3

Executive Functions: Theory, Assessment, and Treatment

Mary H. Purdy

Speech-language pathologists in health care settings are responsible for the evaluation and treatment of patients with a wide variety of cognitive-communication disorders. Consider the following referrals: a 37-year-old policeman involved in a car accident who no longer can stay on topic and answer questions during a public safety demonstration; a 56-year-old self-employed salesman who suffered a cerebral hemorrhage and now cannot schedule appointments efficiently nor adequately describe his products to a customer; a 69-year-old retired man who has had several small strokes and his wife now complains he never talks to her nor follows through on activities. All three patients had a goal in mind—demonstrate public safety techniques, sell a product, complete a "to-do" list—yet none were able to reach their goal. Although each presented with different symptoms, all three patients exhibited a deficit in executive functioning.

Executive functions typically are described as:

> integrated cognitive processes that determine goal-directed and purposeful behavior and are superordinate in the orderly execution of daily life functions, which includes the ability to formulate goals; to initiate behavior; to anticipate the consequences of actions; to plan and organize behavior according to the spatial, temporal, topical or logical sequences; and to monitor and adapt behavior to fit a particular task or context. (Cicerone et al., 2000, p. 1605)

Executive functions play an important role in tasks that are fluid in nature. That is, those that require novel problem solving and place minimal demands on previous learning (Busch, McBride, Curtiss, & Vanderploeg, 2005). It is critical for speech-language pathologists to understand the nature of executive functions and their relation

to cognitive-communicative behavior. This chapter reviews the theoretical basis of executive functioning, its neuroanatomic correlates, its impact on communication, and issues related to assessment and management.

Conceptual Models of Executive Functions

Many definitions of executive function exist and the components and nomenclature vary, often depending on the specific field of study (e.g., cognitive psychology, educational psychology, neuropsychology). This often can be confusing to clinicians as they study the nature of executive functions. Miyake, Emerson, and Friedman (2000) identified some of the issues to be considered when reviewing the executive function literature. First, concepts among the different models may overlap. Second, researchers may use the same terms to refer to conceptually different functions, or use different terms to refer to the same function. Finally, there is a lack of agreement among researchers on the issue of whether executive functions should be considered unitary (a single, general construct with multiple interrelated subprocesses) or nonunitary (a collection of dissociable or independent processes). A sampling of theories is reviewed below, and a summary of primary components of these theories is presented in Table 3–1.

Luria (1966) was a prominent neuropsychologist who was intrigued with the brain and behavior. His astute observations led him to make the connections among the frontal lobes, executive functioning, and problem solving. He documented the behaviors of individuals who sustained frontal lobe damage while they attempted to solve a problem and noted that they typically lacked a specific plan, did not acknowledge constraints of a problem, and were impulsive, a phenomenon he described as an impairment in self-regulation. Luria concluded that problem-solving behavior was dependent on a number of overriding skills, or executive functions, which were dependent on the frontal lobes. He described the major components of executive functioning as anticipation (setting realistic expectations, understanding consequences), planning (organization), execution (flexibility, maintaining set), and self-monitoring (emotional control, error recognition). Table 3–2 provides an example of how these components may be applied to a task required of the 37-year-old policeman recently referred to your practice.

Both Stuss and Benson's (1986) and Lezak's (1995) models of executive function are closely related to Luria's, although the nomenclature is different. Stuss and Benson first discuss initiation of behavior, followed by planning, sequencing, and organization. These three subprocesses are similar to Luria's components of planning and execution. However, Stuss later placed executive functions in the middle of a hierarchical framework (1991). According to this model, executive functions receive input from lower level, or basic processes (e.g., attention, memory, language, perception), as well as higher level metacognitive processes. Lezak proposed a four-component executive function

Table 3–1. A Summary of Executive Function Theories

Luria (1966)	Stuss and Benson (1986)	Lezak (1995)	Sohlberg and Mateer (2001)	Keil and Kaszniak (2002)
Anticipation	Initiation	Volition (including self-awareness and self-monitoring)	Initiation and drive (starting behavior)	Planning, scheduling, strategy use, rule adherence
Planning	Planning	Planning	Response inhibition (stopping behavior)	Generation, fluency, initiation
Execution	Sequencing	Purposive action	Task persistence (maintaining behavior)	Shifting and suppression
Self-monitoring	Organization	Effective performance	Organization (organizing actions and thoughts)	Concept formation and abstract reasoning
	Regulation		Generative thinking (creativity, fluency, cognitive flexibility)	
			Awareness (monitoring and modifying one's own behavior	

model that closely corresponds to Luria's model: volition (including self-awareness and self-monitoring), planning, purposive action, and effective performance. She frequently described individuals with executive functioning problems as demonstrating a disconnection between "knowing" and "doing." That is, these individuals often could describe a problem and/or a solution, but could not effectively carry out the solution.

