The Functional Repertoire of the Hand and Its Application to Assessment

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• hand therapy
• injury
• manual skills

Functional assessment of the hand typically involves evaluation of proficiency using a test battery rather than identifying the range of hand skills available to a client. Establishing a client's hand function by reference to the movement repertoire of his or her fully-functioning hand offers numerous benefits for clinicians and researchers. A functional repertoire model of the hand is proposed as a framework for guiding assessment and therapy. The model identifies four main components relating to hand function: personal constraints, hand roles, hand actions, and task parameters. The model provides a common language for assessment, program development, and research across populations. Application here is to hand-injured clients, but the framework is equally valuable for hand function assessment of developmentally and physically challenged individuals, persons with neuromuscular disorders, or geriatric populations.

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A diverse range of clients undergo functional hand assessments, conducted by various professionals in the medical and health care fields, for a variety of reasons. Hand assessment can include the following: evaluating the severity of hand and upper-extremity injury, neurological events or diseases; evaluating baseline for outcome measures; screening for therapy program entry, return to work, or job placement; developing a therapy program; documenting developmental shifts; evaluating capability for independent living; or simply comparing the performance capabilities of the right and left hand in a research study (Baxter-Petralia, Bruening, Blackmore, & McEntee, 1990; Falconer et al., 1991; Greer & Lockman, 1998; Provins, 1997; Schultz-Johnson, 1995; Shahar, Kizony, & Nota, 1998; Swanson, De Groot Swanson, & Goetran-Hagert, 1995).

As a result of these diverse client needs, hand assessment is addressed from several different professional perspectives in health care: physical, occupational and hand therapy, neuroscience, and clinical psychology. The study of hand skills is also of interest, however, in the fields of motor learning and control, motor development, developmental psychology, and more recently, ergonomics and robotics (Corbetta & Thelen, 1994; Mackenzie & Iberall, 1994; Scott & Marcus, 1991; Shumway-Cook & Woollacott, 2001).

A critical component in all of the above contexts is functional assessment. Whereas there is agreement on the need and importance of *functional* assessment, no consensus exists on what the term means. The term functional assessment is applied to a broad range of assessment procedures and is often used inconsistently. What is being measured when one assesses "function"? An assessment can focus on impairment (Swanson et al., 1995), be work-oriented and emphasize the evaluation of functional capacity (Schultz-Johnson, 1995), or target the ability to function in daily life (Falconer et al., 1991; Fisher, 1992).

The role of the occupational therapist or the hand therapist who assesses hand function is to delineate functional abilities, limitations, and activities within a meaningful and purposeful context. Such an evaluation is intimately tied to occupation, goal-directed activity (Fisher, 1992) and client interest. A client-centered approach enables the therapist to prepare an appropriate treatment plan and help the client return to an optimal level of functioning across life tasks.

A functional assessment typically consists of an examination of the physical status of the hand and upper extremity, followed by a combination of standardized tests and a variety of nonstandardized activities of daily living (ADL) or structured activities representing the physical demands of target jobs (Schultz-Johnson, 1995). Typically, the clinician identifies the domains to assess and then chooses a test or test battery that claims to assess the domains of interest and has sound psychometric properties (Rudman & Hannah, 1998).

The quantitative documentation of test results may be accompanied by qualitative descriptions of how the client performs the tasks based on the therapist's observations during testing. While these qualitative evaluations give important additional information about the client's ability to function, they are seldom systematic and standardized. Some assessment tools have attempted to formally structure the qualitative aspect (e.g., Movement ABC [Henderson & Sugden, 1992], Test Evaluant les members Supèrieurs des Personnes Ageès, TEMPA [Desroisiers, Hebert, Dutil, & Bravo, 1993]).

Need for a Comprehensive Theoretical Model of Hand Function

A number of issues related to functional assessment have been raised in the literature, including the following: the need to standardize terminology, the inadequacy of the cafeteria approach to selecting test items, the appropriateness of test protocol and measurement interpretation, and the extent of the relationship of test performance to functional application (Fisher, 1992; Kane & Kane, 1981; LaStayo & Hartzel, 1999; Shahar et al., 1998; Swanson et al., 1995). However, a more fundamental issue, which is not addressed, is the absence of a comprehensive solid theoretical foundation for functional hand assessment. A number of different approaches to assessment are available, each designed from a particular theoretical orientation, for a specific context. Detailed anatomical check lists (Swanson et al.) identify the exact site and extent of injury but such lists do not describe the remaining hand functions. Physical demands approaches (e.g., Baxter-Petralia et al., 1990) evaluate work capabilities by listing a series of physical actions that are job related.

