stimulus dimensions that highlight different aspects of visual perception are the degree to which the stimulus is structured, the amount of old or new memory or of verbalization involved in the task, the spatial element, and the presence of interference.

Visual functions can be broadly divided along the lines of verbal/symbolic and configural stimuli. When using visually presented material in the examination of lateralized disorders, however, the examiner cannot categorically assume that the right brain is doing most of the processing when the stimuli are pictures, or that the right brain is not engaged in distinguishing the shapes of words or numbers. Visual symbolic stimuli have spatial dimensions and other visual characteristics that lend themselves to processing as configurations, and most of what we see, including pictorial or design material, can be labeled. Materials for testing visuoperceptual functions do not conform to a strict verbal/configurational dichotomy any more than do the visual stimuli of the real world. Moreover, impairment of basic visual functions (e.g., acuity, oculomotor skills) is likely to result in poor performances on the more complex visuoperceptual tasks (Cate and Richards, 2000). These authors recommend screening for visual competency when evaluating responses to visuoperceptual tests.

The theoretical separation of attentional from perceptual functions reflects more how we conceptualize complex mental phenomena than how they work. The arbitrariness of this division of receptive activities is never more obvious than when considering the inattention phenomenon. It is dealt with in this chapter because *imperception*—conscious unawareness of stimuli—is its most striking aspect, but a good case could be made for placing this topic under *Attentional Functions.*

Visual Inattention

The *visual inattention* phenomenon (also called "visual neglect" or "visual extinction") usually involves absence of awareness of visual stimuli in the left field of vision, reflecting its common association with right hemisphere lesions. Visual inattention is more likely to occur with posterior lesions (usually parietal lobe) than with anterior lesions when the damage is on the right, but it may result from frontal lobe lesions as well (Heilman, Watson, and Valenstein, 2003). The presence of homonymous hemianopsia increases the likelihood of visual inattention, but these conditions are not necessarily linked (Halligan, Cockburn, and Wilson, 1991; Mesulam, 2000a). Visual inattention is more apt to be apparent during the acute stages of a sudden-onset condition such as stroke or trauma, when patients may be inattentive to people on their neglected side, even when directly addressed, or eat only food on the side of the plate ipsilateral to the lesion and complain that they are being served inadequate portions (N.V. Marsh and Kersel, 1993; Samuelsson et al., 1996). Long after the acute stages of the condition and blatant signs of inattention have passed, when these patients' range of visual awareness seems intact on casual observation, careful testing may elicit evidence that some subtle inattention to visual stimuli remains (e.g., see Fig. 10.1, p. 376).

Close observation of the patient when walking (bumping into walls, furniture on one side), talking (addressing persons only on one side), or handling an array of objects (as when eating) may disclose inattention deficits. The inattention phenomenon may also show up on tests designed for other purposes, such as

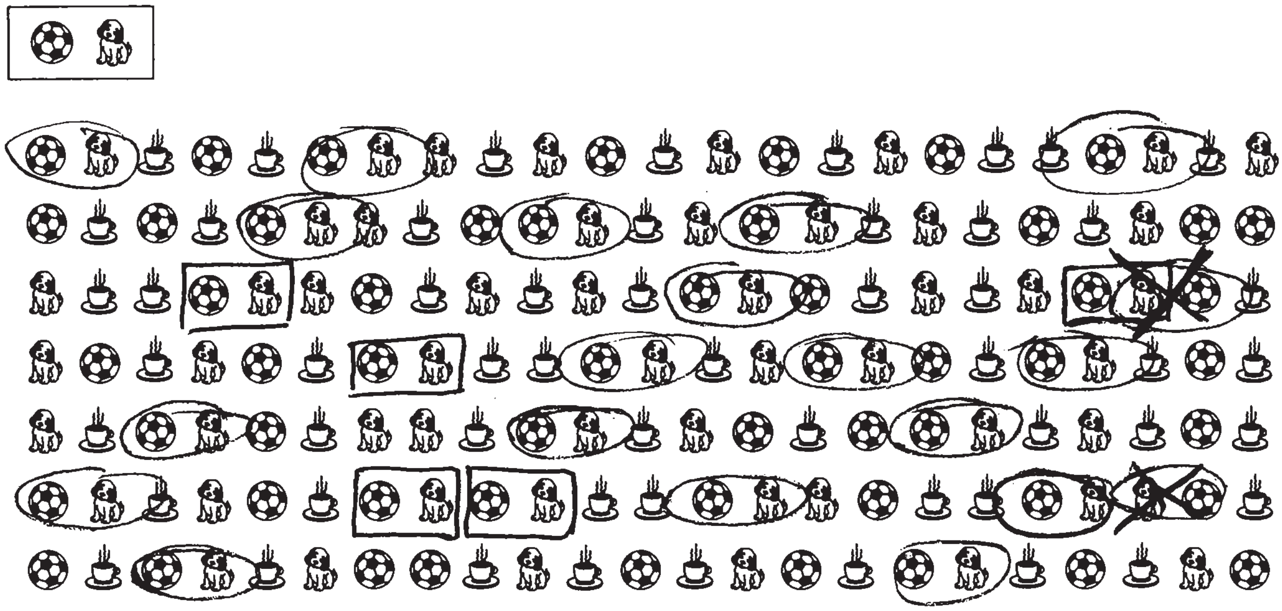


FIGURE 10.1 This sample from the *Pair Cancellation* test (Woodcock-Johnson III Tests of Cognitive Abilities; Woodcock, McGrew, and Mather, 2001c) shows how scanning cancellation tests with horizontally aligned stimuli can elicit subtle unilateral inattention—usually on the left. These top seven (of 21) lines contain four of the eight left-sided omissions (enclosed in rectangles), one of the three right-sided omissions, and two right-sided errors (X'd) made by the 55-year-old dermatologist who had sustained a blow to the left side of his head in a skiing accident (see p. 87). (© Riverside Press. Reprinted with permission)

a page of arithmetic problems (Egelko, Gordon, et al., 1988; see Figs. 3.16, 4.1, pp. 72, 87), or tests in which the stimuli or answers are presented in a horizontal array (see Fig. 10.1).

Testing for unilateral inattention

Different tests for inattention appear to have different levels of sensitivity as indicated by the number of patients in a sample who fail one or more of them, as the nature of the inattention phenomenon varies among patients (e.g., see L. Bachman et al., 1993; Ferber and Karnath, 2001; Halligan, Cockburn, and Wilson, 1991). J. Binder and his colleagues (1992), studying the effects of right hemisphere stroke, reported that cancellation tasks are much more likely to elicit evidence of inattention in patients with anterior or subcortical lesions than line bisection tasks, while the bisection tasks tend to be specifically sensitive to posterior lesions. Thus, the careful examiner will not rely on just one test of inattention if the patient's behavior suggests an inattention problem or the lesion site makes one likely.

On finding that patients were more likely to make errors when fatigued by a task, Fleet and Heilman (1986) recommended that inattention tasks such as letter cancellation tests be given in a long series to increase the likelihood of eliciting evidence of inattention. Meaninglessness and discontinuity of stimuli may also increase a task's sensitivity to inattention (Kartsounis and Warrington, 1989). Distracting stimuli on the side of space ipsilateral to the lesion (in the intact visual field) also enhance the inattention phenomenon (e.g., bilateral simultaneous stimulation; Kinsella, Packer, et al., 1995; Mesulam, 2000a; Strub and Black, 2000). Where patients begin cancellation tests for unilateral inattention also has diagnostic value (Mesulam, 2000a). On several of these tests, 94% of right-lesioned patients began at least one on the right side of the page, about half of patients with right-sided stroke began on the right (Samuelsson et al., 1996; see also Chatterjee, 2003), although normally people in most Western cultures work from left to right (e.g., Rousseaux et al., 2001; Samuelsson, et al., 1996, 2002).

In showing visual material to brain impaired patients, the examiner must always be alert to the possibility that the patient suffers visuospatial inattention and may not be aware of stimuli that appear on one side (usually the left) of the examination material. For tests in which response choices are laid out in a horizontal format (e.g., 3 × 2 or 4 × 2, as in the Test of Facial Recognition or WAIS-III Matrix Reasoning), the examiner may wish to realign the material so that all response choices are set in a column that can be presented to the patient's midline (or right side, if left-sided inattention is pronounced). Alternatively, when visuospatial inattention is obvious or suspected, tests with horizontal formats must be shown to the patient's right side.

Line Bisection Tests

The technique of examining for unilateral inattention by asking a patient to bisect a line has been used for decades (Diller, Ben-Yishay, et al., 1974). The examiner draws the line for the patient or asks the patient to copy an already drawn horizontal line. The patient is then instructed to divide the line by placing an "X" at the center point. The score is the length by which the patient's estimated center deviates from the actual center. When Diller's technique is used, a second score can be obtained for the deviation in length of the patient's copied line from that of the examiner's line. Numerical norms are not available for this technique.

Line bisection characteristics. Examinations of this technique with normal subjects have shown that they tend to mark horizontal lines to the left of center, typically deviating one to two mms, or about 1.6% (Bradshaw, Nettleton et al., 1985; Scarisbrick et al., 1987), but not always (Butter, Mark, and Heilman, 1988). Left-handed performances exacerbate this effect as left-handed subjects show the left-sided deviation more than right-handed ones (Rousseaux et al., 2001; Scarisbrick et al., 1987). The length of the line also affects line bisection accuracy for both normal subjects and patients with lateralized lesions: Short lines are less likely to elicit a deviation from center than long ones, and the longer the line the greater the deviation (Butter, Mark, and Heilman, 1988). Most patients with right-sided lesions give greater deviations to the right, and most left-lesioned patients move the "bisection" further left with increases in line length (Pasquier et al., 1989). Noticeable errors are most often made by patients with visual field defects who tend to underestimate the side of the line opposite to the defective field, although the reverse error appears occasionally (Benton, 1969b). However, many patients with visuospatial inattention do not err consistently (Ferber and Karnath, 2001, see p. 378). Thus, a single trial is often insufficient to demonstrate the defect. The importance of having an adequate sampling of bisection behavior was demonstrated by N.V. Marsh and Kersel (1993) who, using only four lines, reported that this technique was among the least sensitive in their battery.

Line Bisection Test (LB)[1] (Schenkenberg, Bradford, and Ajax, 1980)

In a multiple-trial version of this technique, the subject is shown a set of 20 lines of different sizes arranged so that six are centered to the left of the midline of a typewriter-paper size page (21.5 x 28 cm), six to the right of midline, six in the center. A top and bottom line, to be used for instructions, is also centered on the page (see Fig. 10.2). Since only the middle 18 lines are scored, 180° rotation of the page produces an alternate

[1]This test is in the public domain. The figure may be copied and enlarged.

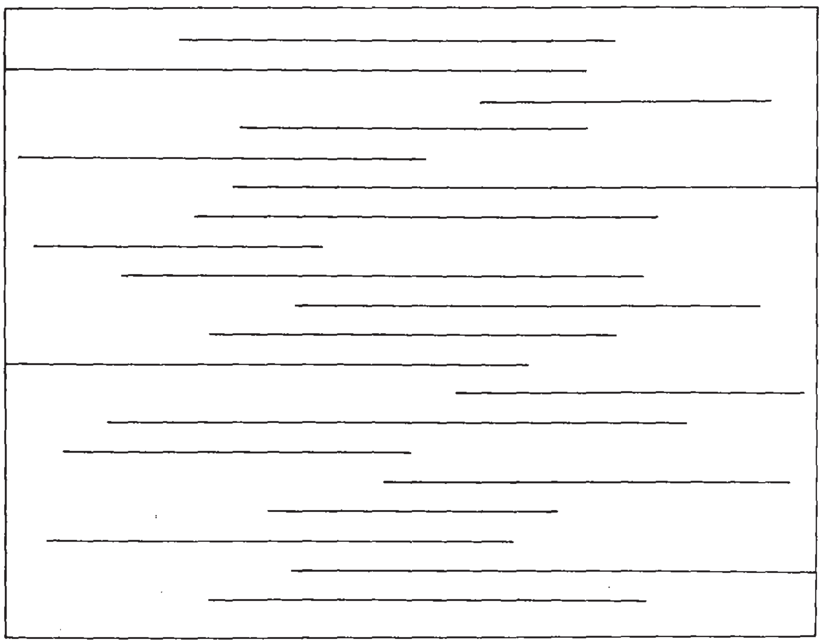


FIGURE 10.2 The Line Bisection test. (Schenkenberg et al., 1980)

form of the test. Instructions ask the patient to "Cut each line in half by placing a small pencil mark through each line as close to its center as possible," to take care to keep the nondrawing hand off the table, and to make only one mark on a line without skipping any lines. All capable patients take one trial with each hand, with randomized orientation of the page on first presentation and 180° rotation of the page on the second trial. Two scores are obtained. One gives the number and position of unmarked lines (e.g., 4R, 1C, 2L). The other is a Percent Deviation score for left-, right-, and center-centered lines derived by the formula:

$$\text{Percent Deviation} = \frac{\text{Measured Left Half} - \text{True Half}}{\text{True Half}} \times 100$$

Percent Deviation scores are positive for marks placed right of center and negative for left-of-center marks. Average Percent Deviation scores can be computed for each of the three sets of differently centered lines or for all lines. For a six-line modification of this test, Ferro, Kertesz, and Black (1987) recorded the score in millimeter deviations from the line centers. With control subjects making an average 2.9 mm deviation to the left, a right deviation cutting score of 15.3 mm indicated left hemispatial inattention. Test–retest correlations run in the .84 to .93 range for the 20-line format (Schenkenberg, Bradford, and Ajax, 1980).

Neuropsychological findings. Schenkenberg and his colleagues found that 15 of 20 patients with right hemisphere lesions omitted an average of 6.6 lines, while only 10 of the 60 subjects in the left-side lesioned, diffusely damaged, and control groups omitted any lines; these 10 omitted an average of only 1.4 lines each. Patients with right hemisphere lesions tended to miss lines, mostly the shorter ones on the left and center of the page, regardless of hand used. Only one control subject overlooked one line. When patients with right hemisphere damage used their right hands, their cutting marks tended to deviate to the right on both left- and center-centered lines, but not on right-centered lines. The other groups displayed no consistent deviation tendencies when using the right hand. A tendency to deviate to the left was generally manifested on left-hand trials, regardless of the site or presence of a brain lesion. Examining right-sided stroke patients, Kinsella, Packer, and their colleagues (1995) found that this test distinguished between those having demonstrated inattention in occupational therapy and those without apparent inattention. The identified inattention group performed significantly differently than the other stroke patients or control subjects, deviating most on left-sided lines, least on lines on the right of the paper. Using a cut-off criterion of 14% relative displace of the bisection, Ferber and Karnath (2001) reported that 60% of their well-documented inattention patients were identified by the line bisection technique.

Using a similar format with 12 horizontal lines, Egelko, Gordon, and their colleagues (1988) reported correlations between this test and damage site as shown on CT scan for temporal ($r = -.59$), parietal ($r = -.37$), and occipital ($r = -.42$) lobes of right brain lesioned patients. On the six-line version of this test, 10 of 14 patients with lesions limited to right-sided subcortical structures exhibited the right-directional deviation with most of their failures due to their not fully exploring the left side of the lines rather than inattention per se (Ferro, Kertesz, and Black, 1987).

How the test is presented may affect its sensitivity. Rather than varying line length and center as in Figure 10.2, Halligan, Cockburn, and Wilson (1991) used only three same-length lines placed in step-wise fashion on the page. This format identified 65% of right hemisphere–damaged patients with evidence of unilateral inattention along with 75% (3 of 4) patients whose lesions were on the left.

Cancellation tasks for testing visual inattention

These are dual-purpose tests: when given to elicit unilateral inattention they may be untimed or response speed may be secondary as the examiner looks for the location and number of omissions and errors. When timed, these tests require visual selectivity at fast speed with a repetitive motor response. However, the motor response is typically so minimal that it hardly qualifies them as tests of visuomotor functions. These techniques assess the capacity for sustained attention, accuracy of visual scanning, and activation and inhibition of responses. When timed, lowered scores on these tasks can reflect the general response slowing and inattentiveness of diffuse damage or acute brain conditions; disregarding timing brings out the more specific defects of response shifting and motor smoothness or of unilateral inattention.

One common format for these tests consists of rows of stimuli with targets randomly interspersed among a larger number of foils (e.g., Figs. 10.1, 10.5). Another format scatters the stimuli in a seemingly random manner. Stimuli may be short lines, letters, numbers, other symbols, or even little pictures (e.g., Figs. 10.3, 10.4, 10.6). The patient is instructed to cross out all designated targets. Performance is typically scored for omissions and errors, and may be scored for time to completion; or, if there is a time limit, scoring is for errors and number of targets crossed out within the allotted time. Several similar tasks can be presented on the same page. The task can be made more difficult by decreasing the space between target characters or the number of foils between targets (Diller, Ben Yishay, et al., 1974). Talland (1965a) made the task more complex by using gaps in the line as spatial cues (e.g., "cross out every [specified letter] that is preceded by a gap") or by designating two targets instead of one (e.g., Fig. 10.5).

Test of Visual Neglect (M.L. Albert, 1973), also called *Line Crossing* (B. (A.) Wilson, Cockburn, and Halligan, 1987a)

In this technique for eliciting visual inattention, patients are asked to cross out lines scattered in a seemingly random manner over a sheet of paper. Albert's version consists of a sheet of paper (20 × 26 cm) with 40 lines, each 2.5 cm long, drawn out at various angles and arranged so that 18 lines are widely dispersed on each side of a central column of four lines, nine in each upper and lower quadrant (see Fig. 10.3).

M.L. Albert (personal communication, January, 1993 [mdl]) advises:

> I administer the test in two different ways, depending on whether or not I have an actual copy of the test on hand. If I don't, I start with a blank sheet of paper, and draw all the lines on it, free hand, in approximately the correct position. If I am starting with a copy of the test, I present it to the patient or subject and overdraw each line once. My purpose is to assure myself that I have drawn all the lines in front of the subject. I usually start by saying, "I'm going to draw a whole bunch of lines on this paper, and I want you to watch me while I do it." (Or, "Take a look at all of the lines on this paper," at which point I overdraw each line). Then I say, "I'd like you to cross out all of the lines on this paper, like this," at which point I draw a line through one of the lines in the middle of the page, and hand the pencil to the subject.

Neuropsychological findings. Different criteria for abnormality produce somewhat different and even puzzling findings. One or no omissions was the criterion for normality; only one of 40 control subjects made a right field omission and none omitted lines on the left (Vanier et al., 1990). With the inattention criterion of ≥ 2 omissions on the three left or three right columns, unilateral inattention was identified in seven of the 40 patients. Using a fairly strict criterion of six omissions, 24 of 41 right-lesioned patients were classified as having left-sided inattention, but 22 crossed out all the lines, leading to the conclusion that for patients with right-sided lesions, the distribution of inattention is bimodal (Plourde et al., 1993).

This test compares favorably with other commonly used tests for visuospatial inattention (Halligan, Cockburn, and Wilson, 1991); although N.V. Marsh and

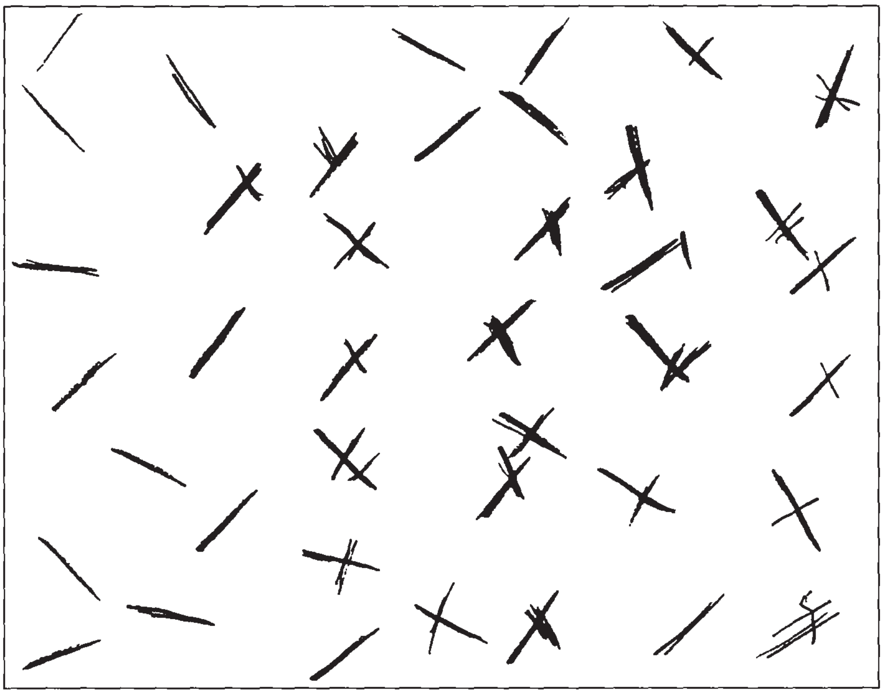


FIGURE 10.3 Performance of patient with left visuospatial inattention on the Test of Visual Neglect. (Courtesy of Martin L. Albert)

Kersel (1993) reported that it identified only 23% of patients who had displayed inattention on at least one of four tests. A few patients with left-sided lesions may also display unilateral inattention on this test but those whose lesions involve the right hemisphere tend to leave many more lines uncrossed (M.L. Albert, 1973; Halligan, Cockburn, and Wilson, 1991; Plourde et al., 1993). Halligan and Marshall (1989) noted that this test also documents the two-dimensional aspect of inattention as patients with inattention may differ not only in neglecting to cross out lines on the left or right side of the page but are likely to omit responses in a quadrant, reflecting a vertical dimension to this phenomenon.