More recently, Mateer (1999) and Sohlberg and Mateer (2001) conceptualized a clinical model of executive functions involving six components including: (1) initiation and drive (activation or starting of a cognitive system), (2) response inhibition (stopping automatic or prepotent response

Table 3–2. Luria's Executive Components and Their Relation to Task Performance

Anticipation	Set a goal to inform the public of potential unsafe situations and self-protection or self-defense techniques
Planning	a. set up a schedule. Plan to meet with elementary school children in their classroom, and set up evening classes for adults b. Organize the presentation: facts, examples, techniques
Execution	Must be flexible; adapt to different constraints that may exist. When setting a schedule, he must consider his own work and personal responsibilities as well as the school's schedule to determine a time that is convenient for both. He must also be flexible with the presentation. The information and examples used for young children will be different from those used for older children and young adults. While presenting the information, he must remain on topic and return back to the topic if interrupted with a question.
Self-Monitoring	Must recognize when an error is made: determine if there is a schedule conflict or that he presented conflicting information.

tendencies), (3) task persistence (maintaining a behavior until task completion), (4) Organization (organizing and sequencing of information), (5) generative thinking (creating multiple solutions to a problem and thinking in a flexible manner), and (6) awareness (monitoring and modifying one's own behavior) (pp. 235–236). They use this model to guide their observations, assessment, and management plan.

Other fields (e.g., developmental, educational, and cognitive psychology) view executive functioning as part of the metacognitive system, rather than part of a hierarchy. In this context, metacognition, or thinking about thinking, refers to, "one's ability to view, observe, and assess more basic cognitive processes and includes self-awareness, self-monitoring and self-control of cognition while performing an activity" (Kennedy & Coelho, 2005, p. 243). Metacognitive beliefs are created and updated by new experiences and situations, thus, there is a dynamic relationship among these concepts. Everyday routines are automatic and, hence, do not require active self-monitoring. However, when an individual is required to perform a task that is different from routine, success is dependent on the ability to detect what is different, monitor performance given this change, make a strategy decision, and execute the strategy. For example, if you regularly give a 45-minute talk in a series on brain-injury and the program director pulls you aside and says you have 30 minutes, you immediately determine the change

in expectations (15 minutes less time), plan your strategy (cut down on several sections, or eliminate an entire section), then select and execute your strategy. Thus, self-regulation is the dynamic relationship among metacognitive beliefs and knowledge, self-monitoring, self-control, and strategy execution.

Relationships Among Executive Functions, Attention, and Memory

As the clinician reviews models of attention and memory, the interrelationships of these constructs with executive functioning becomes evident. A prominent example of this interplay can best be exemplified through the domain of working memory. Working memory has been described as the cornerstone of higher order cognitive operations and complex goal-directed behavior (Just & Carpenter, 1992). Working memory is a cognitive system that permits interactions between attention, perception, and memory (Baddley, 1992; Cowan, 1999). It is a limited capacity system that temporarily maintains and elaborates information, and supports human thought processes (Baddley, 2003). This model has three major components: a control system, referred to as the central executive system (CES), and two subsidiary storage systems, the phonological loop and the visuospatial sketchpad. The two subsidiary systems are responsible for temporarily storing verbal and nonverbal information, whereas the CES processes information in working memory.

Working memory processes are particularly crucial in the initial phases of goal-directed behavior "in which the most suitable strategies to accomplish a task have to be selected among alternatives, "mentally" checked and, if necessary, modified" (Serino et al., 2006, p. 30). Although both executive functions and working memory make significant contributions to the execution of complex tasks, their roles may be quite distinct. Connor (2000) suggests viewing working memory and executive functioning in terms of a hierarchy. Working memory provides the storage and workspace for information, whereas executive functions perform operations on the information held in working memory so the information may be used efficiently (Figure 3–1). To illustrate this concept, think back to the salesman who wants to persuade the customer to buy his product. In order to explain the similarities and differences between his product and a customer's current product, he needs to call up the specific features of the two items and hold those in working memory while the executive functions sort through, organize, and pull out the features relevant to the customer's needs. Following brain damage, performance may suffer for different reasons. There can be a problem with storage space and working memory, or there may be a problem with strategy selection.