Another approach is to simply address hand function generically by the evaluation of "manipulation skills," "eye–hand coordination," or "dexterity." Standardized tests (such as the Minnesota Rate of Manipulation Test [MRMT]) [American Guidance Service, 1969] or the Purdue Pegboard Test [Tiffin, 1968]) are administered to represent these broad capabilities, as opposed to identifying the specific hand skills inherent in the performance of these tests. While criteria for selection and evaluation of instruments can be found in the literature (Rudman & Hannah, 1998), it is not always self-evident what specific functional hand skills these tests represent. Test results on the MRMT, the Purdue Pegboard Test, and other standardized tests (such as the O'Connor Dexterity Tests [Hines & O'Connor, 1926]; Jebsen-Taylor Hand Function Test [Jebsen, Taylor, Trieschmann, Trotter, & Howard, 1969]) are compared to population norms and may be viewed as representing some general ability of the hand to function effectively or ineffectively in a work or daily living environment. The resulting time scores document test performance but, by themselves, do not describe an individual's complex and diverse functional hand skill repertoire.

Models of the hand, and the underlying neural network, can be found in the neuroscience, motor control, and robotics literature (Mackenzie & Iberall, 1994; Shumway-Cook & Woollacott, 2001; Wing, Haggard, & Flanagan, 1996). These models focus primarily on explaining how the movement of the hand is controlled and programmed, not on assessing function. While these models are of theoretical interest to the therapist in understanding the neural basis of hand control and the disruption in control resulting from central nervous system damage, they are not directly applicable to the practical task of carrying out a functional hand assessment.

The purpose of this article is to propose a comprehensive theoretical model of the functional repertoire of the hand to serve as a knowledge base to guide the assessment process and the development of a therapy program. The conceptual framework has been developed from an integration of theory on skill acquisition and task analysis from motor development, motor learning and control and from extensive professional experience observing and assessing children, healthy young adults, and clinical populations of injured workers. The model is rooted in a developmental approach to hand skill acquisition. The different layers of the model represent the increasing complexity of hand skills acquired by the individual through maturation and experience. A task analysis approach has been taken from motor learning. Skill components are identified in order to understand the difficulties inherent in skill learning and the need to adapt the skill to a variety of contexts. From motor control theories we incorporate an appreciation of the many interacting systems that affect hand function, by laying the foundation of the model on the existing capabilities and limitations of the individual's musculoskeletal and neurological systems and his or her psychological status.

The resulting model or framework is a pragmatic one, designed to help the therapist evaluate the selection of assessment and therapy tools. It can be used to carry out a task analysis of the work or ADL demands facing the client, to evaluate what hand functions the available assessment tools actually assess, and to select a test battery of standardized and nonstandardized tasks accordingly. Rather than simply compiling a set of scores, a complete profile of the client's hand skill repertoire can be generated. This profile can then be used to select therapy tasks based on the functional capabilities that need to be developed, identify return to work or daily life limitations or design support devices. This approach is compatible with the current task-oriented approach to intervention (e.g., Shumway-Cook & Woollacott, 2001). The emphasis is not on the performance of a specific task (such as the placing task in the MRMT) but rather on the client's ability to perform the hand function(s) inherent in the task (in this case, reaching, transporting, and inserting an object repeatedly).

The model is applicable across the developmental life span and can be used with different client populations by a broad range of professionals. However, in this manuscript the model is applied to the functional assessment of clients with hand injuries.

