A Review of Conceptual Models for Assistive Technology Outcomes Research and Practice


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A Review of Conceptual Models for Assistive Technology Outcomes Research and Practice


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Conceptual models provide a theoretical basis for advancing scientific knowledge and improving professional practice. Although numerous assistive technology–related models have appeared in the literature, there has been no systematic effort to assess them. Six conceptual models are reviewed here: Cook and Hussey’s Human-Activity-Assistive Technology model; the World Health Organization’s International Classification of Functioning, Disability, and Health; Scherer’s Matching Person and Technology model; Gitlin’s model of an AT user’s “career”; social cognition decision-making theories; and Rogers’ Perceived Attributes Theory. The models are reviewed in terms of six domains: background and goals; descriptive characteristics; indication of outcome measures; predictive characteristics; validation in the literature; and utility to assistive technology practitioners, developers, and consumers. The salient strengths and limitations are highlighted for each. Application of the models to advance theory, research, and practice is discussed.

Key Words: Assistive technology—Human factors models—Outcomes research—Social-cognition models—Usability.

Assistive technology (AT) outcomes researchers and practitioners have long sought a single conceptual model with descriptive and predictive functions that would serve a range of stakeholder audiences: researchers, product developers, practitioners, third-party reimbursement entities, consumers, and educators. Although numerous AT-related models have appeared in the literature, leading AT outcomes researchers have suggested that there is no dominant conceptual model that describes and predicts AT outcomes (Fuhrer, Jutai, Scherer, & DeRuyter, 2003; Jutai, 2002). This paper reviews a convenience sample of six models from the AT, human factors, disability, and social psychology literature. The choice of models reflects our interest in exploring diverse perspectives, each of which offers potentially unique insights to improve our understanding of AT outcomes.

WHAT DO WE MEAN BY “AT OUTCOMES”? 

For the purposes of this paper, we embrace the operational definitions of AT outcomes research suggested by leading researchers in the field. At the most simple level, outcomes are the result of an intervention (Scherer, 1998a) causing impact in the lives of users and their environments (Fuhrer, 2001). DeRuyter defines outcomes measurement as, “The evaluation process in the service delivery system that is designed to measure and establish a baseline of what works; how well something works; for which clients it works; and at what level of economic efficiency it works” (DeRuyter, 1997).

WHAT DO WE MEAN BY “MODEL”? 

Model can connotate different functions in the scientific world, depending on one’s frame of reference (Resen, 1989):

1) Functioning prototype that is worthy of emulation, e.g., model citizen or model service delivery center.
2) A standard or classic approach, which is often
contrasted with other ways of doing things, e.g., the medical model.

3) A structure, taxonomy, or unifying description of a practice area, e.g., model of augmentative communication.

4) An equivalent or replacement feature of other organisms that shows similar characteristics to a human phenomenon, e.g., mouse model for Duchenne muscular dystrophy.

5) A hypothesis or tentative explanation for predicting a system’s behavior, e.g., control theoretical model of spasticity.

6) Mathematically precise description of system behavior that does not necessarily explain the underlying cause of the behavior, e.g., Fitts Law (Fitts, 1954).

According to Sanders, as cited in Lloyd, Quist, and Windsor (1990), models should structure current knowledge, offer a perspective for examining new problems, facilitate integration of new parameters and relationships as a field evolves, and provide a structure for planning and evaluation of professional services and intervention strategies. Edyburn (2001) describes it most succinctly, stating that models help practitioners and researchers to “understand key variables, relationships, and systems” that stimulate “advancements in theory, research and development, policy and practice.” Thus, models provide a basis for advancing scientific knowledge and professional practices (Lloyd et al., 1990).

HOW CAN AT OUTCOMES RESEARCH AND PRACTICE BENEFIT FROM A CONCEPTUAL MODEL?

For AT outcomes researchers, a conceptual model can provide a framework within which to classify areas of inquiry; develop predictive models of utilization patterns (Gitlin, 1998; Light, 1999); evaluate design alternatives and predict human performance (Rouse, 1980; Stanney & Maxey, 1997); and analyze data collection systems across states, regions, and countries (Scherer & Vitaliti, 1997).

For AT practitioners, a conceptual model can answer the essential questions posed by evidence-based practice, e.g., how do AT outcomes vary with different populations of end users who have a range of contextual circumstances (Holm, 2000). In the absence of a valid predictive model, clinicians rely on a process of trial and error to evaluate intervention options (Light, 1999), which hampers research progress (Gitlin, 1998; Jutai, 2002).

WHAT FEATURES ARE NEEDED IN A CONCEPTUAL MODEL?

