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ABSTRACT

Individuals with praxis problems encounter difficulties engaging in occupation, and the occupational therapists who work with these clients are challenged to provide intervention that enables occupational performance. This extensive review of the current literature provides clinicians with information regarding the relevant descriptions and suggested mechanisms of apraxia. Errors noted in performance, different classification systems and the implications of the current knowledge will be discussed. The paper concludes by providing information for clinicians regarding occupational therapy evaluation and intervention strategies for praxis problems.

RÉSUMÉ

Les personnes souffrant d'apraxie ont de la difficulté à s'engager dans des occupations. Le défi des ergothérapeutes qui travaillent avec ces clients est de faire des interventions qui favorisent le rendement occupationnel. Cette revue exhaustive de la littérature actuelle offre aux cliniciens des descriptions judicieuses et de l'information sur les mécanismes possibles de l'apraxie. Les auteurs discutent des erreurs observées par rapport au rendement, des différents systèmes de classification et des multiples façons d'appliquer les connaissances actuelles. Les auteurs concluent l'article en présentant, à l'intention des cliniciens, des stratégies d'évaluation et d'intervention possibles en ergothérapie pour traiter les problèmes associés aux apraxies.

Individuals with praxis problems may encounter a number of difficulties engaging in occupation. The majority of functional activities require effective conceptualization and execution of skilled, purposeful movement. While the relationship between apraxia and occupation has not been extensively researched, Heilman and Gonzalez Rothi (1993) indicate that apraxia is associated with impaired occupational engagement. In order to enable occupational competence, occupational therapists often need to evaluate clients at both the performance component and occupational performance levels (Canadian Association of Occupational Therapists (CAOT), 1991). Titus, Gall, Yerxa, Roberson, & Mack (1991) assert that "Occupational therapy has been one of the key disciplines used for the assessment and treatment of patients [sic] who must learn to live with the residual disability produced by cerebral vascular accident." (p.410).

Early research on apraxia focussed on the location of brain lesions and on the definition and classification of the ensuing movement difficulties. Recent researchers have further grappled with the issue of delineating apraxia, but have also worked toward evaluation and intervention strategies for people with apraxia. The purpose of this paper is to provide clinicians with current information regarding definitions, descriptions, and suggested mechanisms of apraxia, as well as performance errors, different classification systems, and to discuss the implications of this current knowledge. This review will assist occupational therapists to better understand the praxis difficulties underlying occupational performance problems, leading to more detailed evaluation, effective intervention strategies and successful occupational therapy outcomes.

Definitions

There are a variety of definitions of praxis and apraxia described in the literature, as well as a range in the complexity of these definitions, which creates difficulty in conceptualizing the impairment. The review of working terminology for both praxis and apraxia provided here will contribute to an understanding of the discrepancies in explaining apraxia.

Pedretti, Zoltan, & Wheatley (1996) define praxis as an individual's "ability to plan and perform purposeful movement." (p. 235), thus providing the basis for effectively interacting with one's environment. Praxis involves recognizing the need for action (ideation), conceptualizing or planning the action, and actually performing the task (Ayres, 1985; Paillard, 1982; Roy, 1983b). Overall, praxis involves organizing components, both within the individual and the environment for effective performance of purposeful acts (Ayres, 1985). Apraxia is quite simply the absence of this ability. It is defined primarily through exclusion criteria, an approach that emphasizes the need to rule out alternative explanations for functional difficulty (Heilman, Rothi, & Valenstein, 1982; Riddoch, Humphreys, & Bateman, 1995). Geschwind (1975), for example, defined apraxia as a disorder of learned movement which could not be accounted for by muscle weakness, lack of coordination, poor sensation, poor comprehension, or inattention. Two decades later, the literature still reflects similar definitions of exclusion (Foundas, Henchey, Gilmore, Fennell, & Heilman, 1995; Heilman & Gonzalez Rothi, 1993; Papagno, Della Sala, & Basso, 1993). For example, Pedretti et al. (1996) refer to apraxia as "An impairment in the ability to perform purposeful movement, with no loss of motor power, sensation, or coordination and with normal comprehension" (p.235).

Inclusion criteria for apraxia have emerged more recently through analysis of the types of errors characteristic of apraxia, and the conditions under which errors occur. Some errors that have been documented include: perseveration, omissions, faulty sequential organization and clumsiness (Draves York & Cermak, 1995; McDonald, Tate, & Rigby, 1994; Roy, 1983a; Roy & Square-Storer, 1990; Schwartz, Mayer, Fitzpatrick, DeSalme, & Montgomery, 1993; Woodson, 1995). Unfortunately, research focussed on characterizing error types has yet to achieve consensus (Lehmkuhl, Poeck, & Willmes, 1983; McDonald et al., 1994).

Recently, investigators have supported a more circumscribed definition of apraxia which describes an impairment in the ability to perform purposeful movement related to gesturing and object use (Faglioni, Basso, Botti, Aglioti, & Saetti, 1990; Harrington & Haaland, 1992; Roy et al., 1993; Roy, Square-Storer, Hogg, & Adams, 1991; Sirigu et al., 1995). As with broader definitions, the disturbance in gesture performance and object use is not perceived to be a result of muscle weakness, lack of sensation, lack of comprehension, incoordination, or other sensori-motor difficulties (Roy, 1982; Roy et al., 1993). Many of the clinical assessments used to evaluate praxis are consistent with this more recent delineation of praxis, focussing on gesturing and object use (Harrington & Haaland, 1992).