Bells Test (Test des cloches) (Gauthier et al., 1989)[1]

In this test, rather than angled lines, 315 little silhouetted objects are distributed in a pseudo-random manner on the page with 35 bells scattered among them (see Fig. 10.4). Despite their random appearance, the objects are actually arranged in seven columns with five bells to a column. As the subject circles bells, with the admonition to do so "without losing time," the examiner notes by number on a diagramed page the order in which the subject finds the bells. This enables the examiner to document the subject's scanning strategy—or lack thereof.

For the original sample of a small control group and patients with left- or right-sided strokes, no sex or age differences showed up (Gauthier et al., 1989). Half of the control group made no omissions; the other half made up to three, leading to the recommendation that any more than three omissions on one or another side of the page indicates a lateralized attention deficit. Two-week test–retest reliability was .69. A normative study of commonly used tests of inattention involved 450+ healthy subjects from three areas in northeast, north central, and northwest France (Rousseaux et al., 2001). Scoring for omissions, sex did not influence Bells Test performances. Age and education effects were small (see Table 10.1). Most subjects began the task on the left. Errors were virtually nonexistent. Both number of omissions and time to completion increased with age (from ≤ 142 sec for age group 20–34 to ≥ 253 sec for ages 65–80). In comparisons with M.L. Albert's Test of Visual Neglect, this test identified a higher number of stroke patients with visual inattention (22/40 vs.

TABLE 10.1 The Bells Test: Omissions by Age and Education

AGE (YEARS)			
20–34 (n = *163*)	*35–49* (n = *156*)	*50–64* (n = *140*)	*65–79* (n = *117*)
1.50 ± 1.79	2.15 ± 2.18	2.24 ± 2.34	2.54 ± 2.24

EDUCATION (YEARS)		
≤8 (n = *189*)	*9–12* (n = *172*)	*≥13* (n = *215*)
2.55 ± 2.24	2.13 ± 2.20	1.59 ± 1.95

Adapted from Rousseaux et al. (2001)

[1]This test can be ordered from Ortho Édition, 76, rue Jean Jaurès, 62330 Isbergues, France (Tel: [33]-3-61-94-94, Fax: [33] 3-21-61-94-95).

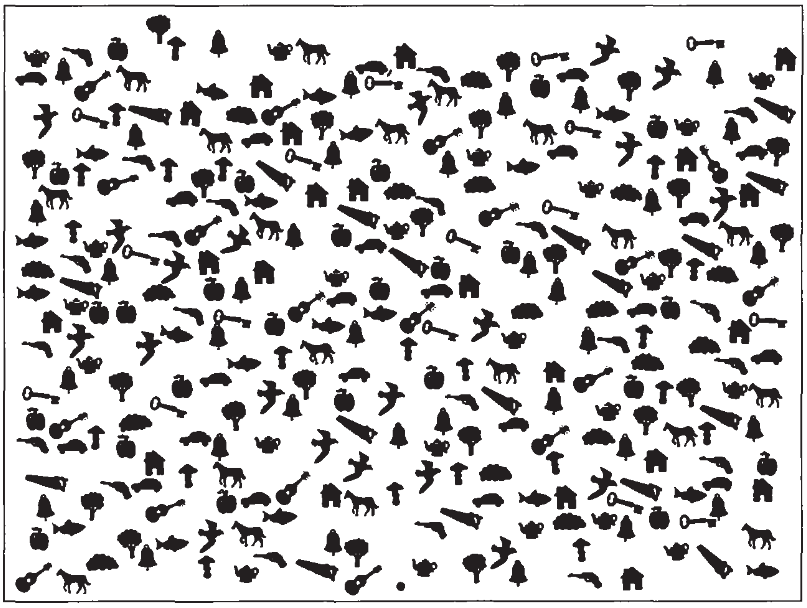


FIGURE 10.4 The Bells Test (reduced size). (Courtesy of Louise Gauthier and Yves Joanette)

7/40, Vanier et al., 1990; 33/35 vs. 22/31, Ferber and Karnath, 2001).

The Balloons Test (Edgeworth, Robertson, and McMillan, 1998)

This test consists of two pages each with 202 circles of the same size scattered in a random appearing fashion. On the first page (subtest A) to be administered, 22 have a short line extending down, much like a balloon with a short string. All but 22 circles have the balloon-like line on the second page (subtest B). For each page the task is the same: to cross out as many balloons as possible in a 3-min time limit. The first task is easy, relying on the "pop-out" phenomenon in which a few different objects are easily detected. The second page requires effortful search. When a patient makes more errors on subtest B than subtest A, the authors suggest that the better A performance demonstrates that visual fields are intact so that B omissions may be interpreted as due to inattention. This test, based on perceptual theory, is simple to administer. It certainly appears to be a promising addition to inattention assessment.

Letter cancellation tests and variants

Diller, Ben Yishay, and their colleagues (1974) constructed nine different cancellation tests; two forms for each of four stimulus categories (digits, letters, easy three-letter words, and geometric figures) plus one form using pictures. For the two-form sets, the first form has one target, the second two (see Fig. 10.5). The basic format consists of six 52-character rows in which the target character is randomly interspersed approximately 18 times in each row. The median omission for 13 control subjects was 1 for both letter and digit cancellation; median time taken was 100 sec on Letters, 90 sec on Digits. For just the letter cancellation task, normal performance limits have been defined as 0 to 2 omissions in 120 sec (Y. Ben Yishay, personal communication, 1990).

Stroke patients with right-sided lesions were not much slower than the control subjects but had many more omissions (*Mdn* Letters = 34; *Mdn* Digits = 24), always on the left side of the page, and no errors. Patients with lesions on the left made few errors but took up to twice as long (*Mdn* Letters time = 200 sec; *Mdn* Digits time = 160 sec). Performance deficits appeared to be associated with "spatial neglect" problems with right-sided strokes, and slowed information processing when strokes involved the left hemisphere.

The *Behavioural Inattention Test* includes a shorter letter cancellation task (Halligan, Cockburn, and Wilson, 1991; B. (A.) Wilson, Cockburn, and Halligan, 1987a). Upper case letters are printed in five lines of 34 items each, of which 40% are targets (E, R), distributed equally on either side of the array. The average number of omissions for 50 control subjects was 2 ± 2.0 (range = 33–40), 26 patients with strokes on the left made an average 5.2 ± 8.1 omissions; 54 patients with right-sided strokes averaged 9.2 ± 9.8 omissions. Using a cut-off score of 8 for patients with documented unilateral inattention, inattention was identified in all left-lesioned stroke patients with this format and 77% of those with right-sided lesions.

Cancel H consists of three letter cancellation forms used to document normal response patterns over the life span (Uttl and Pilkenton-Taylor, 2001). The first, a practice form, consists of 60 upper case letters, 20 to a line, with 13 targets (always H) and 47 foils. The "Trial 1 and Trial 2" forms contain 180 letters each arranged in three rows with 12 H's in each row spaced so that 3 H's went into each of four line sections of equal length. Subjects were 351 healthy adults, ages 18 to 91, divided into seven decades: 20–29 to 80–91 plus an 18–19 age group. No surprises were reported for this study. The youngest group worked the fastest (M = 36.36 sec for Trials 1 and 2); the oldest group was slowest (M = 52.74 sec for these trials). Time increments climbed steadily. The difference between age groups for the number of omissions was negligible; more than two omissions was relatively rare for any but the two oldest age groups. Neither sex, age, nor education was related to cancellation efficiency, but significant correlations were found with tests involving visual search and visuomotor skills. Though relatively rare, more omissions occurred on the rows' right side.

B E I F H E H F E G I C H E I C B D A C H F B E D A C D A F C I H C F E B A F E A C F C H B D C F G H E

C A H E F A C D C F E H B F C A D E H A E I E G D E G H B C A G C I E H C I E F H I C D B C G F D E B A

E B C A F C B E H F A E F E G C H G D E H B A E G D A C H E B A E D G C D A F C B I F E A D C B E A C G

C D G A C H E F B C A F E A B F C H D E F C G A C B E D C F A H E H E F D I C H B I E B C A H C D E F B

A C B C G B I E H A C A F C I C A B E G F B E F A E A B G C G F A C D B E B C H F E A D H C A I E F E G

E D H B C A D G E A D F E B E I G A C G E D A C H G E D C A B A E F B C H D A C G B E H C D F E H A I E

FIGURE 10.5 Letter Cancellation task: "Cancel C's and E's" (reduced size) (Diller, Ben-Yishay, et al., 1974)

Star Cancellation (Halligan, Cockburn, and Wilson, 1991; B. [A.] Wilson, Cockburn, and Halligan, 1987a)

This untimed test was designed to increase cancellation task sensitivity to inattention by increasing its difficulty. Within this apparent jumble of words, letters, and stars are 56 small stars which comprise the target stimuli (see Fig. 10.6). The page is actually arranged in columns to facilitate scoring the number of cancelled small stars. The examiner demonstrates the task by cancelling two of the small stars, leaving a total possible score of 54. The test is available in two versions, A and B. Normal control subjects rarely miss a star: mean score of misses for 50 subjects was 0.28, with two missed at most so that three or more missed stars constitutes failure. A sample for copying and a scoring template are included in the Behavioural Inattention Test kit (B. [A.] Wilson, Cockburn, and Halligan, 1987a). This test correlates well with other tests of inattention ($r = .65$; [with drawing a clock face, a person, a butterfly] to $r = .80$ [with copying a star, a cube, a daisy, and three geometric shapes]). It identified all of a group of 30 patients (26 left, 4 right) with inattention (H. Marshall and Wade, 1989), 33 of 35 stroke patients with documented inattention (Ferber and Karnath, 2001), and was reported to be the most sensitive of a set of four tests (N.V. Marsh and Kersel, 1993).

Two and Seven Test[1] (Ruff, Evans, and Light, 1986; Ruff, Niemann, Allen, et al., 1992)

This test was developed to assess differences between automatic (obvious distractors) and controlled (less obvious distractors) visual search. The "automatic" condition consists of lines of randomly mixed capital letters with the digits 2 and 7 randomly intermixed; "controlled" search is presumably called upon by a format in which 2's and 7's are randomly mixed into lines of also randomly mixed digits. The test consists of 20 3-line blocks of alternating "automatic" or "controlled" search conditions. Each line of 50 characters contains ten 2's and 7's. Time allowed is five min. Scores are obtained both for correct cancellations and for omitted items up to the last item completed within the time limit.

[1] This test can be ordered from Neuropsychological Resources, 909 Hyde St., Suite 620, San Francisco, CA 94109-4839.

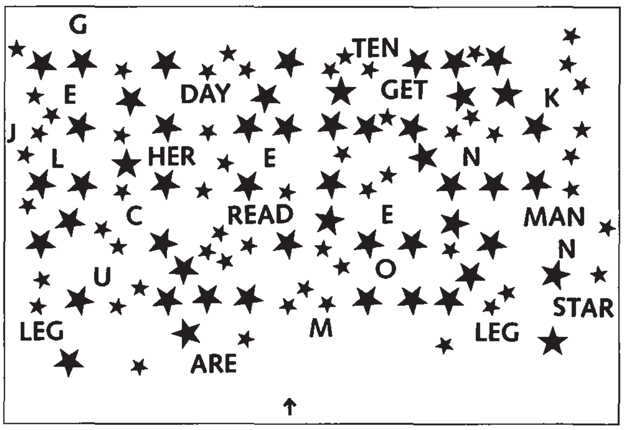


FIGURE 10.6 Star Cancellation test (reduced size). (Courtesy of Barbara A. Wilson)

Test characteristics. Test–retest reliability was in the .84 to .97 range although an average 10-point practice effect appeared. The average score for the "automatic" condition was 147, and that for "controlled" search was 131; this difference was significant ($p \leq .001$). No sex differences appeared on normative studies. Slowing increased linearly with age on both conditions; the relationship between speed and education was also linear up to 15 years, when education effects leveled off.

Neuropsychological findings. On medication trials, patients with AIDS and AIDS-related complex (ARC) showed relatively large differences between medication and placebo performances (F.A. Schmitt, Bigley, et al., 1988). As on other cancellation tasks, a small group (14) of patients with right-sided lesions were faster than patients with left hemisphere involvement but slower than normal subjects (Ruff, Niemann, et al., 1992). Anterior lesions on the right were associated with poorer accuracy than left anterior lesions, but no laterality differences in accuracy scores showed up for patients with posterior lesions. Anticipated differences between the two search conditions showed up most prominently in the right frontal group.

Visual Search and Attention Test (Trenerry, Crosson, DeBoe, and Leber, 1990)

Still another cancellation test consists of four 60 sec trials: one is a straightforward letter cancellation format; the second displays typewriter symbols (e.g., [,], <, >, %); the third and fourth are composed of letters and typewriter symbols, respectively, with color serving as an additional distractor as the characters are randomly printed in red, green, or blue. Each line is 40 characters long with 10 targets to a line and 10 lines to a trial. Performance is evaluated for left and right sides separately to facilitate evaluation of hemi-inattention, and for a total score.

Test characteristics. A pronounced age effect was shown by a normative sample covering the age groups from 18 to 19 years and then each decade through age 60+: the youngest group's mean total score of 166.93 ± 21.88 was the highest, with scores steadily diminishing to the 60+ age group's low mean of 98.98 ± 25.23. Normative tables for the six age groups provide scores for the left and right halves of each worksheet along with the total scores. Education did not contribute to score differences. In validation studies involving the control subjects and patients with various kinds of brain damage, discriminant function analysis generated 13% to 14% false positive and 12% to 22% false negative classifications, which both supports a claim that this test is sensitive to brain damage and suggests the need for caution about using it for screening purposes.

Picture description tasks for testing visual inattention

Symmetrically organized pictures can elicit "one-sided" response biases indicative of unilateral visual inattention. I [mdl] use two pictures taken from travel advertisements: One has a columned gazebo in its center with seven lawn bowlers pictured along the horizontal expanse of foreground; the other is a square composed of four distinctly different scenes, one in each quadrant. I ask patients to count the people and the columns on the first card and to tell me everything they see on the second one. Each of these pictures has successfully brought out the inattention phenomenon when it was not apparent on casual observation.

Picture Scanning (B. [A.] Wilson, Cockburn, and Halligan, 1987*a*)

This test, part of the Behavioural Inattention Test, consists of three large color photographs of common views: a plate with food on it; a bathroom sink with toiletries set around it; and the window wall (of an infirmary?) flanked by a steel locker and wheelchair on the left, a walker and privacy screen on the right. The subject is instructed to "look at the picture carefully" and then both name and point out the "major items" in the pictures. The test is scored for omissions. Fifty intact subjects averaged 0.62 ± 0.75 omissions, with three omissions at most. Of stroke patients with inattention, 65% of those with right-sided lesions failed this task but only one of four whose lesions were on the left (Halligan, Cockburn, and Wilson, 1991).

Reading tasks for testing visual inattention

Two kinds of word recognition problems can trouble nonaphasic patients. Both aphasic and nonaphasic patients with visual field defects, regardless of which hemisphere is damaged, tend to ignore the part of a printed line or even a long printed word that falls outside the range of their vision when the eye is fixated for reading. This can occur despite the senselessness of the partial sentences they read. Patients with left hemisphere lesions may ignore the right side of the line or page, and those with right hemisphere lesions will not see what is on the left. This condition shows up readily on oral reading tasks in which sentences are several inches long. Newspapers are unsatisfactory for demonstrating this problem because the column is too narrow. To test for this phenomenon, Battersby and his colleagues (1956) developed a set of ten cards on which were printed ten familiar four-word phrases (e.g., GOOD HUMOR ICE CREAM, NEWS PAPER HEAD LINE) in letters 1 inch high and 1/16 inch in line thickness. Omission or distortion of words on only one side was considered evidence of a unilateral visual defect.

Two reading tests are part of the Behavioural Inattention Test battery, each appearing in two versions (B. [A.] Wilson, Cockburn, and Halligan, 1987a). One test, *Menu Reading,* is on a large card containing two columns of five food items each, printed in large letters on either side of a centerfold. A number of these items consist of two words (e.g., fried haddock, jam tart). The other test, *Article Reading,* is presented in three columns in print a little larger than newspaper copy. Both articles deal with political economy—one Britain's, the other about Gorbachev's plans for the Soviet Union. Control subjects had no problems with either task. Menu Reading proved to be more sensitive to errors of inattention than Article Reading, respectively identifying 65% and 38% of patients with inattention (Halligan, Cockburn, and Wilson, 1991).

Indented Paragraph Reading Test (IPRT) (B. Caplan, 1987)

The Indented Paragraph is just that (see Fig. 10.7, p. 384). As can be seen on this example of the errors made by the 45-year-old pediatrician described on pp. 73–74, this test is effective in eliciting inattention errors as well as tendencies to misread. The subject reads the text aloud. Caplan recommends that the examiner record "the first word read on each line" and omissions, as well as the time taken to complete the reading. The examiner can follow the subject's reading on another test sheet, noting errors of commission as well as those of omission (e.g., Fig. 10.7). For clinical purposes, when a subject has completed half of the paragraph without errors, the test can be discontinued, as little more information will be gained. By the same token, if many errors are made on the first 14 or 15 lines, these should be sufficient to warrant discontinuing what—in these

With monocle
Without monocle

Trees brighten the countryside and soften the harsh lines of city
streets. Among them are our oldest and largest living
things. Trees are the best-known plants in man's experience. They are
graceful and a joy to see. So it is no wonder that people want
to know how to identify them. A tree is a woody
plant with a single stem growing to a height of ten
feet or more. Shrubs are also woody, but they are usually
smaller than trees and tend to have many stems growing
in a clump. Trees are easiest to recognize by their leaves. By
studying the leaves of trees it is possible to
learn to identify them at a distance. One group of trees has simple leaves
while others have compound leaves in which the blade is
divided into a number of leaflets. The leaf blade may have a
smooth uncut edge or it may be toothed. Not
only the leaves but also the flowers, fruit, seeds, bark,
buds, and wood are worth studying. When you look at a tree, see it as a
whole; see all its many parts; see it as a living
being in a community of plants and animals. The oldest trees live
for as long as three or four thousand years. Some grow almost
as tall as a forty story sky-scraper. The largest
trees contain enough wood to build dozens of average size
houses. Trees will always be one of the most important natural
resources of our country. Their timber, other
wood products, turpentine and resins are of great value. They also are
valuable because they hold the soil, preventing floods. In
addition, the beauty of trees, the majesty of forests,
and the quiet of woodlands are everyone's to
enjoy. Trees can be studied at every season, and they should be. Each
season will show features that cannot be seen at other times.
Watch the buds open in spring and the leaves unfold.

FIGURE 10.7 Indented Paragraph Reading Test with errors made by the 45-year-old traumatically injured pediatrician described on pp. 73–74. Errors made in each of two trials (with a small range magnifying monocle and without it) are marked.

cases—can be a painful task for patient and examiner alike. Of course, for research purposes, a standardized administration is necessary. The patient can be asked to describe what was read as an informal test of reading comprehension (and occasionally of short-term memory). Caplan defines mild neglect as one to nine omissions on the left side of the page; ten or more omissions earn a classification of moderate to severe neglect.