AT outcomes considerations necessitate conceptual models that have wide-ranging descriptive properties delineating the complex elements associated with AT use, including the diversity of end-user abilities, AT devices, tasks and roles to which AT is applied, and contextual environments within which AT is applied (Smith, 1996). In order to support outcomes research, models are also needed that offer predictive theories about usage and impact (Fuhrer et al., in press; Jutai, 2002). In summary, a conceptual model for AT outcomes research and practice should have descriptive and/or predictive functions that support provision of AT that has positive impacts for end users. A mature conceptual model would be validated by multiple research studies.

PREVIOUS REVIEWS OF CONCEPTUAL MODELS

Bromley (2001) presented a brief analysis of five models of AT assessment: Matching Person and Technology (Scherer, 1998c); Lifespace Access Profile (Williams, Stenach, Wolfe, & Stanger, 1995); Student-Environment-Tasks-Tools (SETT; Zabala, 1995); Education Tech Points (Bowser & Reed, 1995); and Wisconsin Assistive Technology Initiative (1998). Bromley (2001) described each model's elements and goals, finding four similarities among the models: (1) all emphasize the process of AT assessment and goal setting; (2) all assess person, environment, and task with an ecological functional orientation; (3) all emphasize a multidisciplinary collaborative approach to AT assessment; and (4) all share the goal of facilitating an effective match between person and AT for the environment of use. Bromley (2001) noted that some of the models are more suited to students and others more appropriate for working adults. The paper does not assess the models’ strengths and limitations, nor does it describe how the models fit in the broader context of the AT field.

Edyburn (2002) reviewed 12 models that “undergird the knowledge base of the special education technology discipline.” He grouped the models into three categories: AT consideration, technology-enhanced performance, and developmental. The AT consideration models included Zabala’s SETT Framework (Zabala, 1995); Bowser and Reed’s (1995) Education Tech Points; Chambers’ (1997) Has AT Been Considered?; and Haines and Sanche’s (2000) AT CoPlanner Model. Each includes specific questions intended to guide and facilitate the process.

The purpose of Edyburn’s (2002) review was to raise awareness of as many models as possible. This egalitarian spirit, combined with limits in publication space, limited the depth at which Edyburn was able to describe and critique each model. Edyburn’s review is valuable for its breadth, classification of three types of models, and attempt to target a practitioner audience that might not otherwise be exposed to the value of conceptual models.

The review articles described above offer a starting point for awareness and understanding of existing conceptual models. A systematic critique of existing models is warranted in order to assess our needs for future theoretical development.

PURPOSE

This paper evaluates six conceptual models using a common structure. Our review is not intended to be exhaustive. Two factors guided selection of the six models evaluated here: the prevalence of several in the AT outcomes literature and our interest in exploring the potential for models from outside the AT field in order to offer fresh perspectives. Each is discussed according to six domains:

1) Background/goals: For what purpose was the model originally developed, and how can it be applied to AT outcomes?
2) Descriptive traits: To what extent does the model describe the Person-Environment-Technology system?
3) Implicit outcome measures: To what extent does the model suggest outcome measures of performance and/or impact of AT on the end user?
4) Predictive traits: To what extent does the model suggest relationships between the descriptive elements and outcome measures?
5) Validation: To what extent has the model been tested in the AT outcomes literature?
6) Utility for practitioners, users and developers: Is the model useful as a decision aid for practitioners, end users, and developers of AT?

PERSON-ENVIRONMENT INTERACTIONS: THE COMMON BASIS

The roots for the person-environment models are apparently in the field of social psychology. Lewin (1936) proposed that an individual’s thoughts and behaviors result from interaction between the person and his or her environmental surroundings. According to Lewin, this was a philosophical shift away from seeking the “cause” of events in a single object or phenomenon to identifying a holistic relationship between a person and his or her surroundings.

Within the many variations on Lewin’s (1936) person-environment-behavior model, the concept of congruence (or “fit”) is used to describe the compatibility of the individual’s abilities, goals, and environment (Steinfield & Danford, 1997). In the AT literature, “match” is used analogously to describe the relative congruence of AT devices with individuals and their contexts of use. Each of the following six models shares a common orientation to the extent that they capture person-environment relationships.

HUMAN ACTIVITY-ASSISTIVE TECHNOLOGY MODEL

Background/Goals

Cook and Hussey (2002) wrote the first comprehensive text on AT, throughout which they emphasized a model called HAAT: Human Activity-Assistive Technology. The HAAT model is adapted from Bailey’s (1996) human performance model, with two principal distinctions: (1) HAAT expands the definition of context to include social and cultural contexts, in addition to environments and physical conditions; and (2) AT devices are an explicit component of HAAT.