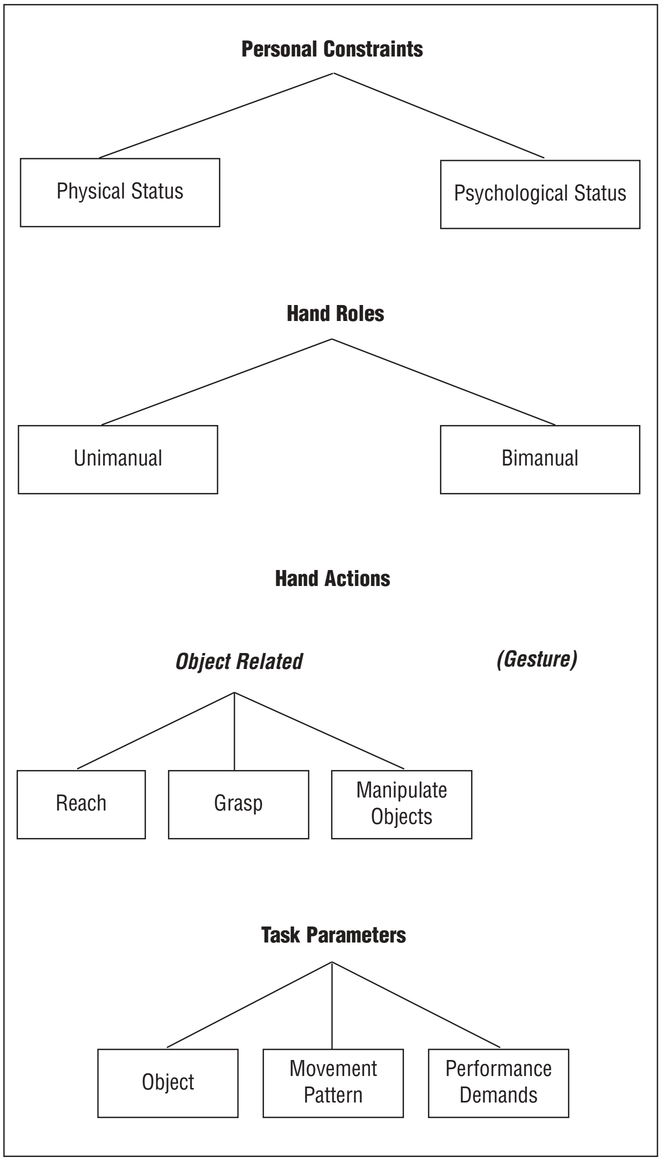

Figure 1. Introduction to the Functional Repertoire of the Hand Model

Introducing the Model

Key Components

The Functional Repertoire of the Hand Model, introduced in Figure 1, can be delineated by four key components: **Personal Constraints, Hand Roles, Hand Actions,** and **Task Parameters.** The first component, **Personal Constraints,** is the starting point of any hand assessment. Both the individual's physical condition and level of functioning of the body and brain and his or her psychological state identify abilities and limits that will affect hand function. The second component, **Hand Roles,** identifies whether one hand is used alone or is capable of different types of collaborative actions with its partner. The majority of assessment procedures focus on the function of one hand, or compare the right to the left hand, while assessment of bimanual function is limited.

The third component, **Hand Actions,** identifies the action capabilities of the human hand. Broadly, these capabilities can be divided into object-related actions and gesturing. The ability to manipulate objects is the central focus of a functional assessment, but it is in this area that a great diversity of language and categories exists. In assessment checklists, one typically finds a list of job-related tasks rather than an analysis of hand action capabilities. Instead, what is proposed here is a clear identification of the reaching, grasping, and manipulating capabilities of the hand. These fundamental actions comprise the hand skills that we apply to carry out many different functions in a variety of contexts, such as dressing, meal preparation, and tool use. Each hand function can be applied in a specific task, for example, buttoning, slicing, and hammering. Evaluation of the initiation and accuracy of reproduction of gestures is an important component in the assessment of certain neurological diseases due to the impact on the individual's communication capabilities. However, doing justice to that broad category of actions goes beyond the scope of this paper, so gestures will not be elaborated further in this paper.

The final component, **Task Parameters,** identifies the task demands. Hand actions are carried out in the context of a specific task with objects of different characteristics, in different movement patterns, and in response to a variety of performance demands. The action categories of reach, grasp, and manipulate identify what the hand(s) can do with objects. The task parameter component of the model, including the categories of object, movement pattern and performance demands, comes from the motor learning literature and represents how skillfully objects are manipulated. These three categories are included to represent the complex demands and potential learning difficulties inherent in the range of ADL and work-related manipulating tasks. An individual's functional hand repertoire thus includes *what* the hands can do and *how well* they perform.

Model Details

Personal Constraints. Figure 2 presents the details of the functional repertoire of the hand. The model starts with the constraints, that is, physical and psychological limitations to hand function. Assessing the **Physical Status** of the hand and upper extremity (typically referred to as physical evaluation, medical or anatomical status, neuromusculoskeletal function, or impairment) is the starting point of any hand assessment (Schultz-Johnson, 1995; Swanson et al., 1995). This is a well-documented area of assessment in the medi-