Every task we perform requires activating a number of specific cognitive processes, and each cognitive process takes up some of the resources we have available to perform the task. The more routine a task is, the less resources it requires, therefore leaving

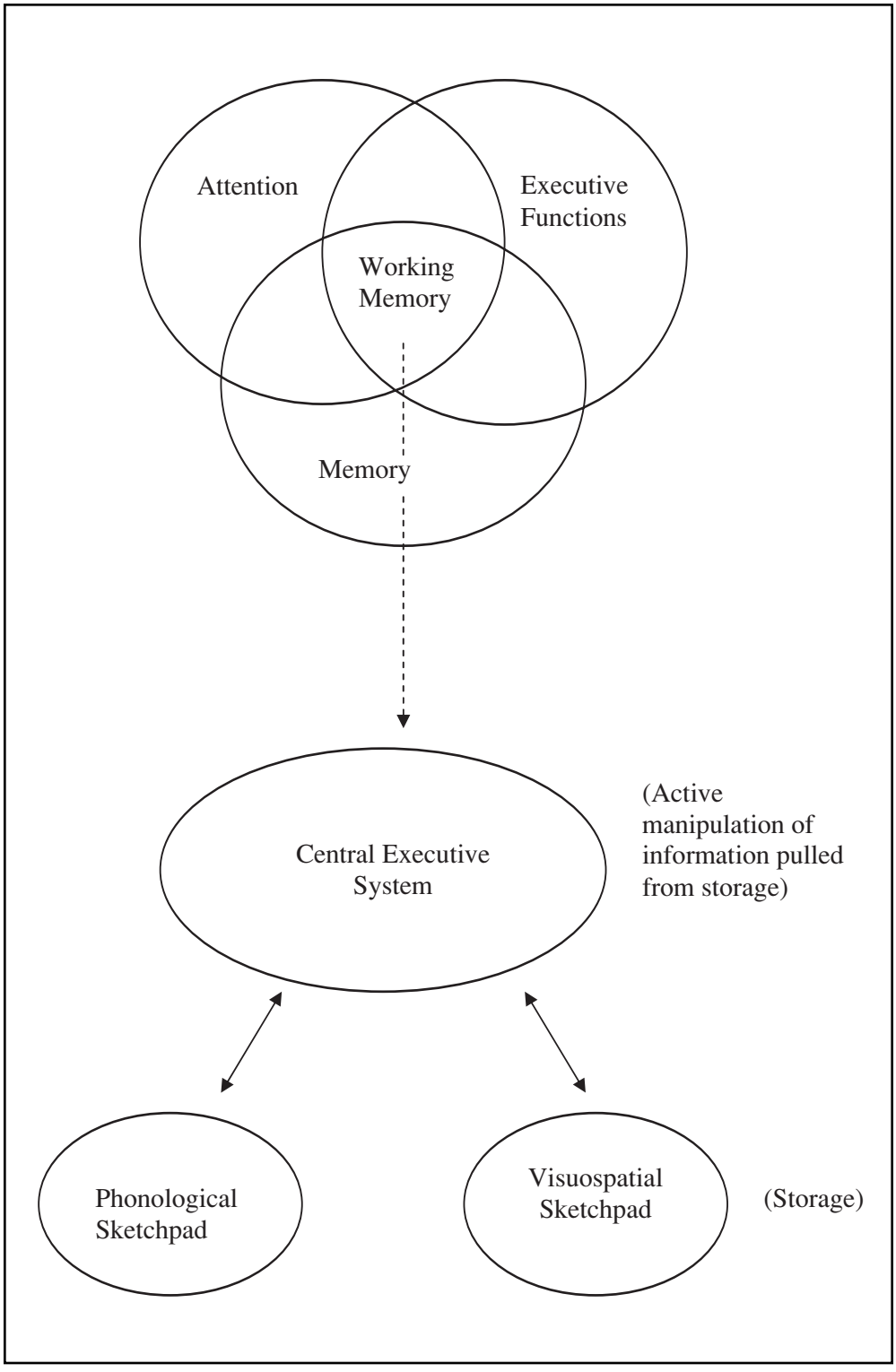


Figure 3–1. Conceptualization of the relationships among attention, memory, executive functions, and working memory.