HAAT describes an AT system in terms of a person (human) using an assistive technology (AT) device to accomplish a desired task (activity) in a given context (environment). Figure 1 illustrates the four interacting domains of the HAAT model. HAAT seeks to characterize AT system performance, rather than restricting focus to human or device performance. HAAT reflects the perspec-
of these affect the performance and impact of the AT system. Many indicators of impact are mentioned specifically, including effectiveness, efficiency, user satisfaction, and quality of life.

**Predictive Traits**

The HAAT model does not offer specific predictions about AT impact beyond the authors' plausible contention that systematic consideration of all four components will reduce the probability that AT will be rejected or underutilized.

**Validation**

Although the independent variables of virtually all AT outcomes studies could be mapped onto HAAT, it has not been tested per se. Its all-encompassing nature affords possibilities as a reference framework upon which outcomes research can be based.

**Utility for Practitioners, Users, and Developers**

The HAAT framework is an intuitive schema for AT practitioners, many of whom are influenced by the holistic traditions of occupational therapy and human factors engineering. For years, the antecedent of this model has been the guiding framework for human factors designers. Cook and Hussey (2002) encourage consideration of HAAT’s four parts in order to identify an AT device most suited for a consumer’s needs.

Two additional strengths are noted. Cook and Hussey (2002) distinguish between an end user's skill and ability, suggesting that AT impacts are influenced by changes in device proficiency (skill) and underlying condition (ability). The model also describes human-AT interaction in terms of the functional allocation of those tasks performed by the human and those carried out by the AT device, which echoes Smith's (2002) discussion of parallel interventions. Both areas suggest the need for future research.

**Summary**

HAAT thoroughly considers person and environment factors, emphasizing the influence of environment and culture on task performance. Although many indicators of impact are mentioned, HAAT does not suggest specific causal relationships between its descriptive elements and outcomes.
INTERNATIONAL CLASSIFICATION OF FUNCTION, DISABILITY, AND HEALTH

Background/Goals

The World Health Organization first published the International Classification of Impairment, Disability, and Handicap (ICIDH) in 1980. The revised version of the model was approved in 2001 and rechristened the International Classification of Functioning, Disability, and Health (ICF; World Health Organization, 2001). The model describes individuals in terms of level of function, rather than describing levels of deficit or dysfunction. Its purpose is to provide a framework for assessment, diagnosis, intervention, and outcomes measurement, regardless of health or ability level.

Descriptive Traits

Individuals are described in terms of six categories: body function and structure, activity, participation, and environmental and personal factors. Body functions include physiological aspects of bodily activity. Body Structures are the anatomical parts of the body, e.g., organs, limbs, and their component tissue. Activities are relatively context-free tasks, e.g., moving an arm or speaking. Participation includes situations that are part of a life role. Environmental factors include the physical and socio-cultural contexts in which people live their lives, including products and technology; the built environment; relationships with others; attitudes; and services, systems, and policies. Personal factors include demographic information and standard of living indicators, e.g., age, sex, marital status, country of birth, living arrangement, education level, employment status, and income.

Several researchers (DeRuyter, 1997; Gray, Quatrano, & Lieberman, 1998; Jutai, Ladak, Schuller, Naumann, & Wright, 1996) have suggested that the ICF model (or its predecessor, the ICIDH) provides a useful framework for AT outcomes research. Table 1 depicts an ICF-AT model that provides a structure for classifying AT devices, reimbursement models, funding criteria, and outcomes measurement tools (Lenker & Jutai, 2002). Each domain is defined broadly enough to encompass all age and disability populations, types of AT employed, and environments of use.

Implicit Outcome Measures

Outcomes are implicit within the model to the extent that there are indicators of performance and function within each domain. Table 1 suggests AT outcome indicators and tools for each domain.

Several AT outcomes measures are depicted to span ICF domains.

Predictive Traits

The principal limitation of the ICF model results from its lack of temporal and causal components (Gray & Hendershot, 2000), both of which are necessary in order to develop a predictive model for outcomes research. The ICF classification does not suggest whether (or how), for example, mobility outcomes are supposed to influence the achievement of outcomes in major life areas. Nor does it suggest how psychosocial factors influence outcomes at any level (Lenker & Jutai, 2002). Fully integrating the ICF model into AT outcomes research and practice requires development of a causal model or models that have a predictive function relating user, AT device, task, and environment.

Validation

There are numerous efforts underway to clarify the categories, develop measurement instruments, and develop hypotheses that could validate portions of the ICF model (NCHS, 2003).

Utility for Practitioners, Users, and Developers

The ICF subdivides the person into three separate levels, an abstraction that probably limits the model’s value for consumers and product developers. The ICF-AT model proposed by Lenker and Jutai (2002) associates functional domains, type of AT, reimbursement model, and outcomes measurement tools in a manner useful for preprofessional education.