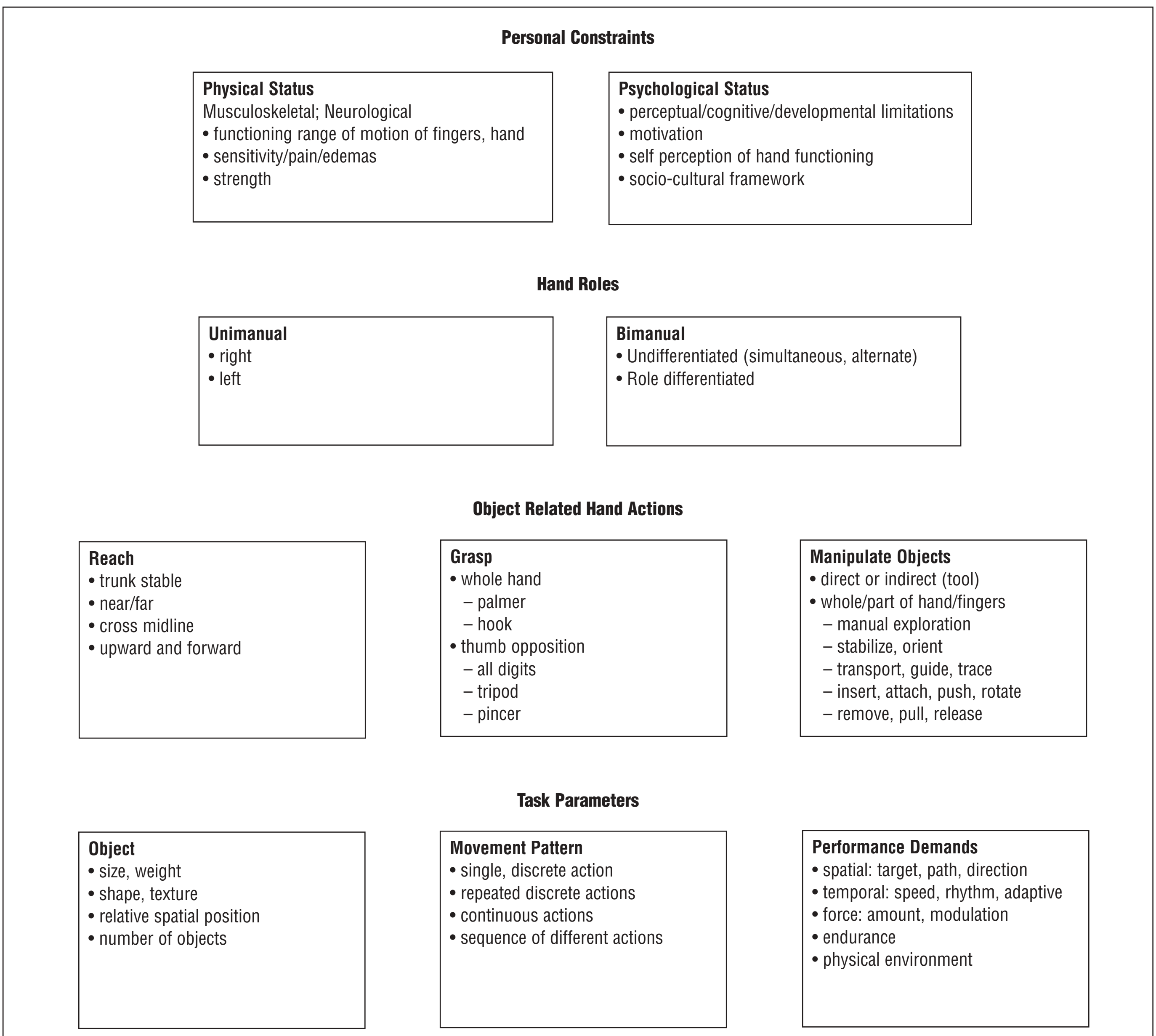

Figure 2. Detailed Model—Functional Repertoire of the Hand

cal literature. Both anatomical and neurological damage will constrain an individual's ability to function. Clearly the absence of digits, restricted range of motion, edema, hyper- or hyposensitivity and pain, along with lack of strength or muscle control and poor trunk and shoulder girdle stability, all set limits on hand function.

These limitations by themselves, however, do not define the person's ability to function. Neither a surgical record of a partial or total amputation of a thumb nor the therapist's report of limited range of motion in the wrist or pain with prolonged activity define the functional capability of the hand. Client X, for example, is missing four digits on the dominant hand, retaining only a functioning thumb. This physical condition typically severely limits object grasping and manipulation capabilities. When assessed, however, the client proves to be quite adept at grasping different objects as well as completing a variety of unimanual and bimanual manipulations. In contrast, client Y, with an intact hand and stiffness and pain in the forefinger, has great difficulty with grasping and manipulating tasks. The physical status of the hand will clearly limit some actions. However, a mathematical calculation, such as an impairment percentage (based on a combination of abnormal motion, amputation and sensory loss, found in Swanson et al., 1995) is just that, a statement of physical impairment. By itself, an impairment percentage does not help to describe a hand function repertoire.

Functional limitations may also be due to **Psychological Factors** that tend to receive less attention than the physical status (Hennigar, Saunders, & Efendov, 2001). A client with cognitive dysfunction, or developmental limitations, for example, may have difficulty with a hand task because of a lack of task comprehension rather than a lack of hand control. Reduced on-task focus in a person with dementia may limit performance of hand skills in ADL. A lack of motivation to produce the best effort during assessment or therapy may also limit performance in some clients. Specific to hand injury clients are factors related to self-efficacy and body image stemming from the trauma of injury and the grieving process associated with loss or damage to a limb (Blue, 1992; Murray, 1982). It is important to consider clients' beliefs in their potential for recovery as well as the presence of cosmetic anxiety, such as the inability to look at the hand after injury. While the client's psychological status is an important consideration, by itself (as is the case with physical status), it does not dictate function, but perhaps limits it.

Hand Roles. Functional assessment often focuses primarily on the dominant hand but it may also be important to test the nondominant hand and establish the extent of asymmetry between the hands. Numerous studies have reported an approximate 90% right hand preference in a variety of population samples (Porac & Coren, 1981). Along with a preference to use the right hand individuals also tend to assume a lack of proficiency in the left hand. However, most individuals are also proficient in a variety of manipulating tasks with the nondominant hand. The degree of proficiency and therefore the amount of asymmetry between the hands depends on the type of task (Kimmerle & Mainwaring, 2000; Provins, 1997; Provins & Glencross, 1968). Assessing the nondominant hand is important, for example, when a severe dominant hand injury has occurred and a dominance transfer is proposed. Realistic performance expectations need to be established for the transfer.