stand other people have ideas, beliefs, and views that differ from one's own (Griffin, Friedman, Ween, Winner, Happé & Brownell, 2006; Happé, Brownell, & Winner, 1999; Martin & McDonald, 2003); the complexity of processing required for interpreting discourse and pragmatics (Monetta & Joanette, 2003; Monetta, Ouellet-Plamodon, & Joanette, 2006); and the interruption of executive function networks based in the frontal lobes (Martin & McDonald, 2003). These theories are discussed in more detail later as they relate to discourse and pragmatic deficits in adults with RHD. They also are used as suggested foundations for developing theoretically based treatments in the absence of evidence for efficacy of treatment in these areas.

There is no commonly used label for communication deficits associated with RHD. Some labels that routinely appear in both research and clinical diagnoses include: cognitive communication deficits, cognitive-linguistic deficits, or nonaphasic language deficits. The label "right hemisphere syndrome" also has been used. A syndrome generally has specific signs and symptoms associated with it, and given that with RHD there is a wide variety of deficits and no specific or predictable pattern of those deficits (Blake, Duffy, Myers, & Tompkins, 2002; see discussion below), "RH syndrome" is perhaps a misnomer. Two other labels that have been suggested include *pragmatic aphasia* (Joanette & Ansaldo, 1999) and *apragmatism* (Myers, 2001). These were selected to highlight the centrality of pragmatic deficits to the communication problems associated with RHD. To date, neither of these labels has been accepted for general clinical use.

Characteristics

Cognitive communication disorders associated with RHD can be divided into three broad categories: attention, communication, and cognition. Attentional deficits include general deficits in the ability to pay attention, to sustain attention over time, and to alternate or divide attention between different tasks or stimuli. One particular type of attentional disorder is neglect, in which an individual has difficulty attending to stimuli presented contralateral to the side of lesion. Communication deficits associated with RHD occur at extralinguistic levels: these are components of language beyond words and single sentences that are necessary for efficient, effective, and appropriate communication. Extralinguistic factors include interpretation of nonliteral language, ambiguities, or other language that can have multiple meanings; the use of context to interpret meaning; the use and interpretation of emotion and affect, and the production and comprehension of prosodic contours to express emotion or intent. Cognitive deficits associated with RHD are less well described. Generally, they include deficits in "executive functions," or goal-directed behaviors. Areas affected include organization, sequencing, problem solving, reasoning, judgment, and insight. These are important as they affect the efficiency and effectiveness of communication. Another cognitive deficit common to adults with RHD is anosognosia, or reduced awareness/recognition of deficits.

The population of adults with RHD is extremely heterogeneous both in the range of severity (which is seen

in various neurologic communication disorders), and also in terms of presentation. Currently, there are no clear patterns of deficits or subtypes (e.g., like aphasia classifications) that have been identified for RHD (Blake et al., 2002).

Prevalence and Patterns of Deficits

Estimates of the frequency of cognitive-communication deficits vary. Studies of an unselected population (e.g., individuals identified for research studies based solely on side of lesion) indicate that approximately 50% of adults with RHD have cognitive communication deficits (Benton & Bryan, 1996; Joanette & Goulet, 1994). In contrast, two studies that have examined individuals in a rehabilitation setting have reported 80 to 90% of groups had such deficits, suggesting that cognitive communication deficits are likely to occur in adults who have concomitant deficits that require ongoing rehabilitation (Blake et al., 2002; Côté, Payer, Giroux, & Joanette, 2007).

Blake and colleagues (2002) examined the prevalence and patterns of deficits associated with RHD. They reviewed medical records of 123 individuals with RHD admitted to an inpatient rehabilitation unit, and tallied all cognitive and communicative deficits mentioned in the medical records. Data was taken from SLP, occupational therapy, neurology, and neuropsychology reports. Results of the study (summarized in Table 4–1) indicated that attention/perception deficits were the most commonly diagnosed, followed by learning/memory, reasoning and problem solving, and cognitive deficits such as problems with organizing, sequencing and integration. The least commonly reported deficits were aprosodia, pragmatics (interpersonal interactions), and hyperaffectivity (e.g., pseudobulbar affect, emotional lability, hallucinations). It was interesting, although not completely surprising, that communication-specific deficits, such as aprosodia and pragmatic deficits were identified far more frequently by SLPs than the other three disciplines combined (Blake, Duffy, Tompkins, & Myers, 2003). One important consequence of this is that individuals with pragmatic deficits may not be referred to SLPs if neurologists and neuropsychologists do not recognize the deficits.