Neuropsychological findings. In the original study, most (78.3%) patients with left-sided damage read this passage without error, but barely half (53.5%) with lesions on the right read it perfectly. This test elicited the inattention phenomenon in patients in each lateralization group who had given no signs of such a problem on other tests. Of a sample of patients with right hemisphere disease similar to Caplan's original group, 20% scored in the mild inattention category while 50% met the criteria for moderate to severe inattention (L. Bachman et al., 1993). Although only 36% of this patient group had more than a high school education and 8% had at most five years of schooling, educational level was not associated with left-sided omissions. In a comparison of reading errors made by right hemisphere stroke patients on paragraphs with straight margins, doubly indented margins, and the Indented Paragraph, the doubly indented paragraph elicited the most errors ($M = 15.21 \pm 34$), fewer appeared on the Indented Paragraph ($M = 12.50 \pm 25$), and even fewer on the straight-sided paragraph, but these differences were not significant (Towle and Lincoln, 1991). Correlations with the Star Cancellation and Article Reading tests were .37 and .49, respectively. Towle and Lincoln pointed out that the different tests identified somewhat different clusters of patients, again illustrating the need for more than one kind of assessment for visuospatial hemiinattention.

Writing techniques for examining inattention

Left unilateral visual inattention for words, a defect that interferes with the reading accuracy and pleasure of many patients with right brain damage, may be clearly shown by having the patient copy sentences or phrases. Names and addresses make good copying material for this purpose since missing words or numbers

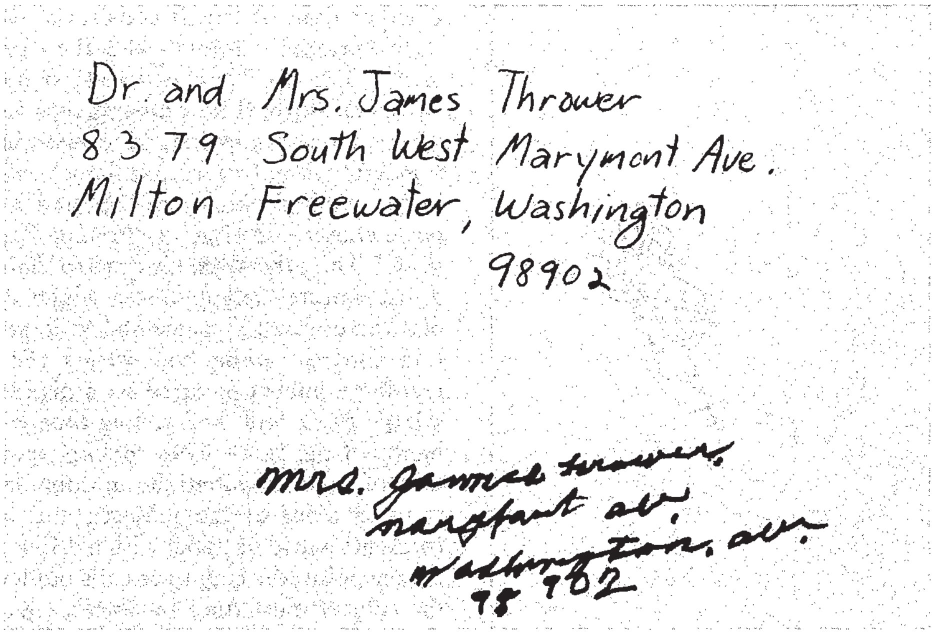


FIGURE 10.8 This attempt to copy an address was made by a 66-year-old retired paper mill worker two years after he had suffered a right frontal CVA. His writing not only illustrates left visuospatial inattention but also the tendency to add "bumps" (e.g., the m in "James") and impaired visual tracking (e.g., "Ave" is repeated on the line below the street address line)—all problems that can interfere with the reading and writing of patients with right hemisphere lesions.

are less apparent than a word or two omitted from the left-hand side of a meaningful line of print. When set up in a standard address format, patients' efforts to copy model addresses readily reveal inattention defects (see Fig. 10.8). The Behavioural Inattention Test contains two little copying tasks in the *Address/Sentence test* (B.[A.] Wilson, Cockburn, and Halligan, 1987a). One consists of a four-line address similar in the number and placement of elements to the one shown in Figure 10.8. The second task is a three-line sentence, such as might be in a newspaper article but presented in type a little larger than ordinary print. The top left-hand word in each is "The," on the left at the bottom is "St.," words that could readily be omitted without compromising the meaning of the sentence. Of a group of right brain damaged patients with inattention, 65% failed this test (Halligan, Cockburn, and Wilson, 1991).

Drawing and copying tests for inattention

Both free drawing and drawing to copy can elicit the inattention phenomenon (e.g., see Figs. 3.13 and 3.15a, pp. 67, 69). Thus most batteries designed to elicit inattention will contain one or both of these techniques. For example, Strub and Black (2000) ask their patients to copy five items (a diamond, a cross, a cube, a three-dimensional pipe, and a triangle within a triangle) and to draw free hand a clock with numbers and hands (time not specified), a daisy in a flower pot, and a house in perspective showing two sides and a roof. The Behavioural Inattention Test (B. [A.] Wilson, Cockburn, and Halligan, 1987a) has both *Representational drawing* (a "clock face with numbers," a man or woman, a butterfly) and *Figure and shape copying* (a star, a cube, a daisy) tasks. The characteristic common to these stimuli is their bilateral nature: many are bilaterally symmetrical (e.g., see Fig. 10.9, p. 386); in the others, left- and right-sided details are equally important.

The bilateral asymmetry of the Complex Figure proved effective in eliciting evidence of left visuospatial inattention (Rapport, Farchione, Dutra, et al., 1996) (see Fig. 14.2, p. 537). The side of errors and omissions on copies of the Complex Figure clearly distinguished right-lesioned stroke patients with ($n = 36$) and without ($n = 32$) already identified unilateral inattention: the former made an average of 3.31 ± 1.33 omissions from the left of the figure; the latter's left omission average was 0.72 ± 0.68. Similar data distinguished patients with left-sided strokes (right-sided omission $M = 0.45 \pm 0.89$) and control subjects who rarely omitted a design element. Of the 36 patients with left visuospatial inattention, 35 gave evidence of this problem when copying the Complex Figure.

Drawings tend to be somewhat less sensitive in eliciting inattention than cancellation tasks generally. In an evaluation of the Behavioural Inattention Test, fig-

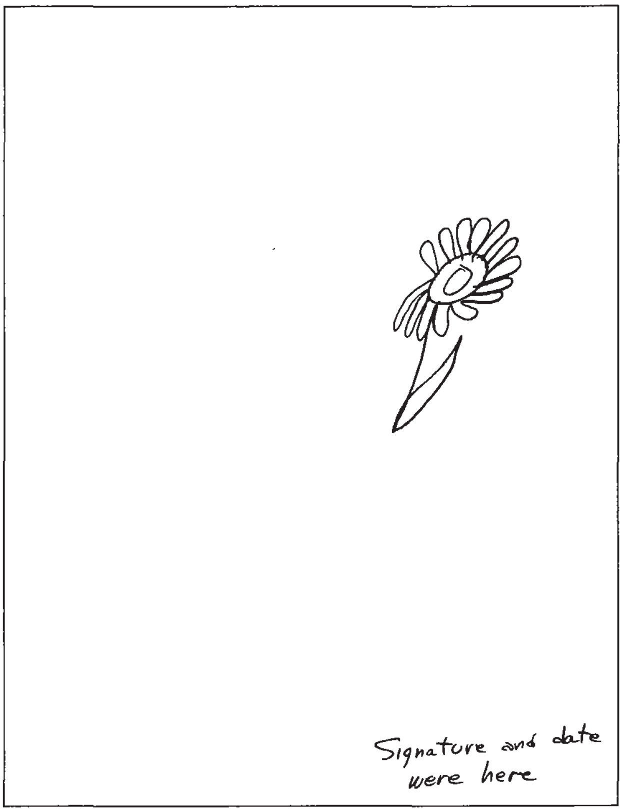


FIGURE 10.9 Flower drawn by patient with left visuospatial neglect. Note placement of flower on the page.

ure and shape copying were much more sensitive than drawing specified objects (eliciting inattention errors for 96% and 42%, respectively, of patients with right-sided strokes) (Halligan, Cockburn, and Wilson, 1991).

Inattention in spatial representation

Unilateral visuospatial inattention is a spatial as well as a visual phenomenon. This can be demonstrated in tests of spatial representation in which the visual component has been eliminated. Left-sided spatial inattention was elicited by requesting the subject to describe a familiar locale (Bisiach and Luzzatti, 1978). Patients were asked to name the prominent features of a scene from two specific viewing points directly opposite one another. Their left-sided inattention appeared as either absence or scant mention of features on the left, in marked contrast to detailed descriptions of structures to the right of each given perspective.

Behavioural Inattention Test (BIT) (B. [A.] Wilson, Cockburn, and Halligan, 1987a)

This test battery was developed to provide a more naturalistic examination of tendencies to hemi-inattention, whether right or left. It consists of two sections, the "conventional subtests" and the "behavioural subtests." The six "conventional" subtests have been described above (Line crossing, Star cancellation, Figure and shape copying, Line bisection, Representational drawing, Letter cancellation). Picture scanning, Menu reading, Article reading, and Address and sentence copying are four of the nine "behavioural subtests." The others are *Telephone dialing* (which uses a disconnected telephone on which the patient must dial three numbers presented in large print on separate cards); *Telling and setting the time* (includes reading numbers pictured on a digital clock; reading a large clock face, and setting time with the movable hands of the face); *Coin sorting* (requires identification of six denominations of coins laid out in three rows in front of the subject); and *Map navigation* (presents a grid of paths with a different letter at each choice point: the examiner calls out letter pairs which the subject must trace by finger, e.g., from A to B).

Test characteristics. Available reliability studies involve very small groups of patients (as few as six, up to 10), but they indicate satisfactory (r = .75 for parallel forms of the set of conventional tests) to excellent reliabilities (r = .97 for test–retest of the set of behavioral tests) (Halligan, Cockburn, and B. Wilson, 1991). The two sets of tests correlated highly with each other (r = .79) and each correlated well (rs of .65, .67) with occupational therapists' reports and an assessment of activities of daily living (ADLs). All of 14 control subjects passed all of the behavioral tests except Map navigation (failed by three) and Picture scanning and Digital time (each failed by one) (B. [A.] Wilson, Cockburn, and Halligan, 1987b). Map navigation was the most sensitive of these tests (eliciting inattention from 14 of 28 patients with lateralized damage), with Coin sorting running a close second (11 patients displayed inattention). This battery identified inattention in 18 of 41 right hemisphere stroke patients (Samuelsson et al., 2002).

Visual Scanning

The visual scanning defects that often accompany brain lesions can seriously compromise such important activities as reading, writing, performing paper-and-pencil calculations, and telling time (Diller, Ben Yishay, et al., 1974), and they are also associated with accident-prone behavior (Diller and Weinberg, 1970). Tests for inattention and cancellation tasks will often disclose scanning problems as will other perceptual tests requiring scanning.

Counting dots

This very simple method for examining visual scanning can be constructed to meet the occasion. The subject is asked to count aloud the number of dots—20 or more—widely scattered over a piece of paper, but with an equal number in each quadrant. Errors may be due to visual inattention to one side, to difficulty in maintaining an orderly approach to the task, or to problems in tracking numbers and dots consecutively. McCarthy and Warrington (1990, p. 85) noted that this technique can make poor scanning strategies evident, as some patients count the same dot more than once thus overestimating the number while others miss or neglect dots and report too few.

Visual Scanning Test (Samuelsson, Hjelmquist, Jensen, and Blomstrand, 2002)

Samuelsson and his coworkers used the Behavioural Inattention Test with acute and postacute stage right hemisphere stroke patients to identify those exhibiting unilateral inattention (n = 18) and those who did not (n = 23). Thirty-two letters and numbers appear scattered on a standard European size paper (approximately 29.5 × 21 cm), but are actually arranged in 8 rows × 4 lines providing 32 "cells" for tracking subject responses. Subjects read the letters and numbers while the examiner tracks the path of target selection on a separate graphed page.

Most of the demographically matched control subjects (29/34) followed a single search strategy (24 by row, 5 by column); all but three of them began at top left; 29 missed no target and no one missed more than one. Patients giving no evidence of inattention differed little from control subjects, but omitted more targets, shifted strategies a bit more, and a few subjects read the same target more than once. Inattention patients showed direction shifts—which were not made by either control subjects or noninattention patients, and more strategy shifts, with a median of 8.7% repeated targets (interquartile range = 23.8%), this latter kind of error being the most important correlate of inattention. A follow-up study six to seven months later found only six (of 36) patients still manifesting unilateral inattention and even their search patterns had become less erratic.

Visual Search (R.F. Lewis and Rennick, 1979)

This test is part of both the computer-assisted and manual forms of the Repeatable-Cognitive-Perceptual-Motor Battery. More recently it was included in the National Institute of Mental Health Core Neuropsychological Battery and in this battery's abbreviated version (N. Butters, Grant, et al., 1990). The test booklet contains four versions of the 9 × 9 checkerboard pattern stimulus figure (see Fig. 10.10). The subject's task is to indicate in which of the outlying grids is the position of the two little black squares like that of eight center test grids. The test is scored for time and errors. For 30 healthy adults (M_{age} = 37.6 ± 11.8, M_{educ} = 15.5 ± 2.7), mean total time was 116.8 ± 36.9 sec., with 1.09 ± 1.4 average errors (McCaffrey, Westervelt, and Haase, 2001). Over five trials given over $1^1/_2$ years, scores remained essentially flat.

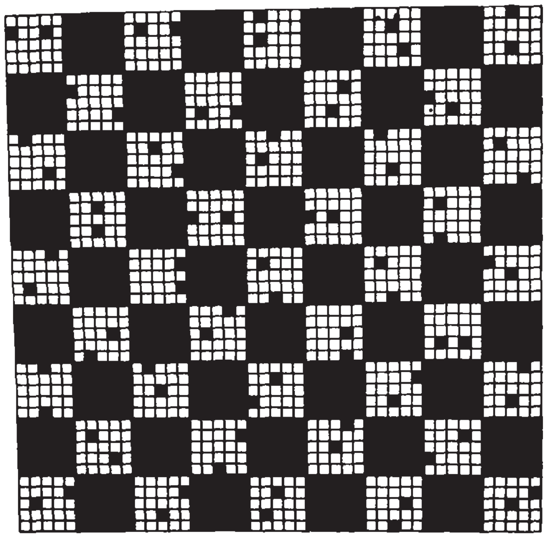


FIGURE 10.10 One of the Visual Search stimulus figures.

In the original format of 16 stimulus figures projected on a screen, brain impaired patients were much slower than normal control subjects and considerably slower than neurologically intact psychiatric patients (G. Goldstein, Welch, et al., 1973). Error scores did not discriminate between these groups. Time scores also proved useful in evaluating the effects of medication changes in epileptic patients (R.F. Lewis, Rennick, Clifford, et al., 1976, cited in Kelland and Lewis, 1994).

In my experience the evaluation standards (provided with the test material) may be too generous [mdl]. A comprehensive normative study would be welcomed.

Color Perception

Tests of color perception serve a dual purpose in neuropsychological assessment. They can identify persons with congenitally defective color vision, or "color blindness," whose performance on tasks requiring accurate color recognition might otherwise be misinterpreted. Knowledge that the patient's color vision is defective will affect the evaluation of responses to such colored material as the color cards of the Rorschach technique, and should militate against use of color-dependent tests such as Stroop tests. Color perception tests can also be used to test for color agnosia and related defects. Evaluation of color recognition (usually measured by color association tasks such as Coloring of Pictures or Wrongly Colored Pictures, discussed below) is important in examining aphasic patients since many of them have pronounced color recognition deficits (Denburg and Tranel, 2003; Vuilleumier, 2001). A small proportion of patients with lesions on the right and of nonaphasic patients with left-sided lesions also have color recognition problems. Color perception itself can be attentuated by some toxic exposures (Mergler, Bowler, and Cone, 1990; Spencer, 2000b). Rarely, brain disease will destroy the ability to see colors (*achromatopsia*) (Bauer and Demery, 2003; Farah, 2003).

Testing for accuracy of color perception

In neuropsychological assessment, the *Dvorine* (1953) and the *Ishihara* (1983) screening tests for the two most common types of color blindness are satisfactory. The *H-R-R Pseudoisochromatic Plates* (Hardy et al., 1957) screen for two rare forms of color blindness, which would not be correctly identified by the Ishihara or Dvorine tests, as well as for the two common types (Hsia and Graham, 1965). The stimulus materials of all three of these tests are cards printed with different colored dots, which form recognizable figures against a ground of contrasting dots.

Farnsworth's Dichotomous Test for Color Blindness (D-15), Lanthony's Desaturated 15 Hue Test (D15-d)[1]

These tests each consist of 16 color caps, all of similar brightness but a little different in hue, together representing a continuous color range. The Lanthony set colors are desaturated (i.e., very pale pastels) and sensitive to even mild forms of defective color vision. In each test set, 15 color caps are spread out randomly in front of the subject, whose task initially is to find the color cap with the hue closest to that of a cap fixed to one end of a horizontal tray. Then, one by one, the subject must try to line up the 15 movable caps in a consistent color continuum, always seeking the hue closest to the one just matched. A scoring form permits discrimination of three kinds of impaired color vision. This technique has identified color vision impairments associated with toxic solvent exposure (Mergler, Bowler, and Cone, 1990) and with alcoholism (Mergler, Blain, et al., 1988). A scoring table is now available for the desaturated test which can be used when conducting field studies (e.g., of toxic exposures) (Geller, 2001).

[1]This test may be ordered from Luneau Ophtalmologie, B.P. 252, 28005 Chartres Cedex, France (e-mail: luneau.export©free.fr).

Neitz Test of Color Vision (J. Neitz, Summerfelt, and Neitz, 2001)

This paper-and-pencil color perception test is suitable for both individual and group testing of both blue–yellow and red–green discrimination deficiencies. The subject sees a sheet with nine grayish circles, each filled with rows and columns of small, mostly grayish dots, but some dots are in muted colors forming a geometric figure (square, circle, etc.; and one large circle has randomly placed colored dots) within the circle that can only be discerned by color competent viewers. Eight of the nine circles have other dots making patterns not normally viewed but seen by persons with color blindness. The type of errors made help to discriminate between the two most common color vision defects. Responses are checked in one of five small circles below each large one: in each array of response circles one contains the outline of each of the four geometric figures and one is empty. The correct response is the circle containing the normally discerned pattern in the large stimulus circle. Error patterns indicate the kind of color blindness a person has. Three parallel versions each test for the same kinds of color defect but the circle patterns are placed differently.

This test was developed for children but can be easily used with adults. In a validity study, failures were compared with genotypes: none of the subjects with an identified gene type for color blindness passed this test; 94% of normal adult males did pass it. In one published study, the authors (M. Neitz and Neitz, 2001) reported on color testing of 5,129 boys. Comparisons with conventional tests of color vision found good agreement.

Color-to-Figure Matching Test (Della Sala, Kinnear, Spinnler, and Stangalino, 2000)

Questioning whether Alzheimer patients had impaired color vision (*dyschromatopsia*), Della Sala and his colleagues showed nine black on white line drawings of common objects which "are not linked with a unique prototypical color" (e.g., an artichoke, a rabbit, a priest [!]) along with 30 colored pencils including many shades of some colors (e.g., five of red, four of green, but just one for black and for white). Correctness of color choices was defined by 33 control subject responses to this test: any color selected for a drawing by 11 or more of them was considered "correct;" colors which six or fewer control subjects had selected for a drawing were "wrong;" colors selected for a drawing by 7 to 10 of the control subjects were classified as "doubtful." Each color choice was scored on a 3-point scale (2–0); with eight drawings (the first, cherries, is a practice trial), the maximum score is 16. Alzheimer patients' average score was 13.18 ± 2.66. Color choice failures correlated significantly ($r = .59$) with disease severity. A designated cut-off score clearly destinguished mildly impaired patients who performed well on this test from moderately impaired patients who made most of the errors.