Descriptions of Apraxia

Liepmann (as cited in Geschwind, 1975) first systematically studied apraxia in the early part of this century. Subsequently, a number of suggested mechanisms of apraxia, descriptions of performance errors and classification systems have been described (Roy, 1978; Square-Storer & Roy, 1989). The complexity of, and the discrepancies between, these descriptions are consistent with the difficulties that individuals with apraxia have in ameliorating performance when interacting with the environment.

Suggested Mechanisms of Apraxia

Much research has been directed at determining the mechanisms underlying apraxia. The mechanisms that have been proposed include viewing apraxia as; a disconnection syn-

drome, a conceptual disorder, a spatial disorder, a conceptual-production disorder, and a movement disorder (Heilman & Gonzalez Rothi, 1993; Roy et al., 1985).

A Disconnection Syndrome

Early in this century, Liepmann (as cited in De Renzi, Faglioni, & Sorgato, 1982; Roy, 1982) first suggested that apraxia may be related to a disconnection between different control centres in the brain. Geschwind (1975) suggested that a disconnection affecting the speech reception areas was responsible for the disorder. The right hemisphere was thought to be incapable of understanding movement-related verbal commands. Further researchers demonstrated that Geschwind's view of apraxia was too narrow, and they have questioned his assumptions regarding the right hemisphere's inability to comprehend verbal commands to elicit movement (Roy, 1982). Heilman (1979) has since broadened the discussion to that which Liepmann first described; apraxia may be the result of a disconnection among a variety of brain control centres.

A Conceptual Disorder

Other researchers suggest that apraxia is a disturbance in understanding or expressing symbols (Roy, 1982). Research related to the co-occurrence of apraxia and aphasia has been used both to support (Alexander, Baker, Naeser, Kaplan, & Palumbo, 1992) and to refute the idea that apraxia is a conceptual problem (Goodglass & Kaplan, 1963; Hecaen & Rondot, 1985; Lehmkuhl et al., 1983; Poeck & Lehmkuhl, 1980; Square-Storer, Roy, & Hogg, 1990). In summarizing this literature, Roy (1982) indicates that "evidence does not strongly support the notion that apraxia is a symbolic disorder." (p.271).

A Spatial Disorder

Some investigators describe apraxia as a spatial deficit (Concha, 1987; Luria, 1966). Although the research regarding constructional apraxia has focussed on difficulties in spatial orientation, or problems in perceiving spatial relationships, the nature of this disturbance remains unclear (Roy, 1982; Carlesimo, Fadda, & Caltagirone, 1993).

A Conceptual- Production Disorder

Research suggests that a lesion in many different regions of the brain can affect praxis (Alexander et al., 1992; Roy, 1983a). The left hemisphere appears to be largely, but not exclusively, responsible for praxis (Haaland & Harrington, 1994). Apraxia is usually observed in association with parietal lobe damage, however the frontal and temporal lobes (Faglioni & Basso, 1985; Haaland & Harrington, 1994), as well as subcortical structures (De Renzi, Faglioni, Scarpa, & Crisi, 1986) have also been implicated. Ayres (1985) asserts that the "difficulty in localizing apraxia favours a position that praxis is dependent upon a complex functional system or network involving cortical and subcortical structures." (p.16). This concept of praxis being dependent upon a complex functional system is the basis used in Roy's (1978, 1983a) discussion of a potential mechanism of apraxia.

Roy and colleagues (1978; Square-Storer & Roy, 1989) propose that apraxia may result from disruptions in the conceptual and/ or production systems. The conceptual system refers to the knowledge base for movement, while the production system is responsible for the actual control of movement (Roy & Square, 1994; Square-Storer & Roy, 1989). The brain has highly differentiated areas that are interdependent, thus forming a complex functional system (Roy, 1983b). Lesions in any part of the system may result in apraxia (Roy, 1983b).

A Movement Disorder

Kelso & Tuller (1981) describe apraxia as a movement disorder in which lesions disrupt supraspinal control of the brain stem and spinal cord. A disturbance in supraspinal control is thought to prevent the individual from assuming the appropriate postures for the movement performance. The motor system is described as a heterarchy "characterized by reciprocity of function" (Kelso & Tuller, 1981, p.229). 'Reciprocity of function' implies that different components within the motor system perform different roles depending on the demands of the activity. Control is exercised based on an interaction between the individual performing the movement and the environment. Apraxia is thus related to the individual's inability to adequately interact with the environment.

None of the mechanisms described above are able to totally account for the performance difficulties demonstrated by clients with apraxia (Platz & Mauritz, 1995; Roy, 1978). However, they can guide our thinking during assessment and intervention by providing a framework of areas of potential performance breakdown.

Considering apraxia as a conceptual-production disorder enables clinicians to classify motor performance into the components of motor planning and motor execution. Intervention can then be customized to address specific errors. For example, an individual whose conceptual system appears to be impaired may be encouraged to use a cognitive strategy, such as a goal-oriented verbal strategy to talk him/herself through a task (Pilgrim & Humphreys, 1994).

Consistent with the movement disorder approach, Fraser & Turton (1986) advise that occupational therapists should be "less concerned with localizing lesions in the brain and more concerned with how the central nervous system processes information from the environment." (p.248). The description of apraxia as a movement disorder, with its environmental influence on performance, meshes well with occupational therapists' recognition of the crucial role that the environment plays in enabling occupational performance (CAOT, 1991).