Blake and colleagues (2002) also explored whether patterns of co-occurrence could be identified. The only deficits that routinely co-occurred were (a) learning/memory and attention, and (b) cognitive deficits and hyporesponsivity. The former pair makes sense, as attention is necessary to encode and retain new information. The latter pair may have been a result of overlapping definitions of the deficit categories, both of which included slowed processing (with either inputs or outputs). Deficits in math, language, and hyperaffectivity were not clearly linked to any other deficits. This result is not surprising, as these deficits are not commonly considered hallmarks of RHD.

Attention

General Attention

General forms of attention, including focused, sustained, alternating and divided attention (as discussed in Chapter 1), all may be affected by RHD.

Table 4–1. Prevalence of Deficits and Deficit Categories Associated with RHD

Deficits and Deficit Categories	Description	Percentage (from 123 cases)
Attention	Ability to focus on stimuli; includes focused, sustained, and divided attention	67.5
Visuospatial neglect	Visual neglect; left neglect	65.9
Reasoning and problem-solving	Cognitive skills associated with identifying problems, identifying relevant information and appropriate solutions, and goal achievement	61.0
Learning/ Memory	Ability to learn and retain new information	63.4
Perception	Visual and tactile perception and construction	63.4
Other cognitive deficits	Cognitive skills associated with organizing, sequencing, categorizing, and integrating information	52.0
Awareness	Awareness of, or insight into, deficits and consequences of the deficits	43.9
Orientation	Orientation to self, time, situation	43.1
Hyperresponsive	Heightened responsivity to stimuli	41.5
Hyporesponsive	Dampened or restricted responsivity to stimuli	39.0
Calculation	Mathematical skills	30.9
Hypoaffective	Dampened or restricted affective response	30.1
Linguistic	Basic expressive and receptive language functions	26.0
Aprosodia	Reduced use or comprehension of prosody	19.5
Interpersonal interactions	Behavioral aspects of interpersonal communication	16.3
Hyperaffective	Heightened affective response	15.4

Source: Adapted with permission from: Blake, M. L., Duffy, J. R., Myers, P. S., & Tompkins, C. A. (2002). Prevalence and patterns of right hemisphere cognitive/communicative deficits: Retrospective data from an inpatient rehabilitation unit. *Aphasiology*, *16*, 537–548.

For example, individuals with RHD may have difficulty focusing on assessment or treatment tasks, especially when there are distractors present. They also may have difficulty sustaining attention for several minutes at a time.

Deficits in either focused or sustained attention may negatively affect communication. The client will have difficulty focusing on a conversation, or not be able to maintain his focus on conversations or reading material. Imagine being in a conversation in which your attention starts to drift away from the speaker. Your comprehension of the conversation topic will be decreased because you miss some information. If the information was not critical, then you can re-focus on the conversation and still get the gist of it. On the other hand, if you miss critical information, then your understanding will be incomplete at best or possibly incorrect (Table 4–2). Alternating and divided attention, because they are more complex forms of attention, frequently are affected by RHD.

Neglect

Neglect (also called hemineglect, visuoperceptual neglect, or hemispatial neglect) is a specific attentional disorder in which the brain does not process stimuli that appear in, or originate from, the side contralateral to the cerebral lesion (e.g., they do not process information from the left side of space after a lesion to the right hemisphere). Sometimes neglect is described as the person "ignoring" information from one hemispace. This term should be used cautiously, as the word "ignore" suggests that the person is aware of the stimulus and chooses not to attend to it. However, neglect is not a conscious ignoring of information, but a decreased ability to process that information.