Discriminating between color agnosia and color anomia

The problem of distinguishing color agnosia, in which colors are seen but have lost their object context (Farah, 2003; see Bauer and Demery, 2003, for a somewhat different definition) from an anomic disorder involving use of color *words* was ingeniously addressed in two tasks devised by A.R. Damasio, McKee, and Damasio (1979). *Coloring of Pictures* requires the subject to choose a crayon from a multicolored set and fill in simple line drawings of familiar objects that have strong color associations (e.g., banana—yellow; frog—green). In *Wrongly Colored Pictures,* the examiner shows the subject a line drawing that has been inappropriately colored (e.g., a green dog, a purple elephant), and asks what the picture represents.

In a refinement of these techniques which investigates the correctness of color associations, Varney (1982) developed a set of 24 line drawings of familiar objects (e.g., banana, ear of corn). Each drawing is accompanied by samples of four different colors, of which only one is appropriate for the item. This format requires only a pointing response. Just four of 100 normal subjects failed to identify at least 20 colors correctly. In contrast, 30% of the 50 aphasic patients failed this standard. It is of interest that all of the aphasic patients who failed the color association test also failed a reading comprehension task, while none who succeeded on the reading task failed the color association test.

Three kinds of color tests together may help to distinguish a color agnosia from an anomia for colors (Beauvois and Saillant, 1985). In the purely verbal "colour name sorting" test, the examiner names a color (e.g., blush, scarlet) and the subject must identify the general color category to which it belongs (brown, red, or yellow). A second verbal task asks for a color name for a purely verbal concept (e.g., "what colour name would you give for being jealous?" " . . . to royal blood?"). Visual tasks include the Color Sorting Test and a test of "pointing out the correctly coloured object." These latter two tests require little if any verbal processing. A third test category, "visuo-verbal tests," asks for "colour naming on visual confrontation;" "pointing out a colour upon spoken request" asks the subject to "show me the colour of a banana" for example; and conversely, the subject is asked to "give the colour name of an object" drawn without color.

Goodglass, Kaplan, and Barresi (2000) include some color items in the Boston Diagnostic Aphasia Examination. *Word Discrimination* asks the subject to point to six colors named by the examiner. The *Visual Confrontation Naming* section asks the subject to name these six colors. In *Written Confrontation Naming,* two colors are shown for their names to be written. Performance on these three tasks may help the examiner sort out the presence and nature of a problem with colors, or at least alert the examiner that a problem with colors needs further investigation.

Although these tests can aid in differentiating an agnosic from an anomic condition, examiners must remain alert to the possibility that the agnosia or the anomia involves much more than colors. Moreover, problems with object recognition or other naming disorders may have contributed to erroneous responses (see also Coslett and Saffran, 1992; De Renzi and Spinnler, 1967).

Visual Recognition

Interest in visual recognition has grown with the rapid expansion of knowledge of the different roles played by the hemispheres and with more precise understanding of the different functional systems. When brain dysfunction is suspected or has been identified grossly, the examination of different aspects of visual recognition may lead to a clearer definition of the patient's condition.

Angulation

The perception of angular relationships tends to be a predominantly right hemisphere function except when the angles readily lend themselves to verbal description (e.g., horizontal, vertical, diagonal) so that they can be mediated by the left hemisphere as well as the right. Thus inaccurate perception of angulation is more likely to accompany right hemisphere damage than damage to the left hemisphere (Benton, Hannay, and Varney, 1975; McCarthy and Warrington, 1990).

Judgment of Line Orientation (JLO)[1] (Benton, Hannay, and Varney, 1975; Benton, Sivan, Hamsher, et al., 1994, test manual)

This test examines the ability to estimate angular relationships between line segments by visually matching angled line pairs to 11 numbered radii forming a semicircle (see Fig. 10.11). The test consists of 30 items, each showing a different pair of angled lines to be matched to the display cards. Its two forms, H and V, present the same items but in different order. A five-item practice set precedes the test proper. The score is the number of items on which judgments for both lines are correct; thus, the score range is 0–30. Scores ≥23 are in the *average* or better ranges (e.g., 29–30 = *superior*). Score corrections are provided for both age and sex (see Table 10.2).

Test characteristics. Internal consistency is high (.90) (Qualls et al., 2000). After one year a retest correlation for elderly control subjects was .59 (B.E. Levin, Llabre, Reisman, et al., 1991). For control subjects and patients in a stable course, practice effects were inconsequential (McCaffery, Duff, and Westervelt, 2000b), and nil for Parkinson patients and controls after 20 min (Alegret et al., 2001). Normative data show that only 5.5% of 137 normal subjects obtained scores below 19 while only two of that group scored below 17 (Benton, Sivan, Hamsher, et al., 1994). Scores between 17 and 20 represent mild to moderate defects in judging line orientation; scores below 17 indicate a severe defect.

[1]The test material is sold by the Medical Sales Department, Oxford University Press, 198 Madison Ave., New York, NY 10016.

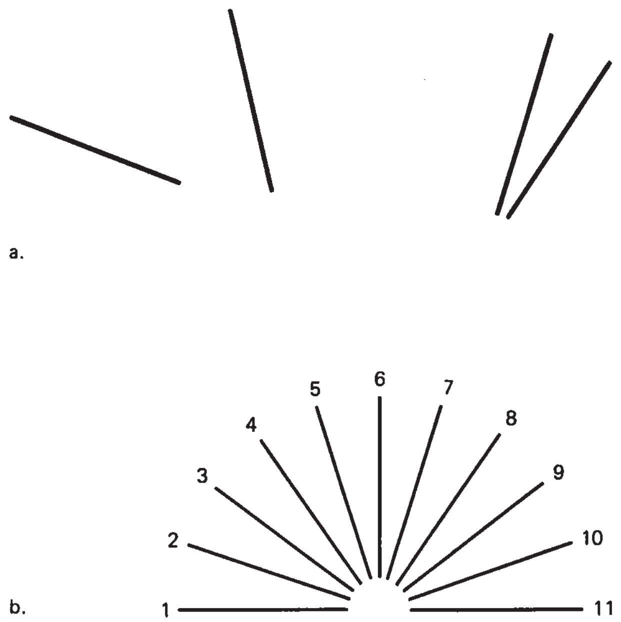


FIGURE 10.11 Judgment of Line Orientation (Benton, Sivan, Hamsher, et al., 1994). Examples of double-line stimuli (*a*) to be matched to the multiple-choice card below (*b*).

TABLE 10.2 Judgment of Line Orientation: Score Corrections

Add	
0	Men under age 65
1	Men between ages 65 and 74
2	Women under age 65
3	Men over age 65, women between ages 65 and 74
4	Women over age 75

Adapted from Benton, Sivan, Hamsher, et al. (1994)

Women's scores tend to run about two points below those of men, a finding virtually identical to that of an Italian study cited in the manual; male superiority also appeared for college students in a group-administered variation of this test (Collaer and Nelson, 2002). Performance declines with age, most noticeably after 65 (Eslinger and Benton, 1983; Mittenberg, Seidenberg, et al., 1989), but in one study this decline did not reach statistical significance (Ska, Poissant, and Joanette, 1990). A group of well-educated elderly people scored well within the normal range until after age 75 (Benton, Eslinger, and Damasio, 1981). JLO performances by over 750 persons ages 55 to 97 generated small correlations with age ($r = -.25$), with sex ($r = -.24$), with education ($r = .21$), and thus required virtually no changes in standard score conversions from ages 56 to 77 (Ivnik, Malec, Smith, et al., 1996). The mean raw score range for this large sample remained at 21–22 from age 56 to 80, dropping to 20–21 for the 81 to 83 age group, and to 19–21 for ages 84 to 97.

Neuropsychological findings. While performing this test, cerebral blood flow in temporo-occipital areas increased bilaterally, with the greatest increases on the right (Hannay, Falgout, et al., 1987). Most patients with left hemisphere damage performed in the *normal* range, as shown when 50 left- and 50 right-lesioned patients were compared with the normative subjects (age-corrected scores): 41 with left-sided lesions performed at *average* or better levels, only one scored below 17; of the patients with right-sided lesions, 21 achieved an *average* or better score and 18 made scores in the *severely defective* range (Benton, Sivan, Hamsher, et al., 1994). Patients with visual field defects showed a slightly greater tendency to failure than those with intact fields. Aphasia in left-hemisphere lesioned patients increases somewhat their likelihood of failure. Most failures were made by patients with posterior or mixed anterior–posterior lesions (see also A.R. Damasio and Anderson, 2003).

Dementia patients frequently fail this test (Eslinger and Benton, 1983; Ska, Poissant, and Joanette, 1990), many receiving scores much below the 18-point cutoff. However, 51.6% of patients with probable Alzheimer's disease overlapped a control group of similar age, and 60.7% of Parkinson patients also overlapped the control group, although the means of both groups were lower (Finton et al., 1998). An analysis of error types in this study did not differentiate these groups with the exception of Parkinson patients' greater incidence of misjudgment of both lines with their spatial relationship maintained. The failures of 16% of a group of Parkinson patients were not associated with general cognitive ability, or with disease severity (Hovestadt et al., 1987), nor were failures associated with PD duration (B.E. Levin, Llabre, et al., 1991). Alegret and his colleagues (2001) concluded that the nature of errors made by Parkinson patients—disproportionately involving intraquadrant dissimilar lines and horizontal lines—demonstrated a visuospatial disorder in this disease.

Short forms. Randomized JLO items comprise two 15-item forms; scores were doubled to make them comparable to the 30-item JLO (Qualls et al., 2000). Using protocols from rehabilitation patients (mostly stroke, some TBI, and a few other neuropathological disorders), these forms had good internal consistency and one form correlated very well (.94) with full score data. However, on testing a different group of stroke patients, scores did not discriminate well between right- and left-lesioned patients. Ten percent of these patients produced scores in the normal range, leading the authors to recommend these forms for visuospatial screening and use of the original JLO when visuospatial impairment is an issue.

Unusual views of pictured objects

Warrington and Taylor (1973; see also McCarthy and Warrington, 1990) examined the relative accuracy with which patients with right or left hemisphere lesions could identify familiar objects under distorting conditions. In the first condition, involving 20 enlarged drawings of small objects such as a safety pin, both patients and control subjects recognized objects drawn in their usual size. The patients made significantly more errors than the control subjects in recognizing the enlarged objects, with only a negligible score difference between the right and left brain lesioned groups. The second condition presented photographs of 20 familiar objects taken from a conventional and an unconventional view. For example, a bucket was shown in a side view (the conventional view) and straight down from above (the unconventional view). This condition resulted in a clear-cut separation of patients with right brain damage, who did poorly on this task, from the left damaged group or the control subjects. In addition, patients with right posterior lesions made the most errors by far.

Riddoch and Humphreys (2001) developed a set of object pictures taken from unusual angles (e.g., a corkscrew: from the side of the handle, facing the handle from the tip of the greatly foreshortened screw). On showing these pictures to patients with right hemisphere lesions, they found a "double dissocation" as one patient failed to recognize only objects reduced to their minimal features (side view of corkscrew) while other patients' recognition impairment was restricted to objects with a foreshortened main axis (view from tip of corkscrew). They note that for the most part these patients had adequate recognition for objects seen in familiar perspectives, and offer some theories to account for these phenomena. Turnbull and his colleagues (1997) suggest that both dorsal (involving the parietal lobes) and ventral (involving the temporal lobe) pathways contribute to unusual view deficits: the temporal lobes are necessary for object recognition; the parietal lobes provide for the spatial conceptualization necessary to identify objects from strange perspectives.

Perceptual Speed (Identical Forms) (L.L. Thurstone and Jeffrey, 1987)

This is a timed paper-and-pencil picture matching task in which both visuoperceptual accuracy and speed in making perceptual judgments contribute to the performance (Fig. 10.12, p. 392). Each of the 140 items displays a target figure—an abstract design of an object such as a clock, a bird, or a shoe or a geometric design—with five similar designs, of which one is identical to the target. A five min time limit insures that virtually no one can complete the test, although most of the items are neither tricky nor difficult. Norms were developed for personnel selection in industry, but this easy to administer test is well-suited to neuropsychological applications.

Test characteristics. Norms are given for jobs in industry and government organizations. Thurstone and Jeffrey (1987) obtained split-half reliability coefficients ranging from .92 to .98 based on a 60-item format. Correlations with nine discrete clerical test scores ranged from .32 (Error Location) to .52 (Alphabetizing). Like its name, this test has had highest or second highest loadings on a Perceptual Speed factor in numerous studies (reported in test manual).

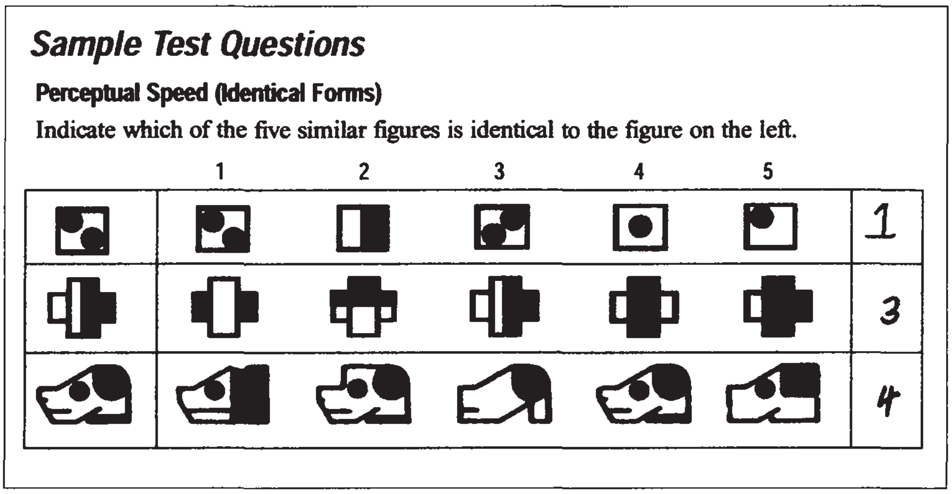


FIGURE 10.12 Perceptual Speed. (© 1984 by L.L. Thurstone, Ph.D. All rights reserved.) This sample test question may not be duplicated in any manner without written permission from the publisher. (Courtesy of Pearson Reid London House, Inc.)

Face recognition

Warrington and James's (1967b) demonstration that there is no regular relationship between inability to recognize familiar faces (*prosopagnosia*) and impaired recognition of unfamiliar faces has led to a separation of facial recognition tests into those that involve a memory component and those that do not (see also Chatterjee and Farah, 2001; McCarthy and Warrington, 1990). Tests of familiar faces call on stored information and ease of retrieval. Typically, these tests require the subject to name or otherwise identify pictures of well-known persons (Warrington and James, 1967b). Two kinds of errors were noted in the earlier studies: Left hemisphere damaged patients identified but had difficulty naming the persons, whereas defective recognition characterized the right hemisphere damaged patients' errors. A third error pattern appears among patients with frontal lesions who lack a search strategy (Rapcsak, Nielsen, et al., 2001). Facial recognition deficits tend to occur with spatial agnosias and dyslexias, and with dysgraphias that involve spatial disturbance (Tzavaras et al., 1970).

Recognition tests of unfamiliar faces involving memory have appeared in several formats. Photos can be presented for matching either one at a time or in sets of two or more. When the initial presentation consists of more than one picture, this adds a memory span component, which further complicates the face recognition problem. The second set of photos to be recognized can be presented one at a time or grouped, and presentation may be immediate or delayed. By having to match unfamiliar faces following a delay, patients with brain damage involving the right temporal lobe demonstrated significant performance decrements, again linking memory for configural material with the right temporal lobe (Warrington and James, 1967b).

Test of Facial Recognition[1] (Benton, Sivan, Hamsher, et al., 1994)

This test was developed to examine the ability to recognize faces without involving a memory component. The patient matches identical front views, front with side views, and front views taken under different lighting conditions (see Fig. 10.13). The original test has 22 stimulus cards and calls for 54 separate matches. Six items involve only single responses (i.e., only one of six pictures on the stimulus card is of the same person as the sample), and 16 items call for three matches to the sample photograph. It may take from 10 to 20 minutes to administer, depending on the patient's response rate and cautiousness in making choices.

In order to reduce administration time, a short form of this test was developed that is half as long as the original (H.S. Levin, Hamsher, and Benton, 1975). The 16-item version calls for only 27 matches based on six one-response and seven three-response items. Correlations between scores obtained on the long and short forms range from .88 to .93, reflecting a practical equivalence between the two forms. Instructions, age and education corrections (see Table 10.3, p. 393), and norms for both forms are included in the test manual.

[1]This test material is sold by the Medical Sales Department, Oxford University Press, 198 Madison Ave., New York, NY, 10016.

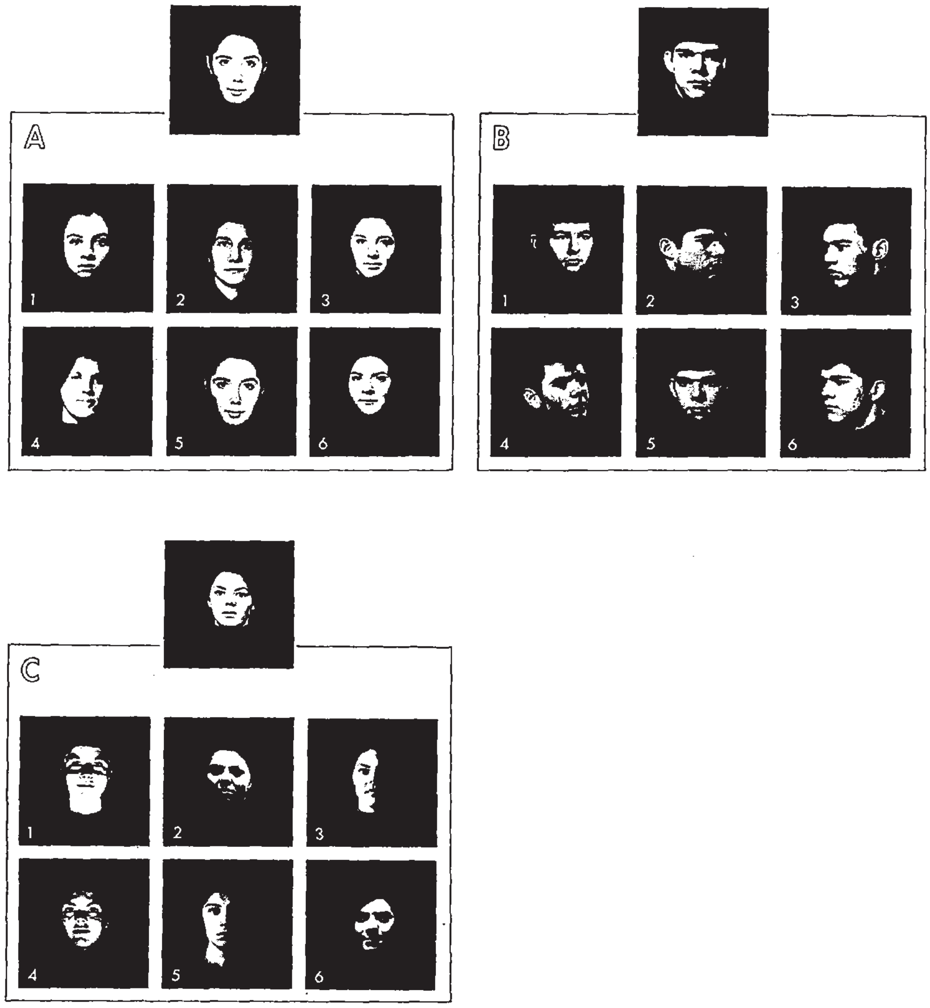


FIGURE 10.13 Test of Facial Recognition (Benton, Sivan, Hamsher, et al., 1994). These photographs illustrate the three parts of the test. *A:* Matching of identical front-views. *B:* Matching of front-view with three-quarter views. *C:* Matching of front-view under different lighting conditions.

Test characteristics. One-year retesting of elderly control subjects gave a reliability correlation of .60 (B.E. Levin, Llabre, Reisman, et al., 1991). Practice effects appear to be mostly negligible (McCaffrey, Duff, and Westervelt, 2000b). A 1.9-point difference between older (55–74) subjects who had completed high school and those who had not was significant ($p < .01$), but the difference in the two education groups at younger ages was smaller and insignificant (Benton, Sivan, Hamsher, et al., 1994). Older age is negatively related to success on this test (Eslinger and Benton, 1983; Mittenberg, Seidenberg, et al., 1989). Even well-educated intact subjects show a significantly large failure rate (10%), beginning in the early 70s and increasing (to 14%) after age 75 (Benton, Eslinger, and Damasio, 1981). No sex differences have been reported.