Summary

The ICF model has successfully transformed the view in rehabilitation research from a perspective that places the “problem in person” to a conceptual framework that features a “problem in system” orientation (Cook & Hussey, 2002). The ICF model does not clearly delineate parallel interventions (Smith, 1996) that affect performance (e.g., the role of personal assistance or alternatives to AT), and it lacks temporal and causal components that would facilitate hypothesis testing. Lenker and Jutai’s (2002) ICF-AT model is an extension of the ICF framework that visually relates functional status and capacity, types of AT devices, areas of practice, reimbursement model, funding criteria, and outcomes measurement tools.
<table>
<thead>
<tr>
<th>ICF domain</th>
<th>Body functions and structures (body level)</th>
<th>Activities (individual level)</th>
<th>Participation (role level)</th>
<th>Contextual factors (societal level)</th>
</tr>
</thead>
</table>
| Domain-relevant examples        | Functional and structural integrity: Normal physiologic processes and organ systems function: cognition, sensory, perception, motor, physiologic and psychological processes | Performance of action or activity (cognitive, sensory, motoric, and/or behavioral) that facilitates performance in multiple roles:  
- initiate, organize, sequence, judge, attend  
- sit, lift, stand, climb, reach, pinch, grasp, hold, release  
- relate, interact, cope  
- hear, speak, see, taste, move  
- read, write, learn, understand | Involvement in life situations and performance in roles (family, work, and educational; self-care, leisure) that take place in specific contexts (physical, social, cognitive) | Features of the physical and social world that affect the individual but are not specific to the individual’s ability or disability; e.g., physical barriers in public spaces, employer attitudes; funding for social service benefits; public policy;  
- devices/products  
- built environment  
- people (friends, relatives, peers) |
| Domain-relevant assistive technology | Heart pacemaker, hip/knee replacement, cochlear implant, baclofen pump | Mobility aids: wheelchairs, crutches, canes, walkers; upper extremity orthotics: eyeglasses, hearing aid, augmentative and alternative communication device | Job modifications of task/device/environment; home modification; vehicle modification; computer-based AT | Accessible public venues: buildings, transportation, communications, recreation; third party reimbursement for AT services and equipment |
| Funding model                   | Medical                                                                                                     | Medical                                                                                      | Vocational rehabilitation                                                                  | Public policy                                                                                   |
| Funding criterion               | Medical necessity                                                                                           | Medical necessity                                                                            | Vocational relevance                                                                        | Societal values                                                                                |
| Domain-specific measures        | EKG, blood pressure, Ashworth muscle tone scale                                                            | FIM, visual acuity, hearing test, language production                                         | Job performance (e.g., raises, promotions)                                                   | Environmental Quality Assessment Scale                                                            |
| Domain-spanning measures        | QUEST: Quebec User Evaluation of Satisfaction with Assistive Technology (user satisfaction with devices and services)  
PIADS: Psychosocial Impact of Assistive Devices Scale (well-being/quality of life)  
COPM: Canadian Occupational Performance Measure  
ATDPA: Assistive Technology Device Predisposition Assessment |                                                                                               | School performance (e.g., grades, degrees)                                                   | Role participation                                                                               |

Note: ICF = International Classification of Functioning, Disability, and Health; FIM = Functional Independence Measure®. Adapted from Lenker and Jutai (2002).
FIG. 2. The Matching Person and Technology (MPT) model, illustrating the interacting influences of milieu, person, and technology that produce a continuum of “positive” and “negative” outcomes (Scherer, 1998b).

MATCHING PERSON AND TECHNOLOGY (MILIEU-PERSON-TECHNOLOGY)

Background / Goals
The Matching Person and Technology (MPT) model (Scherer, 1998c) posits that the interaction of milieu, person, and technology influences long-term use or nonuse of AT devices (Fig. 2). The MPT includes a structured assessment process to facilitate selection of an AT device that is the best “match” for the end user, AT device, and the context of use (Scherer & Craddock, 2002). The premise is that AT devices are a means to an end that may or may not address an individual’s unique needs and circumstances. Scherer (1998c) states clearly that the model is “not designed to predict use or nonuse of a technology.”

Descriptive Traits
A number of instruments have been developed specifically for the purpose of operationalizing the three domains. The MPT instruments explore strengths, limitations, and goals of the person at two key levels: body function and role performance. This is a conscious effort on Scherer’s (1998c) part to preserve consistency with the emerging ICF perspective and terminology. Questions about milieu and AT device usage focus on the individual’s past experiences and goals for the immediate future.