Contralateral neglect may occur after damage to either cerebral hemisphere. Left neglect resulting from damage to the right hemisphere is more severe and lasts longer than right neglect resulting from left hemisphere damage (Mesulam, 1981; Bowen, McKenna, & Tallis, 1999). Thus, although right neglect occurs at approximately the same frequency as left neglect, clinicians are less likely to see it because it resolves relatively quickly, or it is masked by

Table 4–2. Example of Comprehension Affected by Attentional Deficits

You are talking with your friend Marisol about a wedding she attended. Marisol says: *"The bridesmaid dresses were hideous! They were an awful color of pink, and the style was really unflattering on some of the bridesmaids. But you should have seen Katie's cousin Lucas! He just turned five last month. He is so cute! I could hardly take my eyes off him during the ceremony."*
The highlighted areas indicate areas in which your attention was drawn away from the conversation. The first part missed, about the color of the dresses, may not create difficulties with interpreting or understanding the conversation because you know that Marisol didn't like the dresses. However, if you didn't know Lucas before and your attention was drawn away from the conversation when your friend mentioned that he was only 5 years old, you might infer that Lucas is a young adult, and that your friend is interested in getting to know him better. This small lapse of attention could cause an error in comprehension and a miscommunication.

other disorders such as aphasia (Bowen et al., 1999). The remaining discussion focuses on left neglect caused by RHD.

Neglect can affect movement as well as auditory and visual modalities. In left motor neglect, patients do not use their left limbs to the extent possible. For example, an individual may not use his left arm to propel his wheelchair, or for tasks that require both hands (e.g., unscrewing a tube of toothpaste), even if there is only mild weakness present (Mesulam, 1987). Tactile neglect occurs when a person does not process sensory stimulation on the contralateral side of the body, in the absence of a sensory deficit that would prevent such processing. A person with auditory neglect may not process sounds that originate from the left side (Bisiach, Cornacchia, Sterzi, & Vallar, 1984; Pavani, Husain, Làdavas, & Driver, 2004). Auditory neglect can be difficult to identify because of the bilateral (although unequal) representation of sounds in the auditory cortex, and from the transmission of sound through space, such that sounds that originate on the left side are detected and processed by both ears (just softer and slightly later in time for the contralateral ear). Studies have revealed that auditory neglect may manifest as a difficulty in localizing sounds, particularly those that originate from the left side of space. For example, Pavani and colleagues (Pavani, Meneghello, & Làdavas, 2001) reported that adults with RHD were able to discriminate tones from same versus different locations when the tones were either both from the right of a participant's midline, or if one was from the right and the other from the left. In contrast, they were unable to distinguish same versus different locations when both tones originated to the left of midline. Errors attributed to auditory neglect tend to correlate with the severity of visual neglect, suggesting a deficit of multimodal spatial processing (Pavani, Làdavas, & Driver, 2003).

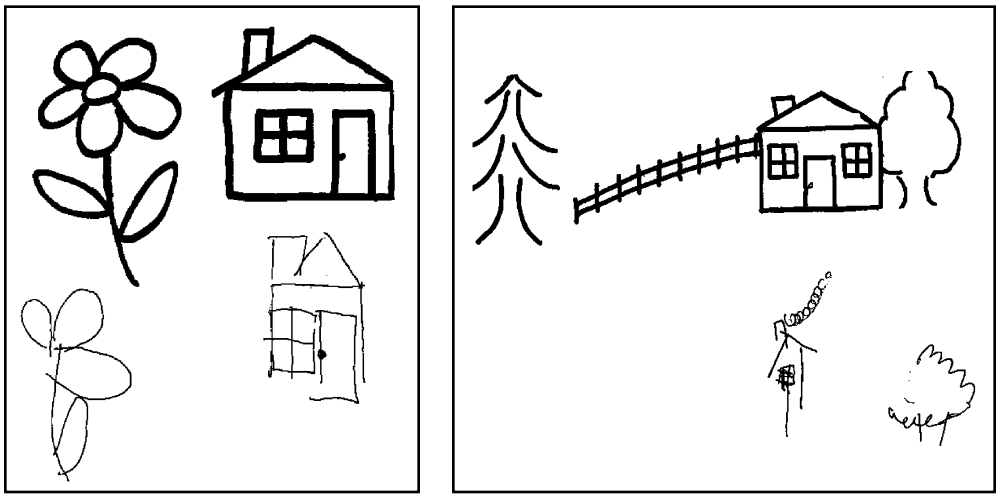
Visual (or visuospatial) neglect is the most common type of neglect. Estimates of prevalence are quite broad, ranging anywhere from 13 to 81% of patients with RHD (Barrett, Buxbaum, Coslett, Edwards, Heilman, Hillis, et al., 2006). The range may be due to spontaneous recovery in some patients, or to the variable sensitivity of tests for neglect. The latter is discussed in the section on assessment. Visuospatial neglect affects one's ability to process visual information from the left visual field or the left side of an object. Neglect is not an all-or-none phenomenon: some individuals can shift their attention to stimuli in the left visual space when cued to do so; some demonstrate excessive variation in response times to left-sided stimuli (Anderson, Mennemeier, & Chatterjee, 2000); others can attend to items in the left hemispace when there are no competing stimuli on the right side. The latter behavior has been attributed to a "magnetic" attraction to items on the right, which "grab" one's attention (Bartolomeo & Chokron, 1999). The client then has difficulty "disengaging" from that attended stimulus in order to shift attention to another one (Posner, 1980; Posner, Walker, Friedrich, & Raphal, 1984).