TABLE 10.3 Facial Recognition Score Corrections

Add	
0	Everyone ages 16 to 54
1	Ages 55 to 64, 12+ years' education
2	Ages 65 to 74, 12+ years' education
3	Ages 55 to 64, 6–12 years' education
4	Ages 65 to 74, 6–12 years' education

Adapted from Benton, Sivan, Hamsher, et al. (1994)

Neuropsychological findings. Normal subjects who are weakly left-handed may do less well on facial recognition tests than right-handed or strongly left-handed normal control subjects (J.G. Gilbert, 1973). This tendency has been related to the relatively decreased lateralization of functions hypothesized as characterizing the brain organization of weakly left-handed persons. A comparison of patients with lateralized brain lesions found that 80% of the 33 with right-sided damage made scores below the median of the left-sided lesioned patients (Wasserstein, Barr, et al., 2003). Patients with right posterior lesions have the highest failure rate on this test (Benton, Sivan, Hamsher, et al., 1994). Patients with right parietal lesions perform more poorly than those with right temporal lesions on the facial recognition task reflecting this task's substantial visuospatial processing component (Warrington and James, 1967b). Wasserstein, Zappulla, and their colleagues (1984) found, for example, that their three patients with right medial–temporal lesions performed in the 85th to the 97th percentile range. However, following temporal lobe resection for intractable epilepsy, patients' (n = 158) Facial Recognition scores dropped a small but significant amount regardless of resection side, although their Judgment of Line Orientation performances remained at the preoperative level (Hermann, Seidenberg, Wyler, and Haltiner, 1993). That the task may have a linguistic component is suggested by findings that aphasic patients with defective language comprehension fail on this test at rates a little lower than those with right parietal damage (Benton, Sivan, Hamsher, et al., 1994). Many more patients with posterior lesions had defective performances than did patients with anterior lesions. Patients with left hemisphere lesions who were not aphasic or who were aphasic but did not have comprehension defects made as few errors as healthy subjects. Visual field defects do not necessarily affect facial recognition scores although they are significantly correlated ($r = .49$, $p < .001$) with failure on this test (Egelko et al., 1988).

The group of dementing patients that had an 80% failure rate on Judgment of Line Orientation performed much better on this test with only a 58% failure rate (Eslinger and Benton, 1983). However, many more (39%) of a group of Parkinson patients failed on this test than on JLO (Hovestadt et al., 1987). This test correlated with the duration of Parkinson's disease and, as may be expected, was sensitive to the dementia that may accompany Parkinson disease (B.E. Levin, Llabre, Reisman, et al., 1991). It also elicited deficits in mildly impaired Parkinson patients (B.E. Levin, Llabre, and Weiner, 1989).

Recognition of the facial expression of emotion

Assessment procedures. A variety of photograph sets for examining facial expressions are available (e.g., Ekman and Friesen, 1975 [facial photos showing anger, disgust, fear, happiness, sadness, surprise, neutral]; Izard, 1971). Some are included in batteries designed to examine various aspects of emotion perception. Borod, Tabert, and their colleagues (2000) list several of these. Some emotional test batteries require more equipment than pictures or cards, such as the *New York Emotion Battery* (*NYEB*), which presents photos of facial expressions on slides using a timed slide projector with exposure times ranging from 5 sec (a matching task) to 20 sec (an identification task) (Borod, Welkowitz, and Obler, 1992). Others have devised their own photo sets. H.D. Ellis (1992) observed that this diversity of stimuli makes it difficult to compare study findings.

Moreover, test formats differ considerably as well. For example, A.W. Young and his colleagues (1996) showed six of the seven emotions depicted in the Ekman and Freisen set in four conditions that paired: same person same expression, same person different expression, different person same expression, and both person and expression different. This technique permitted the examiners to distinguish affect discrimination from facial discrimination. To test for expression recognition, individual photos were shown with emotional names to be selected; for expression matching, target photos were shown with a set of five containing one expression like the target plus four foils. Another group of investigators used all seven emotions in the Eckman and Freisen set: emotion recognition was tested by showing the photographs each with a list of seven emotion adjectives to be selected (Hornak et al., 1996). These subjects had been previously tested with Warrington's Recognition Memory for Faces to ensure their competency in facial recognition. Using the basic emotions photographed by Eckman and Friesen, A. Young, Perrett, and their colleagues (2002) have developed a computerized package that provides both the original Eckman and Freisen stimuli and the capacity to "computer-morph" both emotions onto faces to provide a range of intensity of expression.

Neuropsychological findings. The right hemisphere makes both the earliest and most rapid responses to faces associated with affective states (Pizzagalli et al., 1999; E. Strauss and Moscowitsch, 1981). Thus it is not surprising that when patients with unilateral brain lesions are tested for accuracy in identifying facial affect, those with damage on the right are much more likely to perform poorly than those with left-sided lesions (Borod, Bloom, et al., 2002; see also Heilman, Blonder, Bowers, and Valenstein, 2003). However, this difference may hold only when the task requires identification of emotion (i.e., which of several printed choices does a face photo express?) and not discrimination of expressions (i.e., do paired face photos exhibit the same emotion or different emotions?) (Borod, Cicero, Obler, et al., 1998). Patients with lateralized lesions show a differential sensitivity to different kinds of emotional expressions: patients with right brain damage recognized happy emotional expressions to about the same degree as did patients with left brain disease (83% accuracy vs. 79%), but they were significantly impaired in recognition of negative (38% accuracy to 76% for left brain damage) or neutral expressions (42% accuracy vs. 93%) (Borod, Koff, Lorch, and Nicholas, 1985; see also Borod, Welkowitz, Alpert, et al., 1990). Interestingly, patients with left-sided lesions were more accurate in identifying neutral expressions than were control subjects (93% to 81%). Etcoff's (1986) patients with right hemisphere lesions attempted to analyze the faces they were shown by rather unsystematic efforts at matching features, and, for the most part, they failed. Again, patients with brain lesions on the left side performed much like controls. In using a more complex experimental design that required recall as well as identification of emotional expression, Prigatano and Pribram (1982) found that patients with right posterior lesions were relatively more impaired than those with anterior lesions or than left hemisphere damaged patients.

Frontal leucotomy patients exhibited overall an even greater degree of emotional incomprehension than the right hemisphere damaged group (Cicone et al., 1980). Patients with ventral lesions of the frontal lobe also do poorly identifying facial expressions (Rolls, 1999). Although deficits in recognizing emotional expressions of faces or in voices did not necessarily go together, these deficits were strongly associated with severity of such behavior problems as disinhibition.

Figure and design recognition

Accuracy of recognition of meaningless designs is usually tested by having the patient draw them from models or from memory (e.g., Bender-Gestalt, Complex Figure Test). When design reproductions contain the essential elements of the original from which they are copied and preserve their interrelationships reasonably well, perceptual accuracy with this kind of material has been adequately demonstrated. A few responses to the WIS-A Picture Completion test or a similar task will show whether the subject can recognize meaningful pictures. At lower levels of functioning, picture tests can assess recognition of meaningful pictures (e.g., Peabody Picture Vocabulary Test, Boston Naming Test, or Picture Vocabulary items from Verbal Comprehension of the Woodcock-Johnson Battery-III Tests of Cognitive Abilities). The first 12 items of both forms of Raven's Progressive Matrices test simple recognition of designs. For patients with verbal comprehension problems, children's tests may be useful. When patients' graphic reproductions are inaccurate, markedly distorted or simplified, or have glaring omissions or additions, or when patients are unable to respond correctly to drawings or pictures, there is further need to study perceptual accuracy.

Visual Form Discrimination[1] (Benton, Sivan, Hamsher, et al., 1994)

This is a multiple-choice test of visual recognition. Each of the 16 items consists of a target set of stimuli and four stimulus sets below the target, one of which is a correct match (see Fig. 10.14). The other three sets contain small variations of displacement, rotation, or distortion. No age, sex, or education effects were found for the control subjects (Benton et al., 1994). An internal consistency coefficient (*alpha*) of .66 was thought to be reduced by the similarity of the sample (acute TBI) (Malina et al., 2001). With a cut-off of 28 specificity was 84% although sensitivity was only 59% for the TBI patients.

Based on a 3-point scoring system (2 = fully correct, 1 = a peripheral error response, 0 = all other errors), 68% of the control subjects achieved scores of 30 or

[1]The test material is sold by the Medical Sales Department, Oxford University Press, 198 Madison Ave., New York, NY 10016.

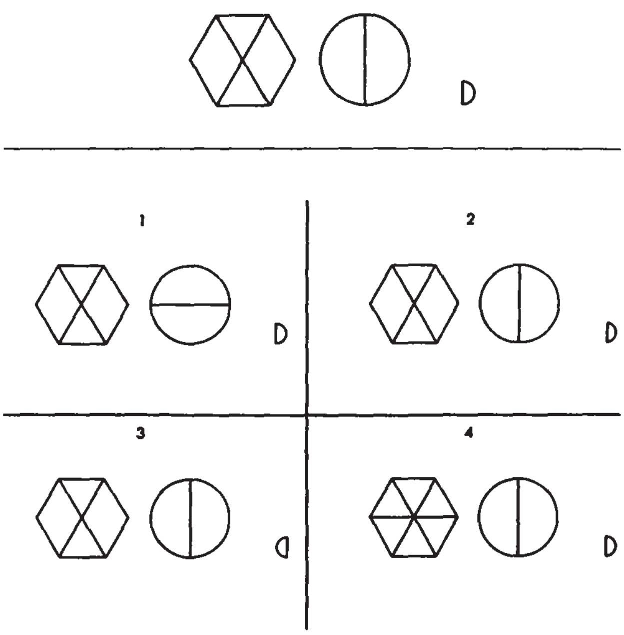


FIGURE 10.14 An item of the Visual Form Discrimination test. (© Oxford University Press. Reprinted by permission)

more, 95% had scores ≥26, and none scored below 23. In contrast, half of a "brain diseased" group (n = 58) made scores of 22 or less. Left anterior, right parietal, and bilateral-diffuse lesions were associated with the highest percentages of impaired performances. With a simple right/wrong scoring system, recently diagnosed Alzheimer patients failed, on average, ten of the 16 items, with most errors involving the small, peripheral figures (Mendez, Mendez, et al., 1990). However, only 32% of the acute TBI sample scored below the cut-off of 26 set by Benton and his colleagues (Malina et al., 2001). For both control subjects and these TBI patients, scores were markedly skewed such that the median and interquartile range describe these populations better than parametric statistics.

The multiple-choice format easily converts to a memory test. Following an immediate recall procedure, B. Caplan and Caffery (1996) showed the target designs for 10 sec to 51 control subjects of wide ranging ages (M = 36, range 21–79) and education levels (M = 14.9, range 7–20). Using the 3-point scoring system (2, 1, 0), a cut-off at 2 SD is 21.2. Number correct correlated positively with education (r = .33), negatively with age (r = −.43). Acknowledging the limitations of this "normative" sample, the authors called for more normative and clinical data for this procedure.

Visual Organization

Tests requiring the subject to make sense out of ambiguous, incomplete, fragmented, or otherwise distorted visual stimuli call for perceptual organizing activity beyond that of simple perceptual recognition. Although the perceptual system tends to hold up well in the presence of brain disorders for most ordinary purposes, any additional challenge may be beyond its organizing capacity. For this reason, tests of perceptual organization were among the earliest psychological instruments to be used for evaluating neuropsychological status. Roughly speaking, there are three broad categories of visual organization tests: those requiring the subject to fill in missing elements; tests presenting problems in reorganizing jumbled elements of a percept; and test stimuli lacking inherent organization onto which the subject must impose structure.

Tests involving incomplete visual stimuli

Of all tests of visual organization, those in which the subject fills in a missing part, such as Wechsler's Picture Completion, are least vulnerable to the effects of brain damage, probably because their content is usually so well structured and readily identifiable. Thus, although technically they qualify as tests of perceptual organization, they are not especially sensitive to problems of perceptual organization except when the perceptual disorder is relatively severe.

Gestalt Completion Tests

Several sets of incomplete pictures have been used to examine the perceptual closure capacity (e.g., see Fig. 10.15). Poor performance on gestalt completion tests has generally been associated with right brain damage (McCarthy and Warrington, 1990; Newcombe and Russell, 1969), yet correlations between four such tests were relatively low (.35 to .60), although each correlated highly (.70 to .90) with a total score when given to college students (Wasserstein, Zappulla, Rosen, et al., 1987). These included the *Street Completion Test* (Street, 1931), unpublished Street items (see Thurstone, 1949), Mooney 's *Closure Faces Test* (not available for clinical use), and the *Gestalt Completion Test* (Ekstrom et al., 1976). Wasserstein and her colleagues suggested that differences in performances on these various closure tasks were due to variations in such stimulus characteristics as whether lines were straight or curved, perspective or content information cues, verbalizable features, or subjective contour illusions. Thus these tests cannot be used interchangeably. The several meanings of the concept of "closure" could account for low intercorrelations of tests purporting to measure a "closure" function (Wasserstein, 2002). Moreover, when Closure Faces was included in factor analyses with nonfacial closure measures (including one set of subjective contour illusions) plus the Test of Facial Discimination, two factors emerged, a *closure* factor and a *facial discrimination* factor: Closure Faces was related to both of them (Wasserstein, Barr, et al., 2003). This held for separate analyses for left- and right-brain injured subjects. The facial discrimination factor was positively related to education; the closure factor was negatively related to age.

Test characteristics. Age contributed significantly to performance differences on all four tests for normal subjects (r = −.49 to −.73) and patients with left hemisphere damage (r = −.42 to −.78) but generally less to the scores of patients with right-sided lesions (r = .09 to −.45) (Wasserstein, Zappulla, Rosen, et al., 1987). Small sex differences favoring males showed up on Street Completion and Closure Faces Test performances of the control subjects, and a larger male advantage appeared on the unpublished Street items and Closure Faces for left brain damaged patients but not those with right brain damage. These authors note that performance on closure tests appears to be independent of performance on facial recognition tests, sug-

Sample Test Questions

Closure Speed (Gestalt Completion)

Identify the pictures.

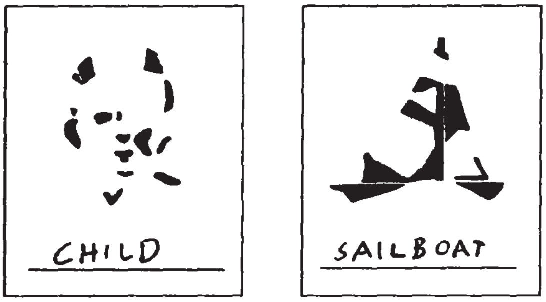


FIGURE 10.15 Closure Speed (Gestalt Completion) (© 1984 by L.L. Thurstone, Ph.D. All rights reserved.) This sample test question may not be duplicated in any manner without written permission from the publisher. (Courtesy of Pearson Reid London House, Inc.)

gesting that two different perceptual processes having different anatomical correlates underlie the two different tests.

Neuropsychological findings. Analysis of the performances of unilaterally brain lesioned patients indicates a relationship between performance on the gestalt completion tests and the perception of subjective *contour illusions* (i.e., visual illusions in which brightness or color gradients are seen when not present [Tovée, 1996]) (Wasserstein, Zappulla, Rosen, et al., 1987). For example, most people will see Figure 10.16 as a solid white triangle overlying an inverted triangular frame and three black circles, although no solid triangle is physically present. Performances on the gestalt completion tests and on a subjective contours task by patients with right hemisphere damage demonstrated lower levels of relationship than did performances by patients with left-sided lesions. This latter group appeared to use a common solution mechanism for solving both gestalt completion and subjective contour problems. Patients with left brain damage consistently made higher scores than those with right-sided lesions on all four of the gestalt completion tests, and had scores close to the control subjects' scores on two tests (actually having a higher mean than the control subjects on one of the two). Performances on the subjective contour tests clearly differentiated right and left hemisphere–damaged groups.

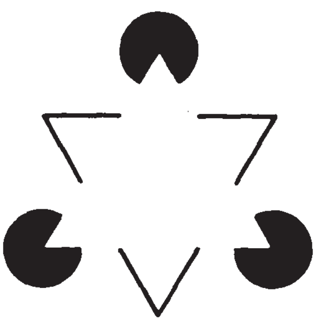


FIGURE 10.16 Example of the subjective contour effet. (From E.L. Brown and Deffenbacher, 1979. © Oxford University Press)

Closure Speed (Gestalt Completion) (L.L. Thurstone and Jeffrey, 1983)

This "figural" test presents 24 degraded pictures of objects or animals to be identified within three minutes. Space is provided for the subject to write in each item name (see Fig. 10.15). The test manual provides norms derived from groups of workers at different technical and professional levels. E.W. Russell, Hendrickson, and Van Eaton (1988) used this paper-and-pencil test to study occipital lobe functions. Some patients dictated their answers. Mean score for 55 male control subjects was 11.23. The average score for patients with left-sided anterior/lateral (i.e., temporal and parietal) lesions was barely higher than for those with occipital lesions (8.58 ± 5.33 to 7.75 ± 4.53); but with lesions on the right, the anterior patients outperformed those with occipital lesions significantly (7.00 ± 5.02 to 2.92 ± 2.23). The ease of administration and accessibility of materials recommends this test for both clinical and research work.

Gollin Figures (Gollin, 1960)

Another test that uses incomplete drawings to assess perceptual functions consists of 20 picture series of five line drawings of familiar objects (e.g., duck, tricycle, umbrella) ranging in completeness from a barely suggestive sketch (Set I) to a complete drawing of the figure (Set V). The score is the sum of all the set numbers at which each picture is correctly identified. Warrington and James (1967a) and Warrington and Rabin (1970) used Gollin's original procedure, but Warrington and Taylor (1973) included only three rather than five items in each picture series. Another shortened format used only three sets of figures, one three-item set for practice and two containing the original five-item series, to be used as alternate versions of the test (J.L. Mack, Patterson, et al., 1993). These workers found that a 30-sec exposure afforded sufficient response time for each stimulus picture. Age effects appeared when younger age ($M = 34.8$) and older ($M = 69$) healthy, well-educated subjects were compared (M.B. Patterson et al., 1999). The younger group identified pictures at a greater level of fragmentation and were faster than the older subjects. However, these two measures were not correlated: fragmentation level appears to relate to perceptual accuracy, reaction time to the cognitive slowing associated with aging. A factor analysis of elderly subjects' and Alzheimer patients' performances on a set of tests assessing visual, verbal, and memory functions demonstrated a significant visuoperceptual component for the Gollin test (J.L. Mack, Patterson, et al., 1993).

Neuropsychological findings. The Gollin figures did not discriminate between right and left hemisphere lesioned groups in the Warrington and Rabin study, patients with right parietal lesions showing only a trend toward poor performance. However, this test was more sensitive to right brain lesions than other perceptual tests used in the Warrington and James or Warrington and Taylor studies, successfully discriminating between patients with right- and left-sided lesions and implicating the right posterior (particularly parietal) lobe in the perception of incomplete contours. With just one picture series, Gollin scores differentiated Alzheimer patients from elderly control subjects (J.L. Mack, Patterson, et al., 1993). An investigation into the nature of TBI patients' difficulties with this test found that they failed to recognize the fragmented drawings and displayed inconsistent search strategies with some tendency to perseverate responses from one drawing to the next (Rahmani et al., 1990). Control subjects were faster than depressed patients in identifying the pictured object, but the difference did not reach significance (Grafman, Weingartner, Newhouse, et al., 1990). Both these groups recognized the degraded pictures much sooner than Alzheimer patients.

Visual Object and Space Perception Battery (Warrington and James, 1991)

Experimental techniques for exploring visual perception have been incorporated into this nine-test battery. As normative data and cutting scores are provided for each little test, these tests can be used individually or the battery can be given as a whole. Factor analysis of test data from a large sample of healthy older (50 to 84 years) adults supported the distinction between space and object perception (Rapport, Millis, and Bonello, 1998).

The first test, *Shape Detection Screening,* only checks whether the patient's vision is sufficiently intact to permit further examination. Half of its 20 cards display an all-over pattern with an embedded and degraded X, the other half have just the all-over pattern; the subject must find the cards with the X. It is rare that any items are failed by patients with right hemisphere disease, and rarer still for intact persons to fail.