Errors in the Performance of Purposeful Movement

Researchers suggest that a clearer understanding of apraxia may develop through the observation of purposeful movement, with an emphasis on recognizing and describing the types of errors evident in performance (Goodgold-Edwards & Cermak, 1990; Haaland & Flaherty, 1984; Square-Storer & Roy, 1989). Errors commonly observed in praxis testing have been examined in a systematic way (Roy, 1982; Roy, Square, Adams, & Friesen, 1985; Square-Storer & Roy, 1989; Quintana, 1995), and there have been a number of attempts to categorize these errors (McDonald et al., 1994; Roy, 1983a; Roy, Brown, & Hardie, 1993; Roy et al., 1985; Schwartz et al., 1993).

Errors in performance can be categorized according to temporal, spatial, postural, action, added movement, sequential and object elements (see Table 1). Although clients with apraxia may present with a variety of execution errors, it appears that perseveration, within the sequential category, and "body part as object" within the object category, are the most common errors (Duffy & Duffy, 1989; Roy et al, 1985; Schwartz et al, 1993). "Body part as object" refers to using a body part as a specific object, rather than performing the gesture posture itself (Duffy & Duffy, 1989; Goodlass & Kaplan, 1963). For example, when asked to pretend to hammer something, a client may hold his/her fist closed, using the fist as a hammer, rather than perform the hand gesture needed to hold the hammer. This notation system guides clinicians in describing detailed performance difficulties and in tailoring interventions to remediate and/or compensate for difficulties discovered.

Classification of Apraxia

Traditional Approaches to Classifying Apraxia

The traditional classification system of apraxia is familiar to occupational therapists working with individuals who have praxis problems. Ideomotor, ideational and constructional apraxia are the most commonly discussed types of apraxia in the literature. It has been argued that these categories include all the symptoms of apraxia (Concha, 1987).

Liepmann described ideational and ideomotor apraxia (as cited in Geschwind, 1975; Roy, 1982). *Ideational* apraxia refers to difficulty in sequencing purposeful movement, and may be caused by a disturbance in the conceptual organization of movement. *Ideomotor* apraxia is an inability to perform purposeful movement tasks, despite being able to conceptualize the task (Goldenburg, 1995; Heilman et al., 1982; Siev, Freishtat, & Zoltan, 1986). Typically, individuals with ideomotor apraxia are able to perform tasks automatically, but are not able to carry out purposeful movement on command (Roy, Elliot, Dewey, & Square-Storer, 1990; Pedretti et al., 1996).

Constructional apraxia is of particular importance to occupational therapists because it has been shown to affect performance in activities of daily living, particularly self-care tasks (Cady Fall, 1987; Titus et al., 1991). Constructional apraxia is described as a perceptual motor deficit, and refers to the inability to organize a number of parts into a whole (Carlesimo et al., 1993; Neistadt, 1989; Pedretti et al., 1996). Impairment is noted in tasks that require recognition of and attention to detail, including the relationships between the subcomponents of a task (Carlesimo et al., 1993). Individuals with constructional apraxia have difficulty constructing designs in two or three-dimensions, and as such may be limited in their ability to engage in occupations that require the use of objects (Siev et al., 1986; Quintana, 1995).

Occupational therapy for persons with apraxia is often based on this traditional apraxia classification system. Assessments are used to determine type of apraxia present (ideational, ideomotor or constructional) and intervention is chosen according to type. Suggestions for remediating ideational apraxia include performing sequencing tasks such as stringing beads or setting a table. Practising the construction of two or three-dimensional designs through the use of puzzles and/or crafts activities is recommended for constructional apraxia (Neistadt, 1988; Pedretti et al., 1996; Siev et al., 1989).

Classifying Apraxia from a Motor Control Perspective

Two recent approaches to classifying apraxia, the 'information-processing' and the 'action system' approach provide thought-provoking, alternative perspectives to the traditional classification system. The 'action system' approach (Roy, 1978; Square-Storer & Roy, 1989), particularly, may enhance therapists' understanding of apraxia and furnish a fresh outlook by providing a valuable initial attempt to explain the underlying processes involved in the disturbance of functional movement.

Information-Processing Approach

Fraser and Turton (1986) take an information-processing approach to classifying apraxia. The importance of determining which part(s) of the information-processing system is/are disrupted when treating a client with apraxia is emphasized. A model of sensori-motor information processing is described, however, the theoretical basis of this model is unclear as no previous work is cited. Unfortunately, Fraser and Turton's (1986) work appears to provide an oversimplified view of potential mechanisms, and little empirical evidence to support the discussion of information processing.

Action System Classification

Roy (1978) first addressed the need to reconsider apraxia. He indicated that while the majority of previous research provid-

Table 1
Categorizing errors: A description of difficulties observed in individuals with apraxia

Category of Error	Examples of Errors within the Category
1. Temporal	• rate of movement • temporal coordination of the subcomponents of the movement • problems initiating movements/delays
2. Spatial	• orientation • spatial targeting
3. Postural	• hand-arm position
4. Action	• clumsiness • augmentation of motor behaviour
5. Added Movement (extraneous movement not related to purposeful movement)	• movement of head during limb gesture
6. No Movement	• no movement observed
7. Sequential	• omissions • faulty sequential organization • perseveration
8. Object	• object misuse • object substitutions • body part as object

Note: Categories 1 and 6 are adapted from Roy, (1985), Roy, Elliott, Dewey and Square - Storer (1990).
Categories 7 and 8 are adapted from Duffy and Duffy (1989), Schwartz et al. (1993).

ed descriptions of apraxia, a true understanding of the nature of apraxia remained elusive.