In contrast to unimanual skills, the evaluation of bimanual actions can sometimes be neglected. Bimanual actions represent a complex, highly coordinated skill category that may need to be assessed. The majority of activities of daily living are typically executed bimanually, for example, getting dressed, cooking, eating, and the majority of tool uses. To properly evaluate bimanual skills, it is important to recognize their diversity. We can identify a number of different coordination roles in grasping: both hands grasping one object, such as picking up a heavy pot; each hand grasping an object, such as a knife and fork; and finally, picking up an object in one hand and transferring it to the other hand. The two hands also have a number of different roles to play in object manipulation. The hands can have identical roles as they manipulate objects, either simultaneously, in for example, the placing of two pegs, or alternatively, in the assembly tasks of the Purdue Pegboard Test. Bimanual actions that require equal participation of the hands may be difficult, or impossible, with a severe injury of one hand. Other types of bimanual skills may still be possible however and should be assessed as part of the hand repertoire.

Many ADL tasks involve a different type of coordination, that is, bimanual collaboration or role differentiation. In these tasks, each hand has a different role and carries out a different action, although both collaborate to achieve a common goal. The nondominant hand has an orienting or stabilizing role and the dominant hand carries out the object manipulation role. Opening a jar, slicing bread, using a screwdriver, and buttoning a jacket all illustrate this type of bimanual action. A fully functioning hand repertoire requires competent actions of both hands in a wide variety of tasks, both individually and in collaboration. If bimanual collaboration is limited due to injury, a variety of stabilizing or adaptive aids may be required for ADL tasks such as a device that stabilizes food for slicing. Another option, perhaps functionally more ideal, is to switch roles and have the dominant, injured hand take on the stabilizing role and the noninjured hand the manipulation.

Hand Actions. The hand actions of concern in this paper are object-related actions. These actions are divided into three basic categories: reach, grasp, and manipulation of objects. They represent a developmental progression, with infants initiating voluntary reaching and grasping actions by 4 or 5 months, achieving a relatively mature level by 14 months, but not achieving skillful manipulation until 5 to 8 years (Gabbard, 1996). The three actions also represent a progression in neuromuscular control. The gross-motor, posture stabilizing actions of the upper body and arm in the reach involve different neural pathways and brain centers than those for fine motor, isolated control of the hand and fingers in the grasp and manipulation (Sage, 1984; Shumway-Cook & Woollacott, 2001). With neurological maturation and practical experience using the hand, the infant's limited reaching, grasping, and manipulation skills develop into the increasingly complex and varied repertoire of an adult. Depending on the location and severity of muscular or nerve damage in an injury, incapacity may occur in any one or all three of the hand actions and the client has to relearn or adapt to the lack of these capabilities. Client Z, for example, has intact, isolated, digit control, but due to an injury to the shoulder girdle cannot voluntarily reach. He must physically place his arm and hand on the table, and can then proceed to grasp and manipulate an object.

Of all the components in the model, the hand action category is most in need of clarification, as the categorization and descriptions of hand actions show the greatest variation from one professional to another. With a standardized test approach, the three actions of reach, grasp, and manipulate may be lost as they are sometimes simply collapsed under a general heading such as fine motor control, dexterity, or finger manipulation. The MRMT placing and turning subtests, for example, require the actions of reach, grasp, rotate, transfer, orient, and insert. Any one of these actions, or all of them, may create difficulty. The time recorded may simply be viewed as a measure of hand or finger manipulation, unless the therapist also documents performance with detailed verbal description. At the opposite extreme are detailed descriptions of the many variations of grasping actions that are anatomically possible. (For an extensive review of grasping terminology used in studies from 1919 to 1989, see Mackenzie and Iberall, 1994.)

In some assessment tools, hand actions are not only collapsed but are combined with task parameters. A physical demands approach to hand actions, (e.g., Baxter-Petralia et al., 1990; Schultz-Johnson, 1995) is suited to a job-related assessment, but is limited in describing the hand action repertoire. The physical demands categories are often confounded by task demands, such as the type and weight of the object and whether it has to be performed repeatedly, quickly, or in a sustained fashion. For clarity, in Figure 2 the three hand actions are each presented separately and they are distinguished from task parameters.

Reaching, and the accompanying postural stabilization, is generally not assessed by itself. However, a reaching component is built into many tasks and can be observed and documented if qualitative comments are included. One can observe postural adjustment in reaching across the midline to insert objects (e.g., the MRMT placing subtests) or in repeatedly reaching overhead (e.g., the Valpar Whole Body Range of Motion Work Sample). Even a simple writing task may uncover trunk tilts, rotation, or a forward lean. In many tasks, documenting how the client accomplishes the reaching action is important in assessing postural stresses and inefficiencies that need to be addressed or identifying adaptive strategies that have been developed.