Visuospatial neglect has been linked primarily to lesions of the right parietal lobe, particularly the inferior parietal lobule or the temporoparietal junction (Buxbaum, Ferraro, Veramonti, Farne, Whyte, Ladavas, et al., 2004; Mesulam, 1981, 1985; Vallar, 1993; Vallar & Perani,

1986). However, it also has been detected after lesions to the right inferior frontal gyrus as well as lesions to the white matter underlying these areas. Bartolomeo and colleagues (Bartolomeo, de Schotten, & Doricchi, 2007) propose that lesions to frontoparietal attention networks may be the source of neglect. Lesions to subcortical structures, including the thalamus (Hillis, Newhart, Heidler, Barker, Herskovits, & Degaonkar, 2005) and the basal ganglia (Buxbaum et al., 2004), also may result in neglect.

Another phenomenon often observed along with neglect is extinction (DiPellegrino & DeRenzi, 1995; Duncan, Bundesen, Olson, Humphreys, Chavada, & Shibuya, 1999). This occurs when a person can attend to a left-sided stimulus only when that stimulus is presented in isolation. When bilateral simultaneous stimulation is presented (e.g., touch both arms or present two objects, one to the left and one to the right of midline), the person reports only sensing the stimulus on the right.

There are subtypes of visuospatial neglect defined by frames of reference: *what* aspect of a stimulus is neglected, and *where* neglected items are in relation to the person. The two most well described types are *viewer-centered* (or egocentric) and *stimulus-* or *object-centered* (also called allocentric) neglect (e.g., Chatterjee, 1994). In viewer-centered neglect individuals fail to attend to the left side of space from their perspective. When asked to copy a scene (e.g., Figure 4–1A), they copy only items that are on the right side of the scene. In contrast, with object-centered neglect individuals may copy only the right side of each object, regardless of where the items appear in the visual scene. Figure 4–1B demonstrates a combination of viewer-



A B

Figure 4–1. A. Viewer-centered neglect: the patient omitted the left-most features of the drawing on the left side of the page. **B.** Object and viewer-centered neglect: the patient omitted the left-sided detail of the two items he drew, as well as all items to the left of midline on the page.

and object-centered neglect. Viewer-centered neglect is the more common type, and very few patients have both types. In 150 participants with new onset of a right hemisphere strokes, Hillis (2006) reported 28% exhibited viewer-centered neglect, 5% had object-centered, and 2% demonstrated a combination of both.

There are three types of neglect related to the region of personal space affected (Appelros, Nydevik, Karlsson, Throwalls, & Seiger, 2004; Buxbaum et al., 2004). Individuals with *personal* neglect fail to attend to the left side of their body. They may not comb the left side of their hair, shave the left side of their face, or dress the left side of their body. Personal neglect has been linked to damage to the supramarginal gyrus in the right parietal lobe (Bartolomeo et al., 2007). Individuals with *peripersonal* neglect do not attend to information within the left space within an arm's reach. These individuals demonstrate neglect on paper/pencil tasks, reading tasks, and when eating or locating objects on a table in front of them. Peripersonal neglect is more common, reported in 23% of a sample, versus 8% with personal neglect (Appleros et al., 2004). The third type is *extrapersonal* neglect, which is reduced attention to the left side of space beyond an arm's reach. Individuals with extra-personal neglect may not notice people or objects that are on the left side of the room. Thus, they may not be able to "find" the TV or window that is on the left side. Hillis (2006) reported dissociations between these types of neglect. For example, individuals can have personal, but not peripersonal neglect, and vice versa. Peri- and extrapersonal neglect have been linked to lesions of the superior temporal gyrus, inferior frontal gyrus, and/or frontoparietal attentional networks (Bartolomeo et al., 2007).