Roy (1983b) suggests that purposeful movement involves two separate systems, the conceptual and the production systems. Together, these two systems comprise the 'action system'. The conceptual system represents the knowledge of actions (planning), while the production system generates the action (execution) (Roy, 1978, 1983b; Roy & Square, 1994). Apraxia is due to a disruption in the action system responsible for the generation and control of movement (Roy & Square, 1994) and results in a disturbance of skilled motor behaviour. Roy (1978) outlines a classification system that is consistent with his description of motor planning and facilitates an understanding of apraxia.

Overall, background knowledge regarding apraxia is crucial for providing optimal intervention for individuals with apraxia. In particular, Roy and his colleagues' work regarding the action system and the error/movement notation system assists clinicians in describing how and when performance breaks down. With a thorough understanding of the performance difficulties the individual has, the therapist is better able to choose intervention strategies aimed at ameliorating performance and/or compensating for limitations.

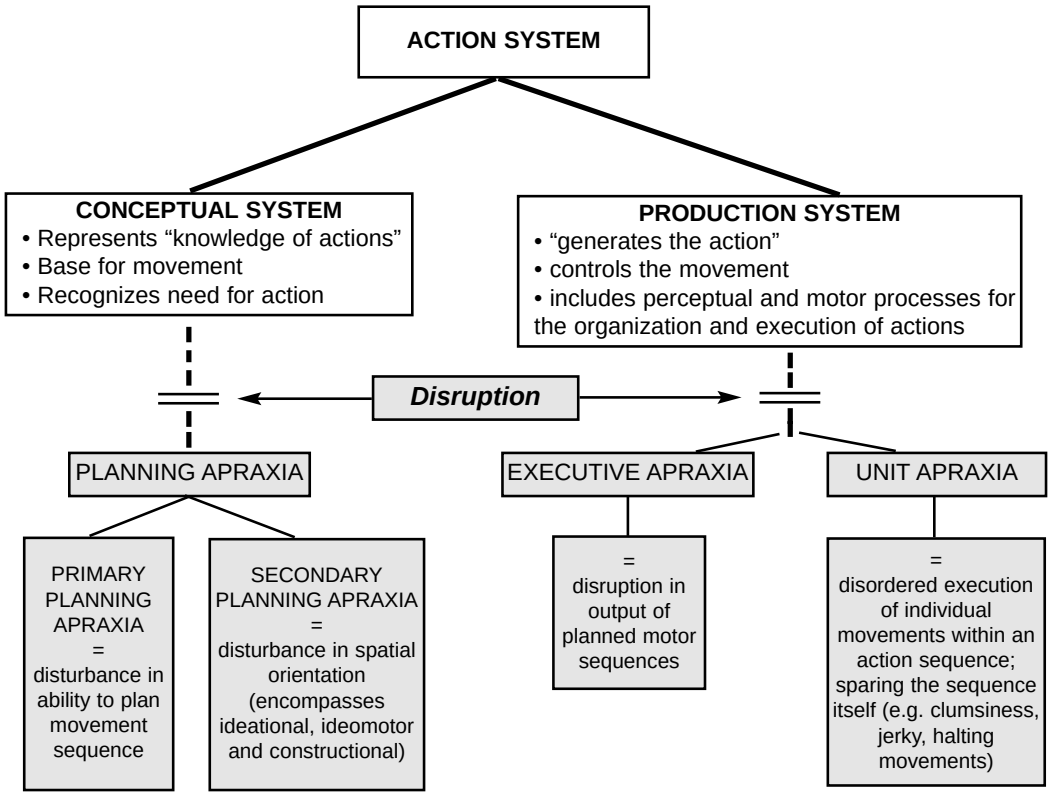
Implications for Occupational Therapy

Individuals with praxis problems encounter a number of possible difficulties when attempting to meaningfully and successfully engage in occupation. Through detailed evaluation, planning and implementing effective intervention, and involving the client throughout the therapeutic process, occupational therapists may enable occupational competence in individuals with apraxia.

Assessment

Effective and efficient evaluation of apraxia is extremely difficult. Traditionally, praxis has been evaluated by asking the client to perform actions (usually gesture performance) in response to verbal command, imitation, or through actual object use (De Renzi et al., 1982; Heilman & Gonzalez Rothi, 1993). In the literature, verbal command, imitation and object use are referred to as separate 'modalities' (Roy et al., 1991). The modalities are hierarchically organized with the most abstract, performance on command, being attempted first and the most concrete, actual object use, attempted at the end of the assessment. First, the client is asked to perform an activity on command. If he or she is unable to do so, he or she is

Figure 1
A diagram of the action system subserving praxis and apraxia, based on work by Roy and colleagues (Roy, 1978, 1983b, Roy & Square, 1994).



asked to imitate another individual's actions. Finally, if the client is unable to imitate, he or she is given the object with which the action corresponds, and asked to perform the task. Each response is scored based on the quality of the response, including errors observed during performance.

Praxis testing also involves performing different types of gestures including; transitive, intransitive, representational and nonrepresentational gestures (Neiman, Duffy, Belanger, & Coelho, 1994; Rapcsak, Ochipa, Beeson, & Rubens, 1993). Transitive gestures involve object use (ex. using a hammer), and intransitive gestures express ideas (eg. waving goodbye) (Heilman & Gonzalez Rothi, 1993; Quintana, 1995). Representational or symbolic movements include transitive and intransitive gestures that are meaningful (eg. drinking from a cup; performing a salute), while non-representational or non-symbolic movements have no inherent meaning (eg. tapping fist on opposite shoulder) (De Renzi, Motti, & Nichelli, 1980; Faglioni et al., 1990; Quintana, 1995).