Based on an extensive review of hand studies (Mackenzie & Iberall, 1994), there appears to be no consensus in the large variety of terms used for **grasping** actions, in part due to the variety of objects that can be grasped. The categories of grasp actions in Figure 2, for simplicity, have only two key categories, with subsets, although many variations could be identified. The first category, whole hand, does not require thumb opposition. This is a critical distinction since loss of thumb function severely restricts tool use. The subsets of whole hand are palmar grasp, where an object is grasped by the whole hand or with a scooping action, and hook grasp where only the digits are used, such as grasping a grocery bag. The second category includes all grasps requiring an opposable thumb, with the subsets involving all other digits, two (tripod) or one (pincer). These five subsets represent the typical repertoire of the human hand. There are variations or adaptation of these grasps due to injury, disease, or specific task demands. The exact configuration of a tripod grasp, for example, is dependent on the nature of the object being used. Further subdivision could be built into the model, if one is interested in the variety of grasps used with a writing tool or a paintbrush (Greer & Lockman, 1998), with an industrial tool (Baxter-Petralia et al., 1990), or if one is interested in the adjustment in grasp made according to the type of object to be picked up (Mackenzie & Iberall, 1994). If one is examining bimanual actions, the two hands could have identical grasps (such as a whole hand bimanual grasp on a basketball or thumb opposition grasps on two barbells), or different grasps (e.g., a whole hand grasp with one hand to stabilize an object and a pincer grasp with the other on a small inserting object).

The term **manipulation** is used in the broadest sense here to include any handling of an object and any action on an object. While reaching and grasping actions have been extensively studied and categorized (Mackenzie & Iberall, 1994; Shumway-Cook & Woollacott, 2001; Wing et al., 1996), there does not appear to be a consistent approach to examining manipulations skills. These often are simply classified as "dexterity" or "fine motor control skills" although they include a large variety of possible actions.

When first approaching a novel object the initial manipulation may consist of manual exploration of the object surface to assist with haptic identification of the object (Lederman & Klatzky, 1996). Once an object is grasped a number of actions can occur: The object can be oriented to reveal an attachment point or placed at the correct functional angle; pressure can be applied to stabilize it, such as holding down a piece of meat with a fork; the object can be transferred from one place to another or to the other hand; the object can be guided along a pathway such as occurs in writing, cutting, or mouse control. Objects can be attached to each other or removed and finally the object has to be released. Manipulating actions can involve the whole hand, one or more fingers, or only parts of the fingers.

If we examine hand actions, a major distinction can be made between direct manipulation with the hand(s) and indirect manipulation with a tool. This is the difference between tightening a bolt with the fingers or with a wrench. Indirect manipulation also extends to the use of a computer mouse, or further, to a robotic tool, where the movement of the hand is translated and scaled in size. In either direct or indirect manipulation, the object is grasped and usually transported to a work surface where it acts upon another object or surface. In terms of the hand roles, manipulation may involve one hand or both hands. Typically the nondominant hand holds the object in position (nail), whereas the dominant hand accomplishes the action (hammers).

The hand action component of the model identifies the functional capabilities of the hand(s)—reach, grasp, and manipulate. The next component, task parameters, identifies how well these skills are performed in a variety of contexts.

Task Parameters. The actions of reaching, grasping, and manipulating are carried out with a variety of objects, requiring different movement patterns, with different performance demands. The hand actions have to be adapted to the task. The bottom section of Figure 2 presents these three categories of object, movement pattern, and performance demands. In these categories the client can demonstrate his or her level of hand skill.

The **object** category is self-explanatory. The object characteristics determine whether more or less stabilization or large muscle involvement is required in the reaching and transport phase due to the weight of the object. The shape and size of the object also determines the type of grasp and whether one or two hands are needed. People appear to use a fairly stereotyped class of exploratory actions for identifying object features and materials (Lederman & Klatzky, 1996). Adjustments of the reach and grasp to an object seems to require little conscious attention. Infants as young as four months are able to systematically differentiate grip configuration as they reach for different sized objects (Newell, Scully, MacDonald, & Baillargeon, 1989). A healthy adults' nervous system readily makes adjustments in the reaching pattern, hand shape, orientation, and size of the opening toward objects of different sizes and to different task goals (for a detailed review of motor control research in this area, see Shumway-Cook and Woollacott, 2001, and Mackenzie and Iberall, 1994). This process of adjusting hand actions to different objects is a key concern however to the therapist. After injury, a client needs to learn to adjust reaching and grasping action to a variety of objects in different contexts. The therapist's evaluation needs to focus on what learned adaptations the client has made, or has to be taught to make, and which objects provide the most difficulty. Reaching for objects also puts different demands on postural stability. The weight of the object and where it is located spatially requires complementary postural adjustment in the trunk. Observing inappropriate postural compensation and teaching adaptive strategies may be an important part of an assessment or therapy program.

Hand actions can be carried out with different **movement patterns.** The simplest task would consist of a single grasp, transport, and release of an object. Repeating this action several times, in for example, the MRMT placing task, does not by itself make the inserting action more difficult, although it may be fatiguing. A continuous guided action such as writing or a mouse tracking task on the computer has more complex motor control demands since ongoing adjustments have to be made in direction and size of movement guided by visual feedback. Sequences of different combined actions present problems of motor planning, particularly if they also include a complex spatial pattern, such as tying shoe laces, or operating a number of different levers on a machine. Functional assessments often are limited to repeated insertion actions and ignore some of the more challenging motor control and planning movements that are difficult to standardize.