Implicit Outcome Measures
The model and associated tools suggest that the preeminent outcome indicators are AT use/nonuse, user satisfaction, and subjective well-being of the end user. The model is not explicit about outcome indicators such as effectiveness and efficiency.

Predictive Traits
Scherer (1998c) modestly emphasizes that the MPT model and its associated measurement tools are not intended to predict AT use or nonuse. However, Scherer (1998c) has identified numerous factors associated with successful and unsuccessful user experiences with AT. These factors are easily classified within the MPT structure, suggesting that the model provides a framework for prospective studies attempting to predict usage and impact of AT.

Validation
The MPT emerged from grounded theory research with 10 adults with physical disabilities (five with spinal cord injury and five with cerebral palsy) who identified factors related to milieu, personal needs and preferences, and desirable features of AT (Brown-Triolo, 2002; Weiss-Lambrou, 2002). Various papers (Scherer & Cushman, 1997; Scherer & Galvin, 1996) have retrospectively identified factors associated with use or abandonment of AT devices, including the following:

1) Environmental factors (milieu): Insufficient training on AT device use, environmental obstacles, and financial disincentives based on benefit structure.
2) Individual characteristics (person): Changes in functional abilities, minimal need for AT device, changes in activities, or motivation; matches consumer’s lifestyle and personality; user expectations; sense of control; sense of status associated with device use; self-esteem; independence desired; focus on barriers; and technophobia.
3) AT device characteristics (technology): Physical demands; sensory requirements; cognitive demands; cost; training; repair and maintenance issues; aesthetics; and usability features, including device performance (Scherer & Cushman, 1997).

Although tools exist for matching technology to the needs of children (Scherer, 1999), the model has not been grounded with data from younger populations.

Utility for Practitioners, Users, and Developers
As with the HAAT model, the MPT schema is useful as a heuristic tool for AT provision.
MPT's associated measures are helpful screening tools for counselors and caseworkers seeking information about an individual's history of technology use, current needs, and readiness for new technology. The user-completed instruments associated with the MPT identify usability and psychosocial factors that highlight salient issues for the end user. The model suggests a framework for developers of AT to structure usability testing as part of product development. Some explications of MPT in the literature suggest existence of an ideal "match" between consumer and technology, which subtly implies that a perfect AT device exists for every consumer. In reality, however, AT devices are often recommended because they represent the best available compromise at the time of evaluation.

Summary

The MPT model emphasizes an inclusive, user-centered orientation that is reflected in the structure of the model and the manner in which the model is disseminated. Although it identifies numerous person and environment factors that influence long-term use and nonuse of AT devices, the MPT model leans more toward the descriptive. Prospective research is needed to determine if the MPT assessment process produces better decision-making and outcomes for AT users.

GITLIN'S MODEL: BIOPSYCHOSOCIAL FRAMEWORK AND CONCEPT OF "CAREER"

Background/Goals

The "career path" model for AT use (Gitlin, 1998) begins in the hospital (Fig. 3). It is grounded in a biopsychosocial framework that considers effects of physical, intrapsychic, and social aspects of a person's existence. Kaufert and Locker (1990) described the "careers" experienced by people with disabilities in terms of phases that represent periods of relative constancy between major life events. Gitlin's rendering of an AT device career path is similar to Cook and Hussey's (2002) suggestion that AT users exhibit time-varying levels of capacity and skill that affect performance of the AT system. The purpose of the career path model is to describe the changing nature of factors that influence AT use and impact over time.

Descriptive Traits

Gitlin's (1998) model is rooted in a biopsychosocial perspective that is consistent with the HAAT, ICF, and MPT models. More uniquely, the career path model emphasizes that device use may extend over many years, during which an individual's abilities, priorities, environmental demands, and resources will all change. Of special interest are the transition points that demarcate a relatively abrupt change of life circumstance (e.g., discharge from hospital) that impacts the use of AT. As individuals acquire skill, they progress from novice to expert AT users.

The environment of novice AT users is defined as "hospital," which is consistent with the focus of the book chapter in which it was introduced. For application to a broader range of AT users, the model requires a broader treatment of the environment and concomitant temporal milestones so that it could be applied to AT users whose goals are educational or vocational in nature. In addition, the
model does not define the four stages of expertise; thus it is not possible to operationalize the skill classifications for theory testing with specific populations of users and/or specific AT devices.

Implicit Outcome Measures

The model suggests a number of outcomes indicators: AT use, functional independence, well-being, and user goals for self-care.

Predictive Traits

This model identifies causal variables that affect device usage at discrete, critical transition points along a linear temporal path (Jutai, 2002). Additionally, it depicts the changing influence of underlying factors as individuals grow from novice to experienced users. These temporal features suggest potential for the career path model as a basis for theories of AT device usage and impact.