Recently, discrimination and comprehension/ recognition of gestures have been added to testing for complete praxis evaluation (Draves York & Cermak, 1995; Heilman & Gonzalez Rothi, 1993). Discrimination of gestures involves asking the client to classify another individual's performance on specific tasks as well-performed or poorly performed, while comprehension is assessed by asking the client to indicate which object corresponds to a pantomimed gesture (Draves York & Cermak, 1995; Gonzalez Rothi & Heilman, 1985). In addition to actual performance, gesture discrimination and comprehension/recognition may be influenced by apraxia, therefore, assessment of each area is important to gain a full understanding of the client's impairment. Many of the tests used to evaluate praxis, including Benton's Three-dimensional Constructional Praxis Test and the Goodglass Test for Apraxia are available in a text by Siev et al. (1986).

Constructional praxis testing involves copying two or three-dimensional designs from an actual model or a pictorial representation, using a pen and paper, matchsticks or block designs (Carlesimo et al., 1993; Grossi, Orsini, & Modafferi, 1986; Cady Fall, 1987; Siev et al., 1986). Some researchers claim that evaluations of both two and three-dimensional activities are needed to detect constructional apraxia (Benton, 1979). However, Baum and Hall (1981) suggest that the existence of constructional apraxia can be determined by either assessment. Of primary importance for clinicians, scores on

constructional praxis tests correlate with scores on activities of daily living scales; most functional tasks require intact constructional praxis (Cady Fall, 1987; Titus et al., 1991; Warren, 1981).

The problem with determining apraxia by structured testing in isolation, is that there may not be strong correlations between formal test results and occupational performance tasks that are important to the individual. Occupational analysis of performance errors will provide the therapist with a means of grading tasks, and adapting the environment to help engage the client in challenging, yet achievable occupations (Concha, 1987; Draves York & Cermak, 1995; Holden, 1988; Magill, 1993; Okkema, 1993). Observing the client engaged in occupation should include an evaluation of the client's ability to sequence during well-learned and novel tasks, perseveration and/or difficulties in initiating purposeful movement, performance of spontaneous gestures in a proper context, and use of objects such as a razor, or utensils (Okkema, 1993). Documenting the errors observed during the performance of these tasks may lead to identification of specific methods for improving occupational performance, such as providing visual cues to facilitate sequencing.

Consequently, comprehensive praxis testing should involve formal assessments, including an evaluation of the recognition, discrimination and production of purposeful movement, as well as observation of the client engaged in occupation. The clinician can use the information gained to facilitate changes in the client's responses and to restructure the environment for successful interaction (Draves York & Cermak, 1995; Heilman & Gonzalez Rothi, 1993; Pedretti & Umphred, 1996; Roy & Hall, 1992). Evaluating praxis will also enable clinicians to determine baseline performance for their clients prior to intervention, and provide a means for monitoring progress (Titus et al., 1991).

Intervention

Research regarding apraxia has focussed on evaluation, with little information available regarding the efficacy or outcome of the various interventions used to address praxis problems (Draves York & Cermak, 1995; Heilman & Gonzalez Rothi, 1993). Despite the paucity of research related to the treatment of apraxia, the field of motor control may provide some guidance (Burgess, 1989; Turton & Fraser, 1988). Some recommended interventions include: using appropriate methods of providing instructions, providing opportunities for repetition, and varying the practice demands and conditions (Draves York & Cermak, 1995; Jarus, 1994; Magill, 1993), multi sensory cueing (Concha, 1987; Draves York & Cermak, 1995; Okkema, 1993), therapeutic guiding and modelling (Davies, 1994; Holden, 1988; Pedretti & Umphred, 1996), visualization (Magill, 1993; Roy & Hall, 1992; Siev et al., 1986), and teaching compensatory strategies, such as goal-oriented verbal strategies (Pilgrim & Humphreys, 1994)

Instructions provided to individuals with praxis problems should be clear, and concise (Pedretti et al., 1996; Siev et al., 1986), and should reflect evaluation results. For example, if the client's ability to discriminate between well performed and poorly performed tasks is impaired, modelling engagement in a task (eg. combing hair) may not benefit the client's (re)learning. Conversely, step by step verbal instruction and physical guidance of the client executing an occupation should lead to a more successful outcome.

Consistent with current thinking in occupational therapy, it is suggested that performing functional activities within the context in which they are normally performed is important for learning and carry over into everyday life (Okkema, 1993; Roy et al., 1990). Regarding the issue of using functional tasks (occupation) versus remedial activities, research seems to indicate that there is little carry over or generalization from remedial activities to occupation (Neistadt, 1988; Toglia, 1991; Quintana, 1995). Use of different cues (including contextual, auditory, visual, and tactile) seems to provide multiple sources of information to the individual, helping guide them in choosing the most appropriate motor response (Draves York & Cermak, 1995; Concha, 1987; Okkema, 1993). Therefore, if the client's goal is to (re)learn how to make a cup of coffee, therapeutic intervention involving making coffee will lead to a more successful outcome than a sequencing activity such as piecing different parts of a story together.

Occupational therapists should focus on assisting clients to develop personal strategies for effective interaction with the environment (Sabari, 1991). Verbal guidance, modelling, and visualization have been described as methods to help clients to improve performance (Davies, 1994; Holden, 1988; Pedretti & Umphred, 1996). Goal-oriented verbal strategies involve breaking down tasks into their component parts, then performing each part in sequence while talking oneself through the process (Pilgrim & Humphreys, 1994). Modelling the desired movement has been found to be a better way to illustrate performance than using verbal description or pictorial representation alone (Holden, 1988). Visualization or imagining performance prior to task performance may elicit motor learning or improve motor control (Magill, 1993; Poole, 1991; Roy & Hall, 1992; Siev et al., 1986).