The final component of hand function involves proficiency in adapting to **performance demands**. The categories of object and movement pattern have identified the task contexts in which clients can function. It is also necessary to identify how efficiently they can use their hands if they are to function effectively in work or ADL tasks. This involves the addition of speed, spatial accuracy, force control, and endurance demands to the hand actions. Once a client can perform an action, increased speed of movement can be encouraged by timing the task. Error scores are recorded in inserting and tracing tasks to promote accuracy. Fatigue level can be determined if many repetitions or a sustained holding position are required. The ability to control force may be evaluated by one maximum effort such as a standard grip strength test, by maintaining a continuous low level of force in controlling the movement of an object, or by continuous force adaptation in, for example, the modulation of grip force in response to a wave pattern on an oscilloscope.

In the task performance category, the therapist has the most choice in selecting task difficulty and can provide the most or least challenge to the client depending on how many levels of task demands from the model are added or removed. Many clients, including young children, for example, can perform spatial precision tasks, such as tracing or object insertion quite well if one simply removes the speed element. In contrast, in a return to work screening, one may wish to provide maximum challenges in speed, accuracy, and endurance demands.

In addition to time, space, and force factors, the physical environment in which the tasks are carried out may also affect hand function. For severely injured clients, a part of their functional hand repertoire is whether or not the hand tasks will be carried out in a work environment, at home with family, or alone. Some clients may need to work with gloves, for example, due to sensitivity to cold or cosmetic anxiety.

In summary of the model, a complete assessment of the functional hand repertoire includes: the physical and psychological constraints limiting hand function; the use of the hands alone and together; the ability to reach, grasp, and carry out a variety of manipulations with a number of objects using different movement patterns; and finally an evaluation of the ability to control the timing, accuracy, and force of the movements. Based on the goals of the assessment and the needs of the client, different components of the model may be emphasized and different tools used. The therapist decides if it is important to evaluate what hand skills the client can demonstrate, or how proficiently he or she can do them, or both, and chooses qualitative or quantitative measures accordingly.

Discussion

In their clinical roles therapists typically have several distinct functions that include the following: evaluation of the ecological context in which the client functions, that is, the work or daily living activities required; the selection of assessment tools to evaluate the client; assessment of the person's performance through the use of standardized tests and observation; the identification of the person's present functional repertoire and the issues to be addressed in therapy; and the establishment and reporting of the client's limitations and requirements to facilitate optimal return to work and activities of daily living. The functional repertoire model presented in Figure 2 provides a potentially valuable tool for therapists through all five of these functions.

Figure 3 illustrates the uses for the functional repertoire model as the basis of decision making by the occupational therapist. Rather than simply identifying specific work or ADL *tasks* that give the client difficulty, the therapist can use the model to identify which *hand functions* and performance demands inherent in specific tasks create the difficulty. A similar process of analysis can be used in selecting assessment tools to ensure that the total hand function repertoire is included, overlap is avoided, and testing efficiency is increased. Many tasks in standardized tests, for example, require grasping and insertion actions, while very few evaluate continuously guided online controlled movements. A comprehensive functional repertoire is developed for the client that goes beyond test scores or the ability to perform a few very specific tasks. Based on this repertoire, the therapist can decide whether there is a need to focus on specific actions, teach the client adaptive strategies, emphasize the speed or control of manipulations, switch to the use of the noninjured hand, or recommend adaptive aids. At the end of therapy, changes in the functional repertoire can be documented as outcome measures. In preparation for a return to work or ADL, the therapist can identify specific hand functions that are limited and suggest strategies to compensate for the limitations, such as adapting the work or home environment to remove some of the task difficulties.

An illustration of the application of the model in an assessment is described in the following case example. Client W, an industrial worker, sustained a mutilating injury to his right dominant hand. A vocational goal that involved office work was proposed but the referral source questioned whether the client was physically suitable for this job based on his injury. The first step in answering this question was to establish the client's current level of hand function using the different components in the functional repertoire model. The client's *physical status* was noted as amputation of the long finger at the metacarpal level; the absence of active and passive motion at the metacarpal phalangeal and interphalangeal joints of both the index and ring fingers; and the presence of scarring in the hand and forearm with sensation intact. No restrictions were observed in the left hand. On observation the client kept the injured hand in his lap out of sight when not being test-