Validation

Gitlin (1998) describes several factors that predict early use of AT: independence, ability to use the device at home, stigma associated with device use, personal identity, and social factors. These are consistent with many of the factors identified in Scherer’s (1998a, b, c) research. Gitlin’s (1998) model does not define the characteristics differentiating novice users from early, experienced, and expert users. Although the model is no doubt informed by Gitlin’s extensive research with elders using assistive devices in their homes, it would be strengthened if clearer associations were drawn between elements of the model and published research findings.

Utility for Practitioners, Users, and Developers

Practitioners might benefit by considering the influence of Gitlin’s (1998) factors on individual AT users. From the consumer’s perspective, however, the concept of career path and skill may be esoteric. The model’s focus on factors that affect early adoption of AT would be very useful for AT product developers who are testing the usability of product designs.

Summary

The temporal nature of this model has promise for hypothesis formulation and testing. The four stages of user expertise are clearly identified, although not defined, and causal variables at two stages of an AT user’s career (novice and early user) can be readily operationalized. Development of the model would require definitions of novice, early, experienced, and expert users in order to conduct theory testing with specific populations of users and/or specific AT devices. Application of the model to vocational or educational contexts would require expanded descriptions of environmental and temporal milestones.

SOCIAL COGNITION MODELS

Background/Goals

The field of psychology offers several social cognition models whose goal is to predict behavior (Carter, 1990). An implicit assumption with social cognition theories is that people naturally seek behaviors that maximize expected benefit. Individuals weigh their attitudes, perceptions of benefit, and perceived control of behaviors against the expectations of significant others, ultimately choosing behavioral alternatives that offer the most favorable set of consequences.

As illustrated in Figure 4, Carter (1990) contends that behavior is preceded by intentions that are influenced by the individual’s attitude toward the behavior and the immediate social environment. Personal attitudes toward behavior are
formed by the perceived positive and negative consequences of the behavior, which are modulated by personal motivation. The influence of social environment includes the effects of normative beliefs held by salient others, e.g. spouse, coworkers, and practitioners. For example, an individual’s intention to use an augmentative communication device will be affected by the supportiveness of her communication partners as well as the personal consequences she associates with using the device to supplement her unaided verbal and nonverbal expressive language skills.

Multiattribute Utility (MAU) Theory is a related social cognition model based on value expectancy theory. MAU predicts behavior from an individual’s assessment of the consequences that are associated with competing behavioral options (Carter, 1990). Smith (2002) applies MAU theory to the context of AT usage, suggesting that the behavioral decision to use AT is influenced by the relative merits of six competing “parallel interventions”: (1) use of AT devices and services, (2) modified strategies or technique, (3) environmental modification, (4) task modification, (5) change in functional capacity, and (6) assistance from others. Each of the latter five factors offers relative advantages and disadvantages compared with the option of using AT, including the degree to which the parallel factor supports or impedes AT effectiveness. In this manner, Smith’s six parallel interventions influence the perceived benefits associated with AT usage.

Bellamy, Brickley, and McAndrew (1996) describe influences on behavior that are applied here to the behavior of AT usage. Personal motivation and the perceived benefits of AT are the drivers of AT usage. Individuals are motivated to use AT only if they believe they are worse off by not using AT. The perceived impact of AT is influenced by perceptions of three factors: (1) potential gains from AT use, (2) perceived consequences of not using AT, and (3) the perceived effort and costs of AT use. Consumers with ostensibly similar goals and abilities may have differing perceptions regarding their need for AT and the possible performance gains with the use of AT.

**Descriptive Traits**

The social cognition models described above are variations on a theme. They do not explicitly describe systems in terms of the person, task, and environment. Rather, they focus on the influence of environment, task, and tools on behavioral decisions (e.g., whether or not to use AT). This family of models is applicable to people of all ages, abilities, and environmental contexts.

**Implicit Outcome Measures**

The goal of social cognition models is to predict behavior. For our purposes, the principal outcome indicator of interest with these models is the behavior of AT usage.

**Predictive Traits**

Social cognition models suggest that the perceived benefits of AT use (e.g., enhanced performance and/or quality of life) are predictors of AT use. Smith’s (1990) description of parallel interventions suggests competing behavioral alternatives that influence perceived benefits of AT use.

**Validation**

In one study of workplace adoption of computer software (Davis, Bagozzi, & Warshaw, 1992), it was hypothesized that perceived usefulness and enjoyment are the antecedents to software usage. The findings indicated that perceived usefulness is influenced by perceived ease of use, output quality, and task importance.