Combining different modalities often assists performance of individuals with apraxia (Holden, 1988; Pedretti & Umphred, 1996). It should be emphasized, however, that the efficacy of interventions in addressing praxis problems has not been definitively established (Draves, York & Cermak, 1995; Heilman & Gonzalez Rothi, 1993; Quintana, 1995).

Conclusion

Understanding apraxia and its effect on occupational performance is important for clinicians working with individuals who are neurologically impaired, because praxis problems may be significant impediments to successful occupational engagement. Most functional activities require effective planning and performance of purposeful sequenced movements, thus apraxia can be devastating to an individual's ability to positively interact with the environment. A review of the classification system and types of errors noted in individuals with apraxia can provide guidance to occupational therapists, and should result in improved outcomes for individuals with apraxia.

References

Alexander, M.P., Baker, E., Naeser, M.A., Kaplan, E., & Palumbo, C. (1992). Neuropsychological and neuroanatomical dimensions of ideomotor apraxia. *Brain, 115,* 87-107.

Ayres, A.J. (1985). *Developmental dyspraxia and adult-onset apraxia.* Torrance, CA: Sensory Integration International.

Baum, B., & Hall, K.M. (1981). Relationship between constructional praxis and dressing in the head-injured adult. *American Journal of Occupational Therapy, 35,* 438-442.

Benton, A.L. (1979). Visuoperceptive, visuospatial, and visuoconstructive disorders. In K.M. Heilman & E. Valenstein (Eds.), *Clinical Neuropsychology* (pp. 151-186). New York: Oxford University Press.

Burgess, M.K. (1989). Motor control and the role of occupational therapy: Past, present, and future. *American Journal of Occupational Therapy, 43,* 345-348.

Cady Fall, C. (1987). Comparing ways of measuring constructional praxis in the well elderly. *American Journal of Occupational Therapy, 41,* 500-504.

Canadian Association of Occupational Therapists. (1991). *Occupational therapy guidelines for client-centred practice.* Toronto, ON: CAOT Publications ACE.

Carlesimo, G.A., Fadda, L., & Caltagirone, C. (1993). Basic mechanisms of constructional apraxia in unilateral brain-damaged patients: Role of visuo-perceptual and executive disorders. *Journal of Clinical and Experimental Neuropsychology, 15,* 342-358.

Concha, M.E. (1987). A review of apraxia. *British Journal of Occupational Therapy, 50,* 222-226.

Davies, P.M. (1994). *Starting again: Early rehabilitation after traumatic brain injury or other severe brain lesion.* New York: Springer-Verlag.

De Renzi, E., Faglioni, P., Scarpa, M., & Crisi, G. (1986). Limb apraxia in patients with damage confined to the left basal ganglia and thalamus. *Journal of Neurology, Neurosurgery, and Psychiatry, 49,* 1030-1038.

De Renzi, E., Faglioni, P., & Sorgato, P. (1982). Modality-specific and supramodal mechanisms of apraxia. *Brain, 105,* 301-312.

De Renzi, E., Motti, F., & Nichelli, P. (1980). Imitating gestures: A quantitative approach to ideomotor apraxia. *Archives of Neurology, 37,* 6-10.

Draves York, C., & Cermak, S.A. (1995). Visual perception and praxis in adults after stroke. *American Journal of Occupational Therapy, 49,* 543-550.

Duffy, R.J., & Duffy, J.R. (1989). An investigation of body part as object (BPO) responses in normal and brain-damaged adults. *Brain and Cognition, 10,* 220-236.

Faglioni, P., & Basso, A. (1985). Historical perspectives on neuroanatomical correlates of limb apraxia. In E.A. Roy (Ed.), *Neuropsychological studies of apraxia and related disorders* (pp.3-44). Amsterdam: North-Holland.

Faglioni, P., Basso, A., Botti, C., Aglioti, S., & Saetti, C. (1990). Gesture Learning and apraxia. In M. Jeannerod (Ed.), *Attention and Performance XIII* (pp. 837-856). Hillsdale, NJ: Erlbaum.

Foundas, A.L., Henchey, R., Gilmore, R.L., Fennell, E.B., & Heilman, K.M. (1995). Apraxia during Wada testing. *Neurology, 45,* 1379-1383.

Fraser, C.M., & Turton, A. (1986). The development of the Cambridge Apraxia Battery. *British Journal of Occupational Therapy, 49,* 248-252.

Geschwind, N. (1975). The apraxias: Neural mechanisms of disorders of learned movement. *American Scientist, 63,* 188-195.

Goldenberg, G. (1995). Imitating gestures and manipulating a mannikin: The representation of the human body in ideomotor apraxia. *Neuropsychologia, 33,* 63-72.

Gonzalez Rothi, L.J., & Heilman, K.M. (1985). Ideomotor apraxia: Gestural discrimination, comprehension and memory. In E.A. Roy (Ed.), *Neuropsychological studies of apraxia and related disorders* (pp. 65-74). Amsterdam: North-Holland

Gonzalez Rothi, L.J., Heilman, K.M., & Watson, R.T. (1985). Pantomime comprehension and ideomotor apraxia. *Journal of Neurology, Neurosurgery, and Psychiatry, 48,* 207-210.

Goodglass, H., & Kaplan, E. (1963). Disturbances of gesture and pantomime in aphasia. *Brain, 86,* 703-720.