Object perception tests. The next four tests present views of letters, animals, or objects that have been rendered incomplete in various ways. Rotated silhouettes (tests 2 to 4) has the effect of obscuring recognizable features of an object to a greater or lesser degree (Warrington and James, 1986). 1. *Incomplete Letters* shows 20 large alphabet letters, one to a card, which have been randomly degraded so that only 30% of the original shape remains. 2. *Silhouettes* are blackened shapes of 15 objects and 15 animals as they appear at angular rotations affording a range of difficulty beginning with an item identified correctly by only 36% of the controls and ending with highly recognizable stimuli (100% recognition by control subjects) (see Fig. 10.17, p. 399). 3. *Object Decision* presents the subject with 20 cards each printed with four black shapes of which one is a silhouette of a real object, thus giving only minimal clues to the object's identity (see Fig. 10.18, p. 399). 4. *Progressive Silhouettes,* presents only two items—both elongated objects—to be identified, first at a virtually unrecognizable 90° rotation from the familiar lateral view, then sequential rotation of the other nine silhouettes gradually approaches the familiar lateral view (the tenth silhouette). The score is the number of silhouettes seen before correct identification of the object.

Age contributed to control subject performances on these four tests, requiring a 1-point difference in cutoff scores between persons under 50 and 50+. As pre-

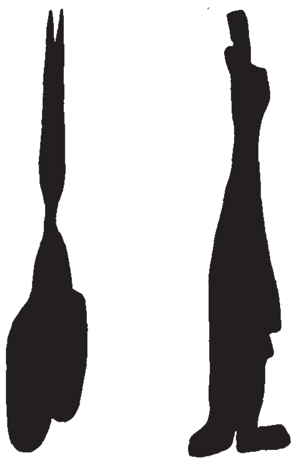


FIGURE 10.17 Two items from the Silhouettes subtest of the Visual Object and Space Perception Test. (© 1991, Elizabeth Warrington and Merle James. Reproduced by permission)

dicted, the average scores for each of these four tests discriminated patients with right and left hemisphere lesions, the latter group performing at levels within the average score range of the control subjects. Failure rate for patients with right hemisphere disease was from 25.7% to 34.5%; patients whose lesions were on the left failed at rates from 3.8% to 12%.

Space perception tests. The last four tests examine different aspects of space perception. 5. *Dot Counting* presents ten arrays of five to nine dots each, randomly arranged on separate cards. The cut-off for failure is 8 correct, as few normal subjects made any errors. 6. Each of the 20 items of *Position Discrimination* presents a card with two identical horizontally positioned squares, one containing a black dot in the center, the other with a black dot slightly off-centered—to the left on half of the items, to the right on the other half. The subject must decide which square contains the centered dot. This too was very easy for intact subjects, resulting in a cut-off score of 18. 7. *Number Location* also presents two squares each on ten stimulus cards, this time one square is above the other with the numbers from 1 to 9 randomly spaced within the top square. The bottom square contains a dot in the location of one of the numbers which the subject must identify. 8. *Cube Analysis* is a ten-item block counting task (see Fig. 15.11, p. 607 for a similar task). A cut-off score of 6 reflects the greater difficulty of this task relative to the others in the space perception set.

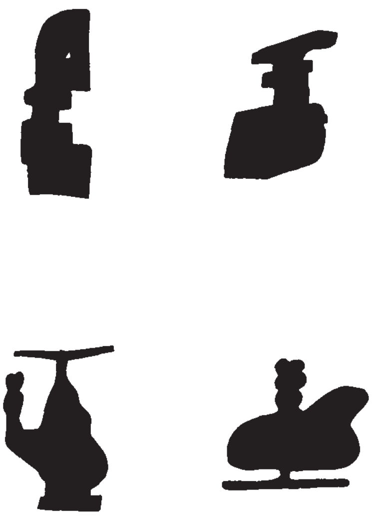


FIGURE 10.18 Multiple-choice item from the Object Decision subtest of the Visual Object and Space Perception Test (© 1991, Elizabeth Warrington and Merle James. Reproduced by permission)

Age was not associated with performance on any of these four tests. On all of them, more patients with right hemisphere disease failed (from 27.0% to 35.1%) than patients whose damage was on the left (from 9.3% to 18.7%), although the left-damaged patients consistently failed in greater numbers than normal expectations would warrant.

Tests involving fragmented visual stimuli

Perceptual puzzles requiring conceptual reorganization of disarranged pieces test the same perceptual functions as does Object Assembly. The visual content can be either meaningful or meaningless (e.g., Minnesota Paper Formboard [Likert and Quasha, 1970]).

Hooper Visual Organization Test (HVOT), (Hooper, 1983)

The HVOT was developed to identify mental hospital patients with "organic brain conditions". It consists of 30 pictures of more or less readily recognizable, cut-up objects (see Fig. 10.19, p. 400). The subject's task is to tell each object's name if the test is individually administered, or to write the object's name in spaces provided in the test booklet. The finding that, on the individual administration, a cut-off of 5 consecutive errors changed the rating of only 1% of a large subject sample, allows for early discontinuation of a poor performance (Wetzel and Murphy, 1991).

Test characteristics. On three administrations repeated after 6 months and again after 12 months, mean HVOT scores did not shift to any appreciable degree, and a coefficient of concordance (W) of .86 indicated that test–retest reliability is high (Lezak, 1982c). A one-year retest reliability coefficient for elderly controls was

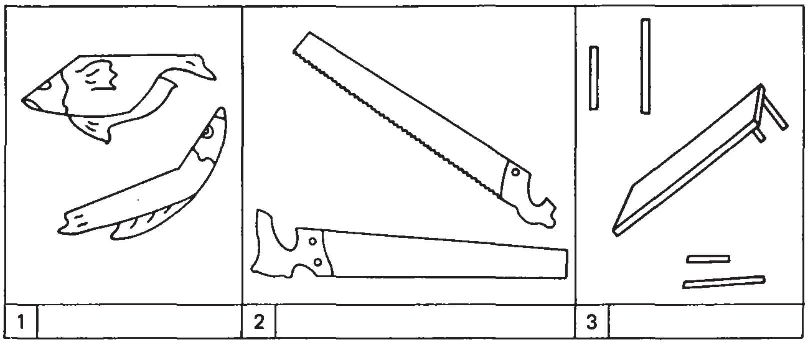


FIGURE 10.19 Easy items of the Hooper Visual Organization Test. (By H. Elston Hooper. © 1958 by Western Psychological Services. Reprinted by permission)

.68 (B.E. Levin, Llabre, Reisman, et al., 1991). This test does not correlate significantly with sex or education, at least for ages below 70, but it has a modest correlation with mental ability. Reports on aging effects are contradictory. Whelihan and Lesher (1985) found a significant drop in the performance of "old-old" (ages 76 to 92) intact subjects compared to a "young-old" (ages 60 to 70) group. Montgomery and Costa's (1983) finding of a median score of 23.7 for a large sample of older persons (ages 65 to 85) suggests that some score drop with advanced age can be expected. E.D. Richardson and Martolli's (1996) age × education data for mostly white men and women show little loss between the <12 years' schooling groups ages 76 to 80 and 81 to 91, as the younger group's mean score (17.90) already fell within the "high probability of impairment" range; but with education level ≥12, the older group scored an average 2 points below the younger one. Merten and Beal (2000) found that item order does not correspond to ranking for item difficulty and raised questions about both the nature of items and scoring standards. Two multiple regression studies including WAIS-R and naming tests found that a perceptual integration/organization factor accounted for 44% (Ricker and Axelrod, 1995) and 45% (Greve, Lindberg, et al., 2000) of HVOT variance, together lending strong support to its validity as a test of perceptual integration/organization. Moreover, the 11% or 15% (respectively) contribution of confrontation naming to HVOT variance indicates that naming ability plays only a minor role (see *Multiple-choice HVOT,* below). Still, Spreen and Strauss (1998) advise that, "Since the test requires naming, results in even mildly aphasic patients may be questionable" (pp. 509–510).

Cognitively intact persons generally fail no more than six HVOT items. Persons who make 7 to 11 failures comprise a "borderline" group that includes emotionally disturbed or psychotic patients as well as those with mild to moderate brain disorders. Persons with scores in this range have a low to moderate likelihood of brain impairment. More than 11 failures usually indicates brain pathology. When this many errors result from a psychiatric rather than a neuropathologic condition, qualitative aspects of the responses will generally betray the etiology. Many brain injured persons perform well on the HVOT (Wetzel and Murphy, 1991). However, a low score on this test usually indicates the presence of brain damage, as false positive performances are rare.

Neuropsychological findings. The frequency of low scores on this test does not differ on the basis of side of lesion or presence of diffuse/medial injury (J.L. Boyd, 1981; P.L. Wang, 1977; Wetzel and Murphy, 1991). However, lesion laterality may be distinguished by the *nature* of the errors as patients with right-sided lesions are more likely to give fragmented or part responses (see paragraph below for examples), those with lesions on the left will make more naming errors (Nadler, Grace, et al., 1996). Brain tumors and stroke tend to be associated with much lower scores than does TBI (J.L. Boyd, 1981). Relatively few in one sample of Alzheimer patients performed *within normal limits;* their average score (11 ± 5.34) was greater than 4 SD below that of control subjects (25 ± 3.03) (Mendez, Mendez, et al., 1990). The HVOT proved to be very sensitive to both dementia and disease duration in Parkinson patients (B.E. Levin, Llabre, Reisman, et al., 1991). Sohlberg and Mateer (1989) recommend it for examining temporal lobe dysfunction. However, it has only little predictive value for rehabilitation outcome (Greve, Lindberg, et al., 2000).

Several of the HVOT items are particularly effective in eliciting the kind of perceptual fragmentation that tends to be associated with lesions of the right frontal lobe, although all patients with right frontal lesions do not make this kind of error. Patients who exhibit this phenomenon will often be able to identify most of the items correctly, thus demonstrating both perceptual accuracy and understanding of the instructions. Yet, on one or more of the three items that contain one piece most clearly resembling an object in itself, patients who have a tendency to view their world in a fragmented manner will interpret that one piece without attending to any of the others in the item (see also Lezak, 1989). For example, the top piece of item 1 may be called a "duck" or a "flying goose" (see Fig. 10.19, also see pp. 564–565 for a discussion of the relationship of the HVOT and constructional tasks). Item 21 becomes "a desert island" when only the center piece is taken into account, and the tail of the "mouse" of item 22 turns into "a pipe." When fragmentation is more severe, the mesh of item 12 may be called "a tennis net," item 14 becomes "a pencil," and item 30 "a plumber's helper" or "plunger."

A multiple-choice HVOT. To reduce the problem of object naming for anomic patients—and to make manifest the HVOT visual integration component—a multiple-choice format (*MC-HVOT*) was developed in which four possible responses are listed vertically in large print under each item (Schultheis, Caplan, et al., 2000). For example, response alternatives for item 1 are "fish, tomato, boomerang, globe." On a small sample of both TBI and stroke patients whose Boston Naming Test scores fell below the 10th percentile, MC-HVOT showed notable improvements for both patients with lesions on the right (M_{gain} = 8 points) and on the left (M_{gain} = 10.9 points), gains which permitted a better understanding of these patients' visual integration capacities.

Tests involving ambiguous visual stimuli

Some tests that use ambiguous stimuli were developed as personality tests and not as tests of cognitive functioning. They were applied to neuropsychological problems as examiners became familiar with the kinds of responses made by different patient groups.

Rorschach technique

This projective technique exemplifies how ambiguous stimuli, originally used for personality assessment, can provide information about a patient's perceptual abilities. When handling Rorschach responses as data about personality (e.g., behavioral predispositions), the examiner looks at many different aspects of the test performance, such as productivity, response style, and the affective quality of the subject's associations. In neuropsychological assessment, Rorschach protocols can be evaluated for a variety of qualitative and quantitative response characteristics that tend to be associated with brain disease (see pp. 740–742). Although perceptual accuracy enters into both personality evaluations and diagnostic discriminations, it can also be treated in its own right, apart from these broader applications of the test.

Evaluation of the perceptual component of a Rorschach response can focus on four aspects of perceptual activity. The first is the accuracy of the percept. Since the inkblots are ambiguous and composed by chance, no *a priori* "meaning" inheres in the stimulus material. Nevertheless, certain areas of the blots tend to form natural gestalts and to elicit similar associations from normal, intact adults. The test for perceptual accuracy, or "good form," is whether a given response conforms in content and in the patient's delineation of a blot area to common ways of looking at and interpreting the blot. A reliable method of determining whether a given response reflects a normal organization of the stimulus uses a frequency count, differentiating "good form" (F+) from "poor form" (F−) responses on a strictly statistical basis (S.J. Beck, 1981; S.J. Beck et al., 1961; Exner, 1986). Beck (1961) lists usual and rare responses to all the commonly used parts of the Rorschach inkblots so that the examiner need only compare the patient's responses with the listed responses to determine which are good and which are poor form. Of the hundreds of good form responses, 21 are given with such frequency that they are called "popular" (P) responses. They are thought to reflect the subject's ability not merely to organize percepts appropriately but also to do so in a socially customary manner. The percentage of good form responses (F+%) and the incidence of popular responses thus can be used as measures of perceptual accuracy.

That these response variables do reflect the intactness of the perceptual system can be inferred from the consistent tendency for brain damaged patients to produce lower F+% and P scores than normal control or neurotic subjects (Aita, Reitan, and Ruth, 1947; D.W. Ellis and Zahn, 1985; Z. Piotrowski, 1937). In normal Rorschach protocols, 75 to 95% of unelaborated form responses are of good quality, with bright persons achieving the higher F+% scores (S.J. Beck, 1981). Brain damaged patients tend to produce less than 70% good form responses (e.g., DeMol, 1975/1976; C. Meyers et al., 1982). Their poor form responses reflect the kind of perceptual problems that are apt to accompany brain injury, such as difficulties in synthesizing discrete elements into a coherent whole, in breaking down a perceptual whole into its component parts, in clarifying figure–ground relationships, and in identifying relevant and irrelevant detail (G. Baker, 1956). Patients' verbatim associations will often shed light on the nature of their perceptual disabilities. Their behavior too may betray the perceptual problems, for only brain damaged patients attempt to clarify visual confusion by covering parts of the blot with the hand.

A second aspect of perceptual organization that may be reflected in Rorschach responses is the ability to process and integrate multiple stimuli. Some brain disorders reduce the capacity for handling a large perceptual input at once, resulting in a narrowed perceptual field and simplified percepts. This shows up in relatively barren, unelaborated responses in which one characteristic of the blot alone dictates the content of the response, for the patient ignores or does not attempt to incorporate other elements of the blot into the percept. The reduced capacity for handling multiple stimuli also appears as difficulty in integrating discrete parts of the blot into a larger, organized percept or in separating associations to discrete blot elements that happen to be contiguous. Thus, the patient may correctly interpret several isolated elements of card X as varieties of sea animals without ever forming the organizing concept, "underwater scene." Or, on card III, the side figures may be appropriately identified as "men in tuxedos" and the central red figure as a "bow tie," but the inability to separate these physically contiguous and conceptually akin percepts may produce a response combining the men and the bow tie into a single forced percept such as, "they're wearing tuxedos and that is the bow tie." Sometimes mere contiguity will result in the same kind of overinclusive response so that the blue "crab" on card X may be appropriately identified, but the contiguous "shellfish" becomes the crab's "shellfish claw." These latter two responses are examples of confabulation on the Rorschach.

Moreover, the number of form responses that also take into account color (FC) is likely to be one per record for brain damaged patients, whereas normal subjects typically produce more than one FC response (D.W. Ellis and Zahn, 1985; Lynn et al., 1945). Some patients simply name colors (Cn), whereas normal subjects do not give this kind of response (DeMol, 1975/1976). There may be relatively few responses involving texture and shading (FT, FY) (D.W. Ellis and Zahn, 1985), and those introducing movement into the percept (M or FM) are apt to be minimal (Dörken and Kral, 1952; Z. Piotrowski, 1937).

A third aspect of perception is its reliability. Many brain impaired patients feel that they cannot trust their perceptions. Uncertainty—the Rorschach term for expressions of doubt and confusion is *perplexity*—about one's interpretations of the inkblots is relatively common among brain damaged patients but rare for other patient groups or normal subjects (G. Baker, 1956, Z. Piotrowski, 1937). Lastly, brain damaged patients tend to have slower reaction times (i.e., ≥ 1 min) on the Rorschach than do normal persons (Goldfried et al., 1971; C. Meyers et al., 1982).

Visual Interference

Tasks involving visual interference are essentially visual recognition tasks complicated by distracting embellishments. The stimulus material contains the complete percept but extraneous lines or designs encompass or mask it so that the percept is less readily recognizable. Visual interference tasks differ from tests of visual organization in that the latter call on synthesizing activities, whereas visual interference tests require the subject to analyze the figure–ground relationship in order to distinguish the figure from the interfering elements. Sohlberg and Mateer (1989) included these kinds of tests in their examination of temporal lobe disorders.

Figure–ground tests

Hidden Figures (L.L. Thurstone, 1944); Closure Flexibility (Concealed Figures) (L.L. Thurstone and Jeffrey, 1982)

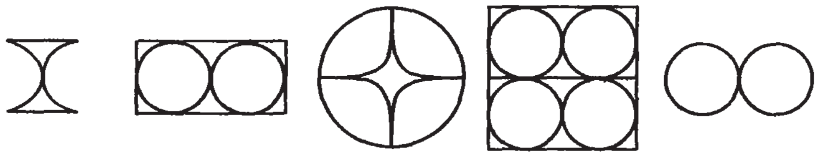
Thurstone proposed a 34-item version of Gottschaldt's (1928) *Hidden Figures Test* that has been used in many studies of abilities of patients with brain damage (see Fig. 10.20, p. 403). The Hidden Figures task requires the subject to identify the hidden figure by marking the outline of the simple figure embedded in the more complex one. At the most difficult levels, the subject has to determine which of the two intricate designs contains the simpler figure. Spreen and Benton (see Spreen and Strauss, 1998) developed a 16-item test, the *Embedded Figures Test.* Closure Flexibility is a 49-item multiple-choice version of this task with two correct solutions for each item. In Thurstone's study of normal perception, successful performance on this task was strongly associated with "the ability to form a perceptual closure against some distraction . . . [and] the ability to hold a closure against distraction" (L.L. Thurstone, 1944, p. 101).

Test characteristics. The normative sample of 3,073 comes from three levels of managerial hierarchies for four occupational categories (Line, Professional, Sales, and Technical). Scores can be evaluated either by a centile scale or a normalized standard score scale providing comparisons with these 12 occupational groupings. The manual cites studies conducted by Thurstone and his students who found significant correlations (r = .59, .63) with inductive reasoning. Factor analytic studies

Sample Test Questions

Closure Flexibility (Concealed Figures)

Put a check mark (✓) in the parentheses under a drawing if it contains the figure. Put a zero (0) in the parentheses under the drawing if it does not contain the figure.



(✓) (O) (✓) (O)

FIGURE 10.20 Closure Flexibility (Concealed Figures). (© 1984 by L.L. Thurstone, Ph.D. All rights reserved.) This sample test question may not be duplicated in any manner without written permission from the publisher. (Courtesy of Pearson Reid London House, Inc.)

have shown significant associations with both analytic reasoning and a space factor.

Neuropsychological findings. Teuber, Battersby, and Bender (1960) found that all groups with brain injuries due to missile wounds performed more poorly on the Hidden Figures Test than did normal subjects. Moreover, the degree of impairment of test performance has been related to the size of the lesion regardless of side (Corkin, 1979). Patients who had had surgery involving the frontal cortex (Teuber, Battersby, and Bender, 1951) and aphasic patients made significantly lower scores than other brain injured patients. Patients whose aphasia resulted from other kinds of brain lesions, mostly vascular, also did poorest among patients studied for the effects of lateralized lesions (Russo and Vignolo, 1967). Interestingly, nonaphasic patients with left-sided lesions performed within the control group range. The scores of patients with right sided lesions were midway between the two groups with left hemisphere damage. The presence of visual field defects did not affect these performances. Talland (1965a) reported that patients with Korsakoff's psychosis performed very poorly on this test, attributing their almost total failure to problems in perceptual shifting and focusing.