Roelands, Van Oost, Depoorter, and Buysse (2002) operationalized a social cognition model (Fig. 5) in research conducted with 491 community dwelling elders in Belgium. Their findings suggest that awareness of an assistive device impacts attitudes and normative beliefs toward using the device. In addition, they found that intention to use AT devices was impacted by attitudes, normative beliefs, and self-efficacy regarding AT use.

Although the findings were promising, several acknowledged limitations to the measurement methods mitigate the degree to which the Roelands et al. (2002) study validates the social cognition model. Participants were queried about their knowledge of and intention to use 32 different AT devices, regardless of relevance to the individual’s circumstances. With this format, participants were potentially biased to indicate high awareness of assistive devices in order to avoid appearing ignorant. In addition, there would have been a natural bias for respondents to inflate their intention to use AT devices, since usage was being hypothetically projected to an indeterminate time in the future.

**Utility for Practitioners, Users, and Developers**

Perceived value is a promising predictor of AT usage and impact. One study found that anticipat-
ed psychosocial impact of environmental aids to daily living (EADL) for persons with Duchenne's muscular dystrophy (MD) was similar to the psychosocial impact experienced by users of EADL with MD (Jutai, Rigby, Ryan, & Stickel, 2000). Although it has not been associated with published research, the Device portion of the AT Device Pre disposition Assessment (Scherer, 1998) includes 12 questions eliciting the usability and stigma users associate with an AT device. Practitioners could use these or other measures to identify areas of consumer confidence and doubt with respect to AT device options. Consumers might find it useful to rate the relative value of AT compared with other intervention options available to them. Developers could use the parallel interventions model to structure usability testing and descriptions of relative advantage associated with new product designs.

Summary

The social cognition models seek to predict behavior. As applied here, perceived benefits, personal motivation, attitudes of others, and relative advantage compared with parallel intervention options are factors influencing AT usage behavior. To date, none of the social cognition models has been fully realized for prediction of AT usage and outcomes. The study conducted by Roelands et al. (2002) demonstrates the potential of this model to predict AT usage, although methodological limitations indicate the need for additional validation research.

ROGERS’ PERCEIVED ATTRIBUTES THEORY

Background/Goals

Everett Rogers is a social science theorist who has published four editions of a book titled Diffusion of Innovations (Rogers, 1995). The diffusion model describes two interrelated processes, innovation diffusion and innovation adoption, that occur between conception of a new product design and consumer usage of the resulting product. Rogers describes an innovation as any idea, practice, or object that is perceived as “new.” Diffusion is a macrolevel process by which an innovation evolves from raw form to prototype to finished product to product that is sold and used by adopters of the innovation (Rogers, 1995). Innovation diffusion is a macrolevel process in which an innovation spreads to general use (Carr, 1999). Innovation adoption is the complementary stage at which an individual chooses to adopt a technology for his or her own use (Carr, 1999).

Rogers (1995) describes a Perceived Attributes Theory that identifies seven factors influencing innovation adoption: (1) relative advantage, (2) compatibility, (3) complexity, (4) trialability, (5) observability, (6) re-invention, and (7) change agent contact (Carr, 1999). Each factor is described below as it might apply to the AT arena.

Relative advantage is the benefit of continued device use compared with the benefits of nonuse or discontinued use, which is analogous to the “perceived consequences” construct included in the social cognition models. In the context of AT outcomes, relative advantage would be comprised of factors such as functional performance gains, in-
creased independence, cost savings, and quality of life impact.

Compatibility is the degree to which a product is consistent with the socio-cultural and technical elements that comprise the adopter's environment of use. Applied to AT, compatibility implies that the AT device is consistent with the consumer's abilities, role expectations, and socio-cultural environment.

Complexity is the user's perception regarding ease of use, which is similar to the idea of learnability that is described in the human factors literature (Jordan, 1998).

Trialability is the degree to which the adopter can use the product prior to acquisition. Typically, there is limited opportunity for trial use of AT because of three factors: the technology is too expensive for centers to buy all devices within a particular AT category; distributors are geographically scattered, making it difficult to borrow some devices; and practitioner's time is expensive and limited by third party payers who minimize costs by placing normative limits on billable time for AT assessments.

Observability is the degree to which a product is visible. Desire for personal privacy, embarrassment, and device esthetics contribute to a negative level of observability for some who feel that use of AT sets them apart from their peers.

Re-invention is the degree to which products can be modified or adapted. Many AT devices have a multiplicity of configuration options, so re-invention is typically possible as the user's ability, skill level, or needs change. However, re-invention of AT often requires the skills of an advanced user or experienced AT practitioner.