Goodgold-Edwards, S.A., & Cermak, S.A. (1990). Integrating motor control and motor learning concepts with neuropsychological perspectives on apraxia and developmental dyspraxia. *American Journal of Occupational Therapy, 44,* 431-439.

Grossi, D., Orsini, A., & Modafferi, A. (1986). Visuoimaginal constructional apraxia: On a case of selective deficit of imagery. *Brain and Cognition, 5,* 255-267.

Haaland, K.Y., & Flaherty, D. (1984). The different types of limb apraxia errors made by patients with left or right hemisphere damage. *Brain and Cognition, 3.* 370-384.

Haaland, K.Y., & Harrington, D.L. (1994). Limb-sequencing deficits after left but not right hemisphere damage. *Brain and Cognitive, 24,* 104-122.

Harrington, D.L., & Haaland, K.Y. (1992). Motor sequencing with left hemisphere damage: Are some cognitive deficits specific to limb apraxia? *Brain, 115,* 857-874.

Hecaen, H., & Rondot, P. (1985). Apraxia as a disorder of a system of signs. In E.A. Roy (Ed.), *Neuropsychological studies of apraxia and related disorders* (pp.75-97). Amsterdam: North-Holland.

Heilman, K.M. (1979). Apraxia. In K.M. Heilman & E. Valenstein (Eds.), *Clinical Neuropsychology* New York: Oxford University Press.

Heilman, K.M., & Gonzalez Rothi, L.J. (1993). Apraxia. In K.M. Heilman & E. Valenstein (Eds.), *Clinical Neuropsychology* (3rd ed.,) (pp. 141-163.) New York: Oxford University Press.

Heilman, K.M., Rothi, L.J., & Valenstein, E. (1982). Two forms of ideomotor apraxia. *Neurology, 32,* 342-346.

Holden, U. (1988). Management, rehabilitation and retraining. In U. Holden (Ed.), *Neuropsychology and ageing: Definitions, explanations and practical approaches* (pp. 193-207). London: Croom Helm.

Jarus, T. (1994). Motor learning and occupational therapy: The organization of practice. *American Journal of Occupational Therapy, 48,* 810-816.

Kelso, J.A.S., & Tuller, B. (1981). Toward a theory of apractic syndromes. *Brain and Language, 12,* 224-245.

Lehmkuhl, G., Poeck, K., & Willmes, K. (1983). Ideomotor apraxia and aphasia: An examination of types and manifestations of apraxic symptoms. *Neuropsychologia, 21,* 199-212.

Luria, A.R. (1966). *Higher cortical functions in man.* New York: Basic Books.

Magill, R.A. (1993). *Motor learning: Concepts and applications* (4th ed.). Madison, WI: WCB Brown & Benchmark.

McDonald, S., Tate, R.L., & Rigby, J. (1994). Error types in ideomotor apraxia: A qualitative analysis. *Brain and Cognition, 25,* 250-270.

Neiman, M.R., Duffy, R.J., Belanger, S.A., & Coelho, C.A. (1994). Concurrent validity of the Kaufman Hand Movement Test as a measure of limb apraxia. *Perceptual and Motor Skills, 79,* 1279-1282.

Neistadt, M.E. (1988). Occupational therapy for adults with perceptual deficits. *American Journal of Occupational Therapy, 42,* 434-440.

Neistadt, M.E. (1989). Normal adult performance on constructional praxis training tasks. *American Journal of Occupational Therapy, 43,* 448-455.

Okkema, K. (1993). C*ognition and perception in the stroke patient: A guide to functional outcomes in occupational therapy.* Gaithersburg, MD: Aspen.

Paillard, J. (1982). *Apraxia and the neurophysiology of motor control. Philosophical Transactions of the Royal Society of London, B298,* 111-134.

Papagno, C., Della Sala, S., & Basso, A. (1993). Ideomotor apraxia without aphasia and aphasia without apraxia: the anatomical support for a double dissociation. *Journal of Neurology, Neurosurgery, and Psychiatry, 56,* 286-289.

Pedretti, L.W., & Umphred, D.A. (1996). Motor learning and teaching activities in occupational therapy. In L.W. Pedretti (Ed.), *Occupational therapy: Practice skills for physical dysfunction* (4th ed., pp. 65-75). St. Louis, MO: Mosby-Year Book.

Pedretti, L.W., Zoltan, B., & Wheatley, C.J. (1996). Evaluation and treatment of perceptual and perceptual motor skills. In L.W. Pedretti (Ed.), *Occupational therapy: Practicie skills for physical dysfunction* (4th ed., pp. 235-239). St. Louis, MO: Mosby-Year Book.

Pilgrim, E., & Humphreys, G.W. (1994). Rehabilitation of a case of ideomotor apraxia. In M.J. Riddoch & G.W. Humphreys (Eds.), *Cognitive Neuropsychology and Cognitive Rehabilitation* (pp. 271-285). Hove, England: Lawrence Erlbaum.

Platz, T., & Mauritz, K.H. (1995). Human motor planning, motor programming, and use of new task-relevant information with different apraxic syndromes. *European Journal of Neuroscience, 7,* 1536-1547.

Poeck, K., & Lehmkuhl, G. (1980). Ideatory apraxia in a left-handed patient with right-sided brain lesion. *Cortex, 16,* 273-284.

Poole, J.L. (1991) Application of motor learning principles in occupational therapy. *American Journal of Occupational Therapy, 45,* 531-537.

Quintana, L.A. (1995). Evaluation of perception and cognition. In C.A. Trombly (Ed.), *Occupational therapy for physical dysfunction* (4th ed., pp. 202-203, 211-216). Baltimore, MD: Wilkins & Williams.