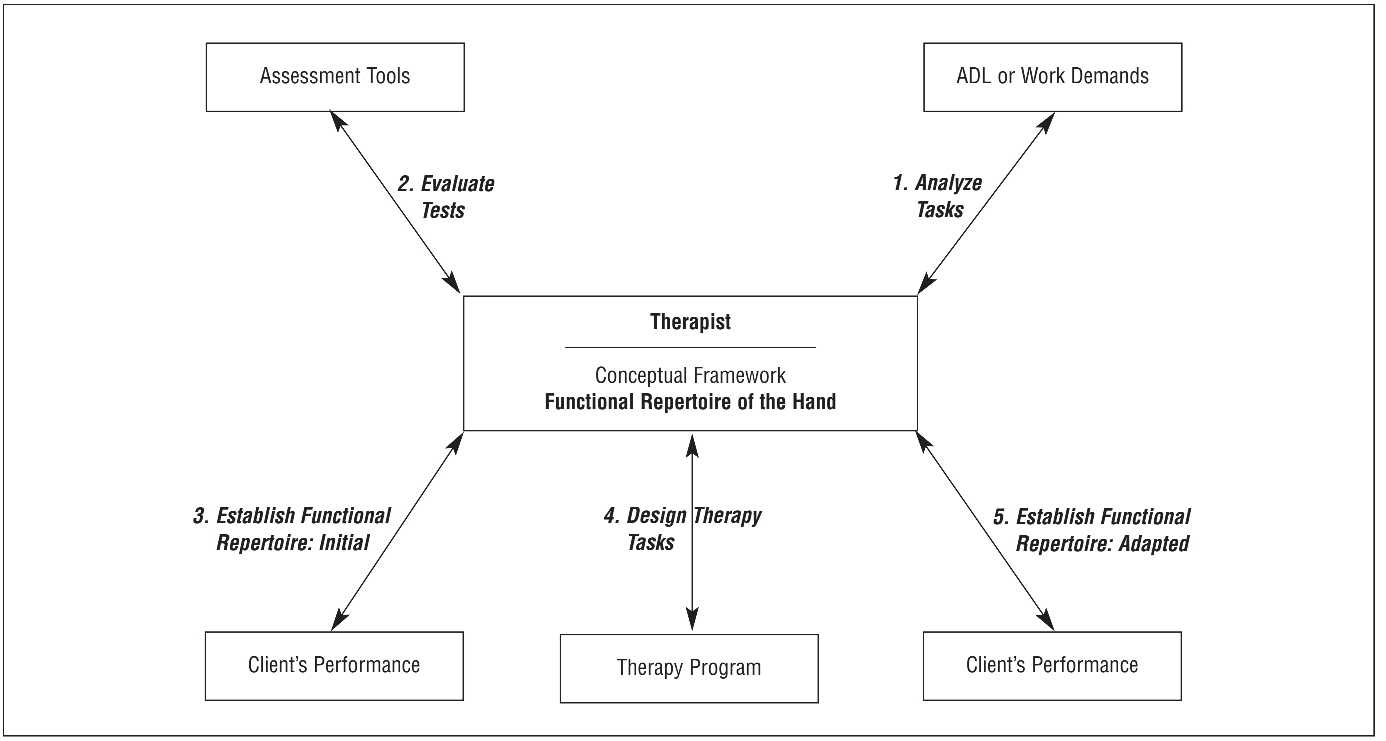

Figure 3. Application of the Functional Repertoire Model to the Occupational Therapist's Role

ed. He described himself as socially isolated and reluctant to go out in public *(psychological status)*.

Tests were chosen to assess the use of both hands in tandem and each hand in isolation *(hand roles)*. During testing the client used the left hand for most unimanual tasks when he was given a choice. Bilateral hand tasks were often initially attempted with only the left hand though the right hand was used in a stabilizing role if the left was unsuccessful at the task.

The client could reach with either hand action. A right hand palmar grasp was used when moving objects but he was unable to manipulate the objects through the fingers and switching objects between the hands was difficult *(hand actions)*. In terms of the task parameters, the client had difficulty in orienting *objects* with the left hand, could only handle light objects, and worked slowly, for short periods, with limited accuracy *(performance demands)*. Performance fell well below competitive levels.

Based on his current functional level, the therapist determined that the client would not be able to meet the skill demands associated with his vocational goal, but with training there was potential for the left hand to compensate for the dominant hand functional loss. A program to address the areas of deficit was outlined and included a goal for the right hand to function as an assist for the left *(hand roles)*. Activities focused on increasing accuracy, control, and speed in the left hand. A specific skill to be developed was handwriting. The *movement pattern* of writing involves a smooth, continuously guided action, controlling both size and force. In addition to practicing writing tasks, a variety of other tasks, such as cutting out objects with scissors, learning to paint, and using a computer mouse to follow a maze, were used to augment the development of writing skills. Program objectives also included increasing the right hand exposure within a public setting and reviewing the options of an aesthetic prosthesis to address cosmetic anxiety *(psychological status)*.

Many therapists do take a comprehensive approach in assessing hand function rather than simply documenting test scores on specific tasks. The model may, however, provide a more formal structure for the assessment process, provide a rationale for choice of assessment and therapy tasks, and provide a common hand repertoire language for clinicians and researchers in the field. The functional repertoire model may be particularly helpful to beginning therapists who are just learning to appreciate the complexity of hand functions. For experienced therapists the task parameters section may provide new insight into how to make task adaptations in therapy to challenge the client's skill development once basic functions have been restored. Although the use of the model in this paper has focused on its application to assessment and therapy of injured workers, we feel the model is equally valuable for therapists administering hand assessment to physically or developmentally challenged individuals and those with neuromuscular disorders. ▲

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