Overlapping Figures Test

This little test was originally devised by Poppelreuter ([1917] 1990) to study the psychological effects of head injuries incurred during World War I (see Fig. 10.21). Its popularity is reflected in the number of formats that have been devised. For most formats subjects are asked to name as many of the figures as they can.

Ghent (1956) employed nine similar figures, each with four overlapping line-drawn objects, to examine the development of perceptual functions in children. Luria (1966) used several versions of an overlapping or "*superimposed figures*" test to examine the phenomenon of simultaneous agnosia. In her systematization of Luria's examination methods, A.-L. Christensen (1979) included three Pöppelreuter-type figures as part of "the investigation of higher visual functions." An expanded version of this test that included ten stimulus figures with a total of 40 objects presented in such categories as "clothing" or "animals" was developed by Masure and Tzavaras (1976) under the name of *Ghent's Test* (i.e., *le test de Ghent*). Total time to completion was recorded and subjects indicated their responses on a multiple-choice form. Gainotti, D'Erme, and their colleagues (1986, 1989) devised an *Overlapping Figures* test, consisting of five overlapping line drawings on each of six cards with a multiple-choice presentation of target figures and foils; both test figures and responses are vertically aligned. The most

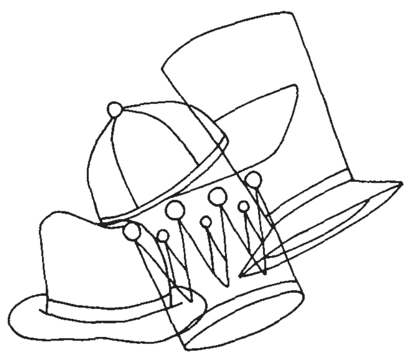


FIGURE 10.21 Example of a Poppelreuter-type overlapping figure.

complex of the overlapping figure tests, the *15-objects test,* contains two figures, each an overlapping drawing of 15 different items (Pillon, Dubois, Bonnet, et al., 1989). This format was scored for both response time and erroneous identifications. A more recently developed format contains three sets of overlapping figures, each set presenting a different number and category of figures (3 simple geometric figures; 4 man-made objects; 5 fruits) (Mori et al., 2000). Subjects name items in the first two categories; fruits is a matching task. In all but the Mori sets, Overlapping Figures, and the 15-objects test, the figures are composed of items in the same category (e.g., fruits, clothes) and some examiners also ask subjects to identify the general category of items (e.g., Rahmani et al., 1990).

Neuropsychological findings. Both Luria and A.-L. Christensen described several ways in which a patient can fail this test. Both pointed out the difference between the inability to perceive more than one object at a time or to shift gaze that may accompany a posterior lesion and passivity or inertia of gaze, perseverated responses, or confused responses, which are more likely to be associated with an anterior lesion. Christensen also noted that a perceptual bias to the right may indicate left visuospatial inattention. On a multiple-choice format, right-lesioned patients performed significantly more poorly than control subjects and patients with left-sided damage, who also did less well than the controls (De Renzi and Spinnler, 1966; Gainotti, D'Erme, et al., 1986, 1989). Patients with posterior lesions performed more poorly than the anterior group and those with left posterior lesions were by far the slowest.

Responding to the three different figure categories with a maximum score of 12, patients with probable Alzheimer's disease made significantly more correct identifications (10.6 ± 1.8) than did patients with Lewy body dementia (LBD) (8.1 ± 2.6) (Mori et al., 2000), and LBD patients who did not have visual hallucinations outperformed those who did (10.2 ± 1.5 vs. 7.4 ± 2.5); unfortunately, control data were not provided. Alzheimer patients' difficulty on this task was attributed to impaired analysis of figure–ground relationships (Mendez, Mendez, et al., 1990). Parkinson patients responded much slower than the controls and made more errors on the most complex format of this test (Pillon, Dubois, Bonnet, et al., 1989). Performances on this test correlated significantly with verbal and memory test scores. A simpler version with only three or four overlapping figures also proved sensitive to mental deterioration in Parkinson patients and was significantly related to disease duration (B.E. Levin, Llabre, Reisman, et al., 1991). Rahmani and his colleagues (1990) listed the kinds of errors made by TBI patients: misidentification; objects not perceived as related to one another; perseveration of a concept from one card to another; only part of an item is noted and then misidentified; only the most prominent items are noted; idiosyncratic relationships are drawn about the items in the figure.

Picture search

Hidden Pictures of the *Snijders-Oomen Nonverbal Intelligence Test* (*SON-R $5^1/_2$-17; rev. ed.*) (Tellegen et al., 1998) involves visual search and recognition of parts of objects or of objects at unusual angles. It has much in common with children's playbook puzzles that ask for a count of objects (e.g., kites) hidden in drawings, in unlikely places as well as likely ones. In this test, line drawings of four different scenes contain 7 or 8 items in whole or part view. Following two trial scenes on which the examiner can provide explanations and examples, the subject is allowed $1^1/_2$ min to search each scene. The 17-year-old norms of the SON-R $5^1/_2$-17 provide an adequate standard for evaluating most adult performances.

AUDITORY PERCEPTION

As is the case with vision, the verbal and nonverbal components of auditory perception appear to be functionally distinct (Bauer and Demery, 2003; McGlone and Young, 1986; I. Peretz, 2001). Also as with vision, many techniques are available for examining the verbal auditory functions. Unlike visual perception, however, psychologists have paid less systematic attention to nonverbal auditory functions. Thus, the examination of nonverbal aspects of auditory perception is limited to a few techniques. The most common sources of defective auditory comprehension are deficiencies in auditory acuity resulting from conduction and/or sensorineural hearing losses, and deficits in auditory processing associated with cortical damage (Ceranic and Luxon, 2002).

Auditory Acuity

Many patients whose hearing is impaired are aware of their problem. Unfortunately, some individuals with mild to moderate deficits are embarrassed and do not report them to the examiner, or they may try to hide their disability even at the cost of a poor performance on the tests. When hearing loss is mild, however, or involves very specific defects of sound discrimination without affecting loudness, the patient may not appreciate the problem. Occasionally a patient incurs a reduction in hearing sensitivity as a result of brain injury, in which case hearing on the ear opposite the side of the lesion is likely to be the more impaired. More common is diminished auditory acuity with aging (E. Wallace et al., 1994). When such a hearing loss is slight, and particularly when it is recent or when aphasic defects also contribute to speech comprehension problems, the patient may be unaware of it.

Frequently, patients who do not report their hearing problem betray it in their behavior. Persons whose hearing is better on one side tend to favor that side by turning the head or placing themselves so that the better ear is closer to the examiner. Mild to moderately hard of hearing persons may display erratic speech comprehension as the examiner's voice becomes louder or softer, or not hear well if the examiner turns away when speaking to them. The examiner who suspects that the patient has a hearing loss can test for it crudely by speaking softly and noting whether the patient's level of comprehension drops. When the patient appears to have a hearing loss, the examiner should insist that the patient see an audiologist for a thorough audiological examination. An audiological assessment is of particular importance when a tumor is suspected, for an early sign of some forms of brain tumor is decreased auditory acuity. It is also important for brain impaired patients with other sensory or cognitive defects to be aware of hearing problems so that they can learn to compensate for them and, when indicated, get the benefits of a hearing aid or, for some conditions, surgical remediation.

Auditory Discrimination

Some patients have difficulty discriminating sounds even when thresholds for sound perception remain within the normal hearing range and no aphasic disability is present (Ceranic and Luxon, 2002; R.A. Levine and Häusler, 2001). Auditory discrimination can be tested by having the patient repeat words and phrases spoken by the examiner, or by asking the patient to tell whether two spoken words are the same or different, using pairs of different words, such as "cap" and "cat" or "vie" and "thy," interspersed with identical word pairs. Auditory discrimination is evaluated routinely in audiometric examinations. When the problem is suspected, referral to an audiologist is indicated.

Phoneme Discrimination (Benton, Sivan, Hamsher, et al., 1994)

Rather than real words, this 30-item tape-recorded task uses half identical, half similar pairs of nonsense words (e.g., "ur–ur," "pedzap–pelzap") as stimuli. The word list may be read by the examiner, as explicit pronunciation instructions are given in the manual. Since by chance alone subjects can get 15 items correct, only scores above 15 are considered (scores that fall much below 15 may indicate a motivation problem). Using a cut-off score of 22 (the lowest score made by normal subjects), auditory discrimination problems were found in 24 of 100 aphasic patients, and all but two of the 24 had defective oral comprehension.

Wepman's Auditory Discrimination Test (Wepman and Reynolds, 1987)

Wepman formalized the technique of testing auditory discrimination by using single syllable word pairs, some identical, some differing only by a phoneme coming from the same phoneme category. Thirteen word pairs differ in their initial consonant, thirteen in their final consonant, and four differ in the middle vowel sound. The test comes in two equivalent forms.

Although this test was originally devised to identify auditory discrimination problems in young school children, and the present norms were developed on samples of four- to eight-year-olds, norms for the 8–0 to 8–11 age range are adequate for adults since auditory discrimination is generally fully developed by this age. Alternate form reliabilities of .92 are reported, based on child studies. Test–retest reliabilities in the .88 to .91 range have been obtained on child samples. W.G. Snow, Tierney, and their colleagues (1988) found a test–retest correlation of .68 for 100 normal elderly persons.

Sound Blending and Incomplete Words (W-J III) (Mather and Woodcock, 2001)

The Woodcock-Johnson III *Tests of Cognitive Abilities* contain two tests of auditory–verbal perception, both administered by audio recording. Sound Blending examines the ability to synthesize language sounds by presenting familiar words (e.g., "bunny," "picnic") slowly with syllables separated in time; the subject's task is to identify the word. Age norms are available to >26 which are appropriate for most adults with intact hearing. Incomplete Words is also described as a test of "auditory processing," in which the subject hears words lacking one or more phonemes; again the task is to identify the word. Age norms for this test go to >33 years. While factor and cluster analyses associate Sound Blending with a "general intellectual ability" factor plus "phonemic awareness," Incomplete Words is associated only with "phonemic awareness." Reliability coefficients for adults are in the .90 to .93 range.

Speech Sounds Perception Test (SSPT) (Reitan and Wolfson, 1993)

This test is in the Halstead-Reitan Battery. Sixty sets of nonsense syllables each beginning and ending with different consonants but based on the vowel sound "ee" comprise the items, which are administered by tape recording. Subjects note what they think they heard on a four-choice form laid out in six 10-item sections (called "series") labeled A to F.

The appropriateness of the examination format has been questioned. Reddon, Schopflocher, et al. (1989) point out that for 58 of the 60 test items the correct response is always the second or third response of the four listed horizontally in each item, with the first response choice containing the correct prefix and the last containing the correct suffix. A 14-year-old girl of just *average* mental ability figured this pattern out early in the course of taking the test (Bolter et al., 1984), leading to the suggestion that patients who make few errors should be queried about strategy upon completing the test. However, for 56 patients with diffuse brain injuries, the type of error (prefix, suffix, or both) identified these patients at the same rate as the error score (Charter, Dutra, and Lopez, 1997). Items differ in the degree to which correct choices are phonetically similar or identical to common words, and these items tend to be identified with relatively greater frequency than those that sound less familiar (Bornstein, Weizel, and Grant, 1984). Patients with hearing impairments, particularly those with high-frequency loss, which is common among elderly persons, are likely to perform poorly on this test (Schear, Skenes, and Larsen, 1988). For example, Ernst (1988) found that a group of 85 intact elderly persons achieved a mean score of 7.8 [failures]; when evaluated by Halstead's (1947) recommended cut-off score of 7 [failures], 37% of them failed the test.

Test characteristics. Test–retest correlations rarely run below .60 and most are well above it (G. Goldstein and Watson, 1989). Retesting control subjects show essentially no practice effects, not even a trend (McCaffrey, Duff, and Westervelt, 2000b). Not surprisingly, given the issue of impaired auditory acuity, accuracy diminishes with age; age accounts for about 10% of the variance; education contributes about 17% (Heaton, Ryan, et al., 1996). No sex differences have been reported (Filskov and Catanese, 1986; Heaton, Ryan, et al., 1996). An item analysis found that 19 of the items were more sensitive than the others, and sufficiently sensitive to discriminate between patients and control subjects (Charter and Dobbs, 1998).

Neuropsychological findings. This test is sensitive to brain damage generally, and to left brain damage in particular. Patients with left-hemisphere damage made the most errors when compared with those whose lesions were in the right hemisphere or were bilateral (Bornstein and Leason, 1984; Hom and Reitan, 1990). These latter patient groups also differed in patterns of failure, as those with left-sided lesions made the highest percentage of suffix errors and relatively fewer prefix errors than those with right-sided or bilateral lesions. Bornstein and Leason suggested that patients making more than 70% suffix errors and fewer than 29% prefix errors are likely to have left-sided damage. The SSPT is also sensitive to attentional deficits: Hom and Reitan (1990) categorize this rapidly paced test as one of "Attention and Concentration", a conclusion that my clinical experience supports (mdl). The examiner must be wary of concluding that a patient has left hemisphere damage on the basis of a high error score on this test alone as it may test the subject's capacity to attend to a boring task.

Short form alternatives. Most errors occur on the first two sections, Series A and B, with fewest on D and E (Bornstein, 1982; Crockett, Clark et al., 1982). When scored for just the 30 items in the first three 10-item series (A, B, and C), 96% and 90% of two patient groups achieved similar scores on both this and the full 60-item format (Bornstein, 1982). Crocket, Clark, and their colleagues found an error difference of 2.13 between the half test and the full test. Since the first three (A, B, C) series elicit the most errors, Charter and Dobbs (1998) recommend a cut-off of 5. This form, *SSPT-30,* has a lower reliability than the full test leading Charter and Dobbs to recommend using the 60-item test whenever possible.

Alternatively, Charter (2000) tested a short form consisting of just the last 30 items (*SSPT-DEF*) for use when the original short form is invalid. Based on statistical analyses, Charter concluded that this can be a satisfactory substitute for SSPT-30, but that the original test is always preferable, when possible.

Aphasia

It is always important to look for evidence of aphasia in patients displaying right-sided weakness or complaining of sensory changes on the right half of the body (see pp. 70–71, 75, 77). Aphasia must also be considered whenever the patient's difficulty in speaking or comprehending speech appears to be clearly unrelated to hearing loss, attention or concentration defects, a foreign language background, or a thought disorder associated with a psychiatric condition. The patient's performance on tests involving verbal functions should help the examiner determine whether a more thorough study of the patient's language functions is indicated.

Auditory Inattention

Some patients with lateralized lesions involving the temporal lobe or central auditory pathways tend to ignore auditory signals entering the ear opposite the side of the lesions, much as other brain damaged patients exhibit unilateral visual inattention on the side contralateral to the lesion (Heilman, 2002). Auditory inattention can be tested without special equipment by an examiner standing behind the patient so that stimulation can be delivered to each ear simultaneously. The examiner then makes soft sounds at each ear separately and simultaneously, randomly varying single and simultaneous presentations of the stimuli. Production of a soft rustling sound by rubbing the thumb and first two fingers together is probably the method of choice (e.g., G. Goldstein, 1974) as, with practice, the examiner can produce sounds of equal intensity with both hands.

Auditory–Verbal Perception

Every thorough neuropsychological examination provides some opportunity to evaluate auditory perception of verbal material. When presenting problems of judgment and reasoning, learning, and memory orally, the examiner has an opportunity to make an informal estimate of the patient's auditory acuity, comprehension, and processing capacity. Significant defects in the perception and comprehension of speech are readily apparent during the course of administering most psychological tests. For example, a patient must have a fairly intact capacity for auditory–verbal perception in order to give even a minimal performance on the WIS-A. If just a few tasks with simple instructions requiring only motor responses or one- or two-word answers are given subtle problems of auditory processing may be missed. These include difficulty in processing or retaining lengthy messages although responses to single words or short phrases may be accurate, inability to handle spoken numbers without a concomitant impairment in handling other forms of speech, or inability to process messages at high levels in the auditory system when the ability to repeat them accurately is intact (D.L. Bachman and Albert, 1988). In the absence of a hearing defect, any impairment in the recognition or processing of speech usually indicates a lesion involving the left or speech-dominant hemisphere.

When impairment in auditory processing is suspected, the examiner can couple an auditorily presented test with a similar task presented visually. This kind of paired testing enables the examiner to compare the functioning of the two perceptual systems under similar conditions. A consistent tendency for the patient to perform better under one of the two stimulus conditions should alert the examiner to the possibility of neurological impairment of the less efficient perceptual system. Test pairs can be readily found or developed for most verbal tests at most levels of difficulty. For example, both paper-and-pencil and orally administered personal history, information, arithmetic reasoning, and proverbs questions can be given. Comprehension, sentence building, vocabulary items, and many memory and orientation tasks also lend themselves well to this kind of dual treatment.

Testing for Auditory Comprehension

Most aphasia tests contain a set of items for examining verbal comprehension. The section, *Complex Ideational Material,* of the *Boston Diagnostic Aphasia Examination* (Goodglass, Kaplan, and Barresi, 2000) begins with eight paired questions requiring "yes" or "no" answers. These are followed by four little stories of increasing complexity, each accompanied by four questions, again calling for a "yes" or "no" response.

Putney Auditory Comprehension Screening Test (PACST) (Beaumont, Marjoribanks, Flury, and Lintern, 2002)

This is a 60-item set of a mix of half true, half false statements testing auditory comprehension. The two practice questions are exemplars: "Can babies look after themselves?" "Do surgeons operate on people?" Like the practice questions, the vocabulary consists of words and names in common usage. All questions can be answered with "yes" or "no." Seven different topics are represented in the questions (e.g., "Comparatives," "General Knowledge"). Sentence lengths range from three to eight words. Most sentences are syntactically simple in active tense; a few use passive tense and/or a coordinating or subordinating clause. Impairment is defined as a score ≤56.

The test was validated on 112 neurology service inpatients (age range, 18–90), most of whom took it three times at monthly intervals. Most patients could respond verbally; others used signals or buzzers. No sex differences showed up but performances were positively correlated with education and socioeconomic status and—surprisingly—with lower age, a finding the authors attribute to the relatively greater severity of disability among younger patients. Satisfactory reliability was demonstrated. Validity was tested by correlations of the PACST scores with ward manager and speech therapist evaluations (r = .52, .83 respectively).

Although this kind of evaluation is more often needed with neurologically impaired inpatients than outpatients, it may clarify some communication problems of speaking patients quickly and effectively. The authors observe that the PACST is likely to be most useful with nonverbal patients with severe physical disabilities, such as those with "*locked-in syndrome*" (in which motor control may be limited to eye movements) or advanced multiple sclerosis.

Nonverbal Auditory Reception

So much of a person's behavior is organized around verbal signals that nonverbal auditory functions are often overlooked. However, the recognition, discrimination, and comprehension of nonsymbolic sound patterns, such as music, tapping patterns, and the meaningful noises of sirens, dog barks, and thunderclaps are subject to impairment much as is the perception of language sounds (Kolb and Wishaw, 1996; I. Peretz, 2001). Defects of nonverbal auditory perception tend to be associated with both aphasia and bilateral temporal lobe lesions (D.L. Bachman and Albert, 1988) and, more rarely, with right hemisphere damage alone (Hécaen and Albert, 1978).

Most tests for nonverbal auditory perception use sound recordings. H.W. Gordon (1990) included taped sequences of four to seven familiar nonverbal sounds (e.g., rooster crowing, telephone ringing) in a battery designed to differentiate right and left hemisphere dysfunction. Subjects are asked to recognize the sounds and then write the names of the sounds in the order in which they were heard. Although developed for lateralization studies on sex, age, and psychiatric disorders, this technique has clinical potential.

Seashore Rhythm Test (Reitan and Wolfson, 1993; Seashore et al., 1960)

This test is the one used most widely for nonverbal auditory perception since Halstead (1947) incorporated it into his test battery. This subtest of Seashore's *Test of Musical Talent* requires the subject to discriminate between like and unlike pairs of musical beats. Normal control subjects average between 3 and 5 errors (Bornstein, 1985b; Reitan and Wolfson, 1989); the original cut-off was set between 5 and 6 errors (Halstead, 1947).