Rapcsak, S.Z., Ochipa, C., Beeson, P.M., & Rubens, A.B. (1993). Praxis and the right hemisphere. *Brain and Cognition, 23,* 181-202.

Riddoch, M.J., Humphreys, G.W., & Bateman, A. (1995). Cognitive deficits following stroke. *Physiotherapy, 81,* 465-473.

Roy, E.A. (1978). Apraxia: A new look at an old syndrome. *Journal of Human Movement Studies, 4,* 191-210.

Roy, E.A. (1982). Action and performance. In A. Ellis (Ed.), *Normality and pathology in cognitive functions* (pp. 265-298). London: Academic Press.

Roy, E.A. (1983a). Current perspectives on disruptions to limb praxis. *Physical Therapy, 63,* 1998-2003.

Roy, E.A. (1983b). Neuropsychological perspectives on apraxia and related action disorders. In R.A. Magill (Ed.), *Advances in Psychology: Volume 12. Memory and Control of Action* (pp. 293-320). Amsterdam: North-Holland.

Roy, E.A., Brown, L., & Hardie, M. (1993). Movement variability in limb gesturing: Implications for understanding apraxia. In K. Newell & D. Corcos (Eds.), *Variability and motor control* (pp. 449-473). Champaign, IL: Human Kinetics Press.

Roy, E.A., Brown, L., Winchester, T., Square, P., Hall, C., & Black, S. (1993). Memory processes and gestural performance in apraxia. *Adapted Physical Activity Quarterly, 10,* 293-311.

Roy, E.A., Elliott, D., Dewey, D., & Square-Storer, P. (1990). Impairments to praxis and sequencing in adult and developmental disorders. In M. Bard, M. Fleury & L. Hay (Eds.), Development of Eye Hand *Coordination Across the Lifespan* (pp.358-384). Columbia, South Carolina: University of South Carolina Press.

Roy, E.A., & Hall, C. (1992). Limb apraxia: A process approach. In L. Proteau & D. Elliott (Eds.), *Vision and motor control* (pp.261-282). Amsterdam: North-Holland.

Roy, E.A., & Square, P.A. (1994). Neuropsychology of movement sequencing disorders and apraxia. In D. Zaidel (Ed.), *Neurospsychology* (pp.183-211). New York: Academic Press.

Roy, E.A., Square, P.A., Adams, S., & Friesen, H. (1985). Error/ Movement notation systems in apraxia. Recherches Semiotiques/ *Semiotics Inquiry, 5,* 402-412.

Roy, E.A. & Square-Storer, P.A. (1990). Evidence for common expressions of apraxia. In G.E. Hammond (Ed.), *Cerebral Control of Speech and Limb Movements* (pp. 477-502). Amsterdam: Elsevier Science.

Roy, E.A., Square-Storer, P., Hogg, S., & Adams, S. (1991). Analysis of task demands in apraxia. *International Journal of Neuroscience, 56,* 177-186.

Sabari, J.S. (1991). Motor learning concepts applied to activity-based intervention with adults with hemiplegia. *American Journal of Occupational Therapy, 45,* 523-530.

Schmidt, R.A. (1982). *Motor control and learning: A behavioural emphasis.* Champaign, IL: Human Kinetics Publishers.

Schwartz, M.F., Mayer, N.H., Fitzpatrick DeSalme, E.J., & Montgomery, M.W. (1993). Cognitive theory and the study of everyday action disorders after brain damage. *Journal of Head Trauma*

Rehabilitation, 8, 59-72.

Siev, E., Freishtat, B., & Zoltan, B. (1986). *Perceptual and cognitive dysfunction in the adult stroke patient* (Rev. ed.). Thorofare, NJ: Slack.

Sirigu, A., Cohen, L., Duhamel, J-R., Pillon, B., Dubois, B., & Agid, Y. (1995). A selective impairment of hand posture for object utilization in apraxia. *Cortex, 31,* 41-55.

Square-Storer, P., & Roy, E.A. (1989). The apraxias: Commonalities and distinctions. In P. Square-Storer (Ed.), *Acquired apraxia of speech in aphasic adults: Theoretical and clinical issues* (pp.20-63). New York: Taylor & Francis.

Square-Storer, P. A., & Roy, E.A. (1990). The dissociation of aphasis from apraxia of speech, ideomotor limb, and buccofacial apraxia. In G.E. Hammond (Ed.), *Cerebral control of speech and limb movements* (pp. 451-476). Amsterdam: Elsevier Science.

Titus, M.N.D., Gall, N.G., Yerxa, E.J., Roberson, T.A., & Mack, W. (1991). Correlation of perceptual performance and activities of daily living in stroke patients. *American Journal of Occupational Therapy, 45,* 410-418.

Toglia, J.P. (1991). Generalization of treatment: A multicontext approach to cognitive perceptual impairment in adults with brain injury. *American Journal of Occupational Therapy, 45,* 505-516.

Turton, A.J., & Fraser, C.M. (1988). A test battery to measure the recovery of voluntary movement control following stroke. *British Journal of Occupational Therapy, 51,* 11-14.

Warren, M. (1981). Relationship of constructional apraxia and body scheme disorders to dressing performance in adult CVA. *American Journal of Occupational Therapy, 35,* 431-437.

Woodson, A.M. (1995). Stroke. In C.A. Trombly (Ed.), *Occupational therapy for physical dysfunction* (4th ed.,) (pp. 686-687). Baltimore, MD: Wilkins & Williams.