Unconscious processing of information within the neglected hemispace has been repeatedly documented (e.g., Driver & Mattingly, 1998; Kanne, 2002; Marshall & Halligan, 1988; Tamieto, Geminiani, Genero, & De Gelder, 2007; Vuilleumier, Schwartz, Husain, Clark, & Driver, 2001; Vuilleumier, Schwartz, Clarke, Husain, & Driver, 2002). Individuals with neglect demonstrate processing of color and shape, and even identity and meaning without conscious awareness of seeing the stimuli. Driver and Mattingly (1998) report that individuals with neglect demonstrate semantic priming from visual targets presented to the left visual field. For example, they are faster to read the word "tree" after a picture of a leaf is flashed in the left visual field than when a picture of a bed is shown. The participants, despite showing normal visuo-semantic priming, report no recollection of seeing the pictures that were presented in the neglected hemifield. Vuilleumier and colleagues (Vuilleumier et al., 2002) also demonstrated repetition priming effects in individuals with neglect and extinction. The participants were shown pictures in either the right, left, or both hemifields. In the bilateral presentation condition, participants with neglect reported seeing only the item on the right side. However, in a second task when participants were asked to simply indicate whether or not they saw an item before, recognition times were faster for those items that were extinguished than for items not previously presented.

Communication

Communication deficits associated with RHD appear in the production and comprehension of discourse. Discourse can broadly be defined as two or more connected sentences, and relies on appropriate links (explicit or implicit) between sentences or ideas, and integration of information across sentences. Adults with RHD may exhibit deficits in interpretation of intent, providing or generating links, and using context to aid comprehension. Context, broadly, includes not only verbal information within the text or discourse, but also things such as intonation, facial expression, knowledge of another's beliefs or intentions, prosody, and relevant world knowledge.

The stereotypical description of an individual with RHD involves someone who is overly literal, unable to appreciate metaphors or idioms, but instead interprets them literally; who is verbose, producing more information than needed, much of which is tangential; and who may not seem to have a point that he is trying to get across. He may not "get" jokes, especially those that rely on a play on words. The content of what he says is usually egocentric, and he does not follow the "rules" of conversation in that he does not make appropriate eye contact and he dominates the conversation instead of allowing turn-taking.

Prosody and Affect

Deficits in the use and comprehension of prosodic contours to express meaning and emotion have been attributed to RHD. The term *aprosodia* is used to describe such deficits in the production or comprehension of variations in pitch, duration, loudness, and pause time (Ross, 1981). There are two main categories of prosody: linguistic and emotional. Linguistic prosody is that which is used to segment words, phrases, and sentences, and which conveys syntactic information, such as distinguishing a question from a statement (e.g., "I won a hundred dollars?" versus "I won a hundred dollars!"). Linguistic prosody also is used to emphasize important words within a sentence (e.g., "JULIE had a baby." versus "Julie had a BABY."). Some reports suggest that linguistic prosody is controlled primarily by the left hemisphere, although other work suggests it is controlled bilaterally or primarily by the right hemisphere (Baum & Pell, 1999; Pell, 1998; Sidtis & VanLancker Sidtis, 2003; VanLancker, 1980). Emotional prosody involves intonation patterns used to convey emotion (e.g., "I hate it when I do that," spoken in an off-handed or joking manner versus the same statement proclaimed with anger). Emotional prosody repeatedly has been linked to the right hemisphere (e.g., Baum & Pell, 1999; Ross, 1981; Sidtis & VanLancker Sidtis, 2003).

Aprosodia can be expressive (difficulty producing prosodic contours) or receptive (difficulty interpreting meaning expressed through tone of voice). Individuals with RHD may have difficulty with either type individually, or both may be impaired.

Speech produced by an individual with expressive aprosodia sounds monotone and flat. The listener may also perceive the rate of speech as fast, because of the reduction in prosodic contours to segment words, phrases, and sentences.

Expression or comprehension of affect also can be impaired after RHD. In