Change agents are persons who influence the adopter. AT acquisition is frequently mediated by two powerful change agent parties: a third-party payer and an AT practitioner. Third party payers provide funding for assessment and training services, as well as the AT device itself. Expert practitioners assess individual needs and performance capacity, often facilitating trial use of AT products. Because of the economic power wielded by third party payers, and the socio-technical power possessed by expert practitioners, the dynamics of AT recommendation and purchase do not favor empowerment of the end user. The de facto role of these parties can be more akin to a gatekeeper than a catalyst, making end users "secondary consumers" of AT (Steyaert, 1999).

Descriptive Traits

The Perceived Attributes Theory does not partition characteristics of person or environment. Rather, its seven attributes characterize interaction between person and environment. The theory lends itself to individuals of all ages, functional abilities, and contexts of device or product use.

Implicit Outcome Measures

The principal outcome indicator is product adoption and usage.

Predictive Traits

The seven perceived attributes—relative advantage, compatibility, complexity, trialability, observability, re-invention, and change agent contact—are the predictive elements of Rogers' (1995) theory. In addition, Rogers (1995) describes two reasons for an individual's decision to discontinue product use: replacement and disenchantment. Replacement involves rejection of a product in favor of an improved product, whereas disenchantment is defined as product rejection that can be attributed to user dissatisfaction.

Validation

At least one AT outcomes study (Riemer-Reiss & Wacker, 2000) has used Rogers' (1995) Perceived Attributes Theory as a basis for measurement of variables to predict AT use for 115 participants. Five end users and two practitioners helped the authors devise a study-specific measure with separate subscales for five of Rogers' perceived attributes: relative advantage (nine items), compatibility (one item), trialability (one item), re-invention (one item), and change agent support (seven items). Individual items were not described. Logistic regression analysis revealed that relative advantage was the strongest predictor of AT usage. The authors did not publish their measurement tool, thus thwarting replication studies.

Utility for Practitioners, Users, and Developers

The PerceivedAttributes Theory offers a framework for practitioners and developers to evaluate the potential for device adoption by individuals or groups of individuals.

Summary

Rogers' (1995) Perceived Attributes Theory offers intriguing possibilities for researchers interested in prospectively measuring factors predicting AT adoption and usage. The Perceived Attributes Theory lacks the descriptive strengths of the HAAT and ICF models. Rather, it describes char-
Characteristics of interaction between person, product, and environment that predict device adoption behavior. Rogers (1995) offers a framework within which to classify the factors that Scherer (1999) and Gitlin (1998) associate with successful AT outcomes. Many of the seven attributes are captured by items contained in the Psychosocial Impact of Assistive Devices Scale (PIADS; Day & Jutai, 1996), the Device subscale of the Quebec User Evaluation of Satisfaction with Assistive Technology (QUEST; Demers, Weiss-Lambrou, & Ska, 2000), and the Device section of the Assistive Technology Device Predisposition Assessment (ATD PA; Scherer, 1998c).

DISCUSSION

Conceptual models can classify areas of inquiry, predict usage patterns, reduce trial and error when evaluating intervention options, and structure usability testing of design alternatives—all of which support AT outcomes research and practice. Broadly speaking, the first three models reviewed here—HAAT, ICF, and MPT—offer superior descriptive frameworks for classifying and describing the traits associated with individuals and their contextual environments. The latter three—Gitlin’s (1998) career model, the social cognition models, and Rogers’ (1995) Perceived Attributes Theory—offer temporal and predictive elements that translate more readily to testable hypotheses that might ultimately shape clinical decision-making. From the social cognition models, the concepts of perceived value and relative advantage compared with parallel interventions show greatest promise for predicting AT use. All seven factors from Rogers’ (1995) Perceived Attributes Theory are promising predictors of usage. Together these could form the basis for the type of predictive theory being called for by Fuhrer et al. (in press).

Other models are applicable and worthy of mention. Zabala’s (1995) SETT framework is a structured set of questions that guide AT assessment in school settings based on relevant person and environmental factors: student, environment, tasks, and technology. Bowser and Reed’s (1995) Educational Tech Points and Langton and Hughes’ (1994) Tech Points consider AT service delivery practices as part of the everyday educational and vocational rehabilitation processes, respectively. Each of the above process models would be bolstered by prospective research demonstrating that their usage in everyday practice improves clinical decision-making.

CONCLUSION

Applied fields of practice benefit from conceptual models that provide a common theoretical touchstone for researchers and practitioners. The continued scarcity of funding resources for AT assessments, equipment, and training portends the need for predictive algorithms that can facilitate decision-making by practitioners, reimbursement agencies, and consumers. The lack of a fully realized predictive model for AT outcomes research indicates the need for development and validation. In the latter regard, social cognition models and Rogers’ (1995) Theory of Perceived Attributes introduce fresh insights about elements of person-environment interactions that affect human behavior.

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