Test characteristics. For groups with average ages in the middle 50s or lower, age does not appear to affect ability to do this test (Bornstein, 1985; Reitan and Wolfson, 1989). In the 65– to 75 year age range, one-third of a normal group had scores in the "impaired" range (Ernst, 1988). Similar findings were reported for normal subjects in the 55– to 70 year range (Bornstein, Paniak, and O'Brien, 1987). In a large sample, education contributed to approximately 15% of the variance (Heaton, Ryan, et al., 1996). No sex differences were reported. Musical education, however, can make a significant difference as many cognitively impaired patients with musical backgrounds achieve scores in the normal range; thus Karzmark (2001) recommends that normal scores of patient with musical training be interpreted with caution.

Test–retest differences are small (McCaffrey, Duff, and Westervelt, 2000b). Internal reliabilities (split-half and odd–even) of .77 and .62 have been reported (Bornstein, 1983b). However, Charter and Webster (1997), reporting a reliability coefficient of .78 (n = 617), found that many of the items were too easy to be very discriminating. They also reported that this test is sensitive to fatigue and/or reduced concentration as the last items were passed at a lower rate than the initial ones. "From a purely psychometric standpoint, Seashore Rhythm test is *not* [*sic*] an example of a good test" (Charter and Webster, 1997, p. 167).

Neuropsychological findings. Although originally purported to be sensitive to right hemisphere dysfunction, most studies indicate no differences in performance levels between patients with right-sided lesions and those with lesions on the left (Hom and Reitan, 1990; Reitan and Wolfson, 1989), even for patients with lesions confined to the temporal lobes (Boone and Rausch, 1989). Rather, this test is most useful as a measure of attention and concentration, as brain impaired patients generally perform significantly below the levels of normal control subjects; patients with bilateral and diffuse lesions tend to make even more errors than those with lateralized lesions (Reitan and Wolfson, 1989). Thus, not surprisingly, the number of errors made correlates positively with a measure of severity of TBI. Categorization of this test as one that is most sensitive to attention and concentration deficits (Hom and Reitan, 1990) accords with our clinical experience [hjh, mdl].

Testing for amusia

Defective perception of music or of its components (e.g., rhythm, pitch, timbre, melody, harmonics) is usually associated with temporal lobe disease, and is more likely to occur with right-sided involvement than with left (see I. Peretz, 2001, who notes the importance of differentiating recognition of melody, primarily reduced with right temporal lesions, and rhythm recognition which may be affected by lesions on either hemisphere side).

Tests for this aspect of auditory perception can be easily improvised. The examiner can whistle or hum several simple and generally familiar melodies such as "America" ("God Save the Queen"), "Silent Night," or "Frère Jacques." Pitch discrimination can be tested with a pitch pipe, asking the patient to report which of two sounds is higher or whether two sounds are the same or different. Recognition for rhythm patterns can be evaluated by requiring the patient either to discriminate similar and different sets of rhythmic taps or to mimic patterns tapped out by the examiner with a pencil on the table top. Zatorre (1989) prepared 3- and 6-note melodies, presenting them in pairs that were either the same or differed in the tone or rhythmic value or both of one note. Patients with right temporal lobectomies performed significantly below normal levels on this task. Zatorre (1984) reviewed a variety of other techniques for examining melody discrimination, including use of bird songs and dichotic listening. In evaluating patient responses, the effects of musical training must be considered (Botez et Botez, 1996).

Formalized batteries may be used for systematic examination of musical functions. Benton (1977a) outlined a seven-part battery developed by Dorgeuille that contains four sections for assessing receptive functions: II Rhythmic expression (reproduction of tapped rhythm patterns); IV Discrimination of sounds (comparing two tones for highest pitch); V Identification of familiar melodies; and VI Identification of types of music (e.g., whether dance, military, or church). Wertheim and Botez (1961) developed a comprehensive examination for studying amusic phenomena in musically trained patients with cerebral disorders that, in its review of perceptual aspects of musicianship, tests for: A. Tonal, Melodic, and Harmony Elements; B. Rhythmic Element; C. Agogical (tempo-related) and Dynamic Elements; and D. Lexic Element (testing for ability to read musical notation). Each of these sections contains a number of subsections for examining discrete aspects of musical dysfunction. While providing for a comprehensive review of residual musical capacities in musicians who have sustained brain damage, this battery is too technical for general use.

Recognition of emotional tone in speech

That nonverbal aspects of speech may be as important to communication as its verbal content becomes evident when listening to the often flat or misplaced intonations of patients with right hemisphere damage. The emotionally toned techniques described here may bring to light another dimension of the deficits that are likely to accompany left visuospatial neglect, which can debase the quality of these patients' social adjustment, and can lead to an underestimation of their affective capacity when their problem is one of perceptual discrimination rather than emotional dulling.

Using four sentences with emotionally neutral content (e.g., "He tossed the bread to the pigeons."), Daniel M. Tucker and his coworkers (1977) examined whether the capacity to identify or discriminate the emotional toning of speech was impaired with lateralized cerebral damage. Tape recordings were made of each sentence read with a happy, sad, angry, or indifferent intonation, making a total of 16 sentences presented in random order on a recognition task. These sentences were paired for a discrimination task, in which the subject was asked to indicate which of the pair expressed a specified one of the four moods. Although their patient sample was small those whose damage involved right-sided brain structures (i.e., had left visuospatial inattention) were much less able to appreciate the emotional qualities of the sentences than the conduction aphasics who comprised the left-lesioned group with no overlap of scores on either task. In a similar study using four neutral sentences and three emotional tones, patients with right hemisphere disease performed below normal levels on both test tasks (Borod, Welkowitz, et al., 1990). Several other tests of emotional perception and batteries which include such tests are reviewed by Borod, Tabert, et al. (2000). Regardless of format or test length, patients with right brain lesions consistently performed poorly. Following are two sample formats.

In the *Emotional Perception Test* (*EPT*), recordings of three sentences are each read in five different emotional tones: happy, angry, frightened, sad, and neutral (P. Green, Flaro, and Allen, 1999). One sentence is neutral, the second is a request, the third voices a complaint. An equivalent test (three "sentences," each heard in the five emotional modes) uses nonsense sentences to separate tone from content. Scoring forms can be used for clinical examinations or group administrations, the latter consisting of half the original items. Normal subjects' accuracy did not differ significantly whether heard by the right ear, the left, or both, nor did subjects differ on the two test sets. Errors increased significantly after age 50 and even more so for a 70- to 90-year-old group. Women outperformed men on all measures. The manual reports no studies on neurologically impaired patients.

The *Prosodic perception* task in the New York Emotion Battery (Borod, Welkowitz, and Obler, 1992) uses four neutral sentences, each spoken in one of eight emotional tones. The *discrimination* part of this test presents these sentences in 56 pairs for the subject to decide whether the intoned emotion is the same or different. For the *identification* subtest, subjects must choose which of eight emotional words printed on a card describe the tone of each of 24 spoken sentences (Borod, Cicero, et al., 1998). The mean scores for control subjects and patients with left-sided lesions were identical; patients with right-sided lesions made more errors ($p = .035$).

TACTILE PERCEPTION

Investigations into defects of touch perception have employed many different kinds of techniques to elicit or measure the different ways in which tactile perception can be disturbed. Most of the techniques present simple recognition or discrimination problems. A few involve more complex behavior.

Tactile Sensation

Before examining complex or conceptually meaningful tactile-perceptual functions, the integrity of the somatosensory system in the area of neuropsychological interest—usually the hands—should be evaluated. Some commonly used procedures involve asking patients to indicate whether they feel the sharp or the dull end of a pin, pressure from one or two points (applied simultaneously and close together), or pressure from a graded set of plastic hairs, the Von Frey hairs, which have enjoyed wide use in the examination of sensitivity to touch (A.-L. Christensen, 1979; Luria, 1966; Varney, 1986). The patient's eyes should be closed or the hand being tested kept out of sight when sensory functions are tested.

Tactile Inattention

The tactile inattention phenomenon, sometimes called "tactile extinction" or "tactile suppression," most often occurs with right hemisphere—particularly right parietal—damage. Although it frequently accompanies visual or auditory inattention, it can occur by itself. Testing for tactile inattention typically involves a procedure used in neurological examinations in which points on some part of the body (usually face or hands) on each side are touched first singly and then simultaneously (*double simultaneous stimulation*) (Strub and Black, 2000). This is the method, in standardized format, that is used in the Sensory-Perceptual Examination of the Halstead-Reitan battery (e.g., Reitan and Wolfson, 1993). Patients experiencing left hemi-inattention will report only a right-sided touch on simultaneous stimulation, although when just one side is touched they may have no difficulty reporting it correctly.

Face–Hand Test (FHT) (Kahn and Miller, 1978; Zarit, Miller, and Kahn, 1978)

An examination for tactile inattention that involves two bilateral stimulation points on each trial—the method of double simultaneous stimulation—has been formalized as a brief 10- or 20-trial test administered first with the subject's eyes closed. Upon each stimulation trial, the subject must indicate the point of touch (see Table 10.4). Should subjects make errors with their eyes closed, the test is readministered with their eyes open. Interestingly, under the eyes-open condition, only 10% to 20% of patients who had made errors with their eyes closed improved on their original performances (Kahn, Goldfarb, et al., 1960-61). The original format had 10 touch trials, but this was expanded to 16 trials (Zarit, Miller, and Kahn, 1978). Subjects who do not have an inattention problem and elderly persons who are not demented may make one or two errors on the first four trials but typically make no further errors once they have grasped the idea of the task. Impaired patients show no such improvement. Four or more errors indicates impairment (e.g., Eastwood et al., 1983).

Neuropsychological findings. This technique demonstrates the presence of tactile inattention. Not all errors, though, are errors of inattention. Errors on trials 2 and 6 suggest that the patient has either a sensory impairment or difficulty following instructions. Displacement errors, in which the patient reports that the stimulus was felt on another part of the body, tend to occur with diffuse deteriorating conditions (M. Fink et al., 1952). Beyond middle age, errors on this test tend to increase with advancing years (Kahn and Miller,

TABLE 10.4 The Face-Hand Test

Trial			
1.	Right cheek	and	left cheek
2.	Left cheek	and	left hand
3.	Right cheek	and	right hand
4.	Left cheek	and	right hand
5.	Right hand	and	left hand
6.	Right cheek	and	right hand
7.	Right hand	and	left hand
8.	Left cheek	and	right hand
9.	Right cheek	and	left hand
10.	Left cheek	and	left hand

Adapted from Kahn and Miller (1978)

1978). This test is a sensitive indicator of dementia progression; many mildly demented patients make some errors on this test, but with advancing deterioration they tend to fail more than half of the items on the expanded test format (L. Berg, Danziger, et al., 1984; Eastwood et al., 1983). In contrast, with repeated testing, elderly control subjects improved from an average of almost one error on initial testing to virtually none on a third examination (G. Berg, Edwards, et al., 1987).

Quality Extinction Test (QET) (A.S. Schwartz, Marchok, and Flynn, 1977)

Dissatisfaction with the number of patients with parietal lobe damage who did not display the tactile extinction phenomenon on the usual testing procedures led to the development of a test that requires more complex discriminations. In this test, after becoming familiarized by sight and touch with an assortment of different surface textures (e.g., wire mesh, sandpaper, velvet), blindfolded subjects are required to identify these materials when they are brushed against their hands. On some trials, each hand receives the same material; on the other trials, different material is brushed against each hand. This method elicted the inattention phenomenon when it did not show up with usual testing procedures. Tactile inattention is strongly associated with spontaneous visual inattention but when visual or auditory inattention shows up only on testing, tactile inattention is less likely to be found (A.S. Schwartz, Marchok, and Kreinick, 1988).

Tactile Recognition and Discrimination Tests

Stereognosis (recognition of objects by touch)

Object recognition (testing for astereognosis) is commonly performed in neurological examinations (Strub and Black, 2000; L.A. Weisberg, Garcia, and Strub, 1996). Patients are asked to close their eyes and to recognize by touch such common objects as a coin, a paper clip, a pencil, or a key. Each hand is examined separately. Size discrimination is easily tested with coins. The examiner can use bits of cloth, wire screening, sandpaper, etc., for texture discrimination (Varney, 1986). Intact adults are able to perform tactile recognition and discrimination tests with virtually complete accuracy: a single erroneous response or even evidence of hesitancy suggests that this function may be impaired (Fromm-Auch and Yeudall, 1983). Somesthetic defects are generally associated with lesions of the contralateral hemisphere, although bilateral deficits can occur with right hemisphere lesions (Bauer and Demery, 2003; Benton, Sivan, Hamsher, et al., 1994; Caselli, 1991).

Luria (1966) used four procedures to satisfy reasonable doubts about whether a patient's inability to identify an object placed in the palm results from astereognosis or some other problem. Patients who do not identify the object on passive contact with the hand are encouraged to feel the object and move it around in the hand. Should they not be able to name the object, they are given an opportunity to pick out one like it from other objects set before them. Should they still not recognize it, Luria put the object in the other hand, noting that, "if the patient now recognizes the object without difficulty, when he could not do so before, it may be concluded that astereognosis is present." Of course, as soon as the patient accurately identifies the object, the remaining procedural steps become unnecessary.

Wooden letters and formboard shapes were the stimuli in a study of lateralized tactile discrimination (Pandey et al., 2000). Following a somewhat complex testing protocol, these workers showed differential hemispheric success: patients with right-sided lesions needed fewer trials to recognize letters; those with lesions on the left recognized forms in fewer trials. The almost universal availability of letter and geometrically shaped blocks recommends them for testing tactile perception.

Some workers (e.g., Benton, Sivan, Hamsher, et al., 1994 [see also Fig. 9.2, p. 342, which shows how the Tactile Form Perception test is administered]; Reitan and Wolfson, 1993, 2002) have standardized procedures for examining stereognosis and developed scoring systems for them.

For example, using their scoring system to evaluate the *Tactile Form Recognition Test*—which Reitan and Wolfson (2002) say may take as long as 15 min, these authors compared a group of 50 (diagnosticaly not defined) "brain-damaged persons" with a demographically similar group without apparent neurological disease for ability to identify the shape of four flat plastic pieces (cross, square, triangle, and circle). They found not only a highly significant difference between the two groups' mean scores, but reported that their cut-off score (scoring procedures were not provided in this article) identified 82% of patients, 84% of control subjects.

The refinements of scoring are necessary for many research purposes. However, the extra testing they entail adds little to a clinical examination that gives the patient three or four trials with different objects (or textures) for each hand that has sensation sufficiently intact to warrant the testing.

Skin writing

The technique of tracing letters or numbers on the palms of the subject's hands is also used in neurological examinations. A. Rey (1964) formalized the skin-

FIGURE 10.22 Rey's skin-writing procedures. (Courtesy of Presses Universitaires de France)

writing procedure into a series of five subtests in which the examiner writes, one by one in six trials for each series (1) the figures 5 1 8 2 4 3 on the dominant palm (see Fig. 10.22*a*); (2) V E S H R O on the dominant palm; (3) 3 4 2 8 1 5 on the nondominant palm (Fig. 10.22*b*); (4) 1 3 5 8 4 2 in large figures extending to both sides of the two palms held 1 cm apart (Fig. 10.22*c–h*); and (5) 2 5 4 1 3 8 on the fleshy part of the inside dominant forearm. Each subtest score represents the number of errors. Rey provided data on four different adult groups: manual and unskilled workers (M), skilled technicians and clerks (T), people with the baccalaureate degree (B), and persons between the ages of 68 and 83 (A) (see Table 10.5). In the absence of a

TABLE 10.5 Skin-Writing Test Errors Made by Four Adult Groups

Group		*Right-Hand Numbers*	*Right-Hand Letters*	*Left-Hand Numbers*	*Both-Hands Numbers*	*Forearm Numbers*
M	Mdn	0	1	0	2	1
$n = 51$	CS*	2	3	2	5	3
T	Mdn	0	1	0	1	0
$n = 25$	CS	2	3	1	3	3
B	Mdn	0	1	0	0	0
$n = 55$	CS	1	2	1	2	2
A	Mdn	1	2	1	2	2
$n = 14$	CS	3	4	3	6	3

*CS, cutting score.
Adapted from Rey (1964)

sensory deficit or an aphasic condition, when the patient displays an error differential between the two hands, a contralateral cortical lesion is suspected; defective performance regardless of side implicates a tactile perceptual disability.

Skin-writing tests are useful for lateralizing the site of damage when there are no obvious signs such as hemiparesis or aphasia. The two tests presented here can also provide some indication of the severity of a tactile-perceptual defect. Moreover, in finding that toe writing responses can be indicative of severity of TBI, P. Richards and Persinger (1992) hypothesized that this is due to "the particular vulnerability of the medial hemispheric surfaces to the consequences of shear and compressional forces." They followed the same procedures used in Fingertip Number-Writing Perception (below).

Fingertip Number-Writing Perception (G. Goldstein, 1974; Reitan and Wolfson, 1993)

As part of his modification of Halstead's original test battery, Reitan added these formalized neurological procedures in which the examiner writes with a pencil each of the numbers 3, 4, 5, 6 in a prescribed order on each of the fingertips of each hand, making a total of 20 trials for each hand. Normal subjects are more accurate in identifying stimulation applied to their left-hand fingers than those on the right, and the three middle fingers are more sensitive than the other two (Harley and Grafman, 1983). On this symbol identification task, stroke patients with right hemisphere disease made many fewer errors than those whose damage was on the left, but each group performed best with the hand ipsilateral to the lesion (G.G. Brown, Spicer, et al., 1989).

OLFACTION

Diminished olfactory sensitivity accompanies a number of neurological disorders (R.L. Doty and Bromley, 2002; Jones-Gotman and Zatorre, 1988; Mesholam et al., 1998) and has proven useful in discriminating neurodegenerative disorders from depression in elderly persons (McCaffrey, Duff, and Solomon, 2000; G.S. Solomon et al., 1998), or in predicting cognitive decline (Graves et al., 1999) or possible advent of Parkinson's disease (Berendse et al., 2001). Thus olfaction testing should be considered when preparing an assessment battery. Informal olfaction testing is frequently performed by neurologists using a few common odors (coffee, peppermint, vanilla, vinegar, etc.) (e.g., American Academy of Neurology, 2002; Bannister, 1992; Weisberg et al., 1996). This technique will suffice for most clinical work. In some cases, patient reports alone may provide the necessary information: Varney (1988) found that TBI patients who reported olfactory dysfunction were less likely to be employed. However, almost all of a group of Alzheimer patients were unaware of their olfactory deficits (R.L. Doty, Reyes, and Gregor, 1987).

For the more precise odor detection needed for research, the *University of Pennsylvania Smell Identification Test* (*UPSIT*)[1] is probably the most widely used olfaction assessment technique (R.L. Doty, 1992). The 40 odors in this test include different kinds, both pleasant and unpleasant. They are encapsulated in plastic microtubules positioned in strips, each odor on a page in one of four 10-page booklets. When scratched, the strip releases an odor. For each odor four alternative answers are presented on the page. Additionally, odor detection is assessed in a forced-choice paradigm in which a relatively faint odor is presented with an odorless substance. The odor stimulus is gradually increased to a level at which the subject can make four correct choices; and then it is gradually reduced as a check on the subject's threshold response.

Norms are available for the identification and detection tests of the UPSIT. Women tend to identify odors better than men, even across cultures which show differences, as Korean Americans outperformed African and white American groups, with native Japanese doing least well on this set of comparisons (R.L. Doty, Applebaum, et al., 1985). The sex difference did not hold up when memory for odors was tested (Moberg et al., 1987). Age effects are significant for normal control subjects, with the greatest losses occurring in the seventh decade (R.L. Doty, 1990; R.L. Doty and Bromley, 2002). A smoking habit does not seem to affect olfaction sensitivity for some subjects (R.L. Doty, Applebaum, et al, 1985; Moberg et al., 1987).

Other olfactory testing techniques include presentation of odors discretely to each nostril. This allows testing of lateralized sensitivity and showed that the right nostril tends to be more sensitive among normal control subjects, regardless of sex or apparent hemispheric biases (Zatorre and Jones-Gotman, 1990, 1991). To test olfactory memory, Moberg and his colleagues (1987) developed a 30-item set of odors. Five minutes after smelling a set of 10 target odors, one by one, subjects were exposed to 20 odors, including the original 10 plus five similar and five dissimilar foils. Both Huntington and Alzheimer patients were significantly deficient in odor recall when compared with normal control subjects.

[1]This test, under its trademark name *Smell Identification Test,* can be ordered from Sensonics Inc., Haddon Heights, NJ 08035.