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Assistive Technology as a Self-Management Tool for Prompting Students with Intellectual Disabilities to Initiate and Complete Daily Tasks: A Literature Review

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Abstract: This paper summarizes the results of a review of the empirical literature (1990-2005) focusing on use of assistive technology as a self-management tool for persons with intellectual disabilities. Forty investigations were identified which provided information on assistive technology to assist persons with disabilities to initiate and complete daily tasks. Four areas of research were defined and analyzed through the identified studies: (a) pictorial prompts; (b) tactile prompts; (c) auditory prompts; and (d) computer-aided systems. Research supports assistive technology as an effective tool for providing antecedent prompts that can be self-operated by persons with intellectual disabilities. Implications of the research and suggestions for future research are discussed.

Increased independence and the ability to manage one's own behavior and task performance continue to be areas of concern when working with persons with disabilities. Included in these behaviors are abilities to self initiate, self-instruct, self-maintain, and self-monitor one's behavior and task performance (Post & Storey, 2002). Student self-management strategies provide a means to increase the independence of persons with disabilities, decrease the need for continuous supervision and prompting by others, and free the teacher to attend to other instruction. While self management procedures may be in the form of antecedents or consequences to target behaviors (Browder & Shapiro, 1985), the focus of this review is the application of self management tools in the form of antecedents to influence behavior. Antecedent self-management strategies may cue or guide a person's behavior by using stimuli such as pictures or audio cues that precede occurrence of a behavior (Harchik, Sherman, & Sheldon, 1992). Antecedent prompts such as photographs may

increase a person's ability to respond independently without: (a) waiting for another person to tell them what to do (Riffel et al., 2005); and (b) the need to memorize step sequences (Lancioni, Van den Hof, Furniss, O'Reilly, & Cunha, 1999). Such prompts may further improve performance, increase fluency of responding (productivity, duration of behavior), and promote maintenance of skills already acquired.

Since Congress outlined guidelines for providing assistive technology in the Technology-Related Assistance for Individuals with Disabilities Act of 1988, the use of assistive technology has been applied across a wide range of settings and activities to meet the needs of students with varying disabilities (Gregor & Pachuski, 1996). Increased advancements, awareness, and availability of materials, equipment, and adaptations make the application of assistive technology an ever evolving field, which includes new inventions, and innovate use of existing tools.

The term assistive technology device means "any item, piece of equipment, or product system, whether acquired commercially off the shelf, modified, or customized, that is used to increase, maintain, or improve functional capabilities of a child with a disability." 20 U.S.C. 1401 [25], Sec. 300.5 (Individuals with Disabilities Education Act, 1990). Lewis (1998) describes assistive technology as any

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technology that can enhance the performance of persons with disabilities by augmenting an individual's strengths or providing an alternative mode of performing a task to compensate for the effects of a disability. Assistive technology devices to aid persons with disabilities can be technological (vibrating pager, Palmtop PC) or nontechnological (picture prompts, activity schedules) (Bryant, Bryant, & Raskind, 1998). They can be devices designed specifically for persons with disabilities (alternative and augmentative communication devices) or generic devices developed for the general public to use (cassette tape players, Palmtop PC) (Lewis).

Due to the potential of assistive technology for improving the lives of persons with disabilities (Wehmeyer, 1999) and facilitating participation in society (Parette, 1991), it is no wonder that practitioners are evaluating its use to increase self-management skills. The purpose of this review was to examine the published, empirical literature evaluating assistive technology to assist persons with disabilities to initiate and complete daily tasks. Assistive technology, as a self-management tool, was evaluated as a strategy for controlling antecedents used by persons with disabilities to influence their own behavior (Browder & Shapiro, 1985). The review included studies that used both light tech (picture prompts, picture schedules, recording devices) and high tech devices (Palmtop PC, computer-based systems) to increase self-management skills by transferring behavior control to a prompting device operated by the student.

Method

The purpose of this paper was to conduct a comprehensive review of literature published from over the past 15 years to summarize use of assistive technology as a self-management tool for persons with intellectual disabilities. Electronic and ancestral searches of journals focusing on the education of persons with disabilities were conducted from 1990-2005. The electronic search of ERIC used the keywords: assistive technology, self-management, picture prompts, auditory prompts, tactile prompts, activity schedules, antecedent prompts, prompts, computer-assisted, computer-based, and Palmtop PC, for locating ar-

TABLE 1

Journals Reviewed

Behavior Modification
Education and Training in Developmental Disabilities
Education and Treatment of Children
Exceptional Children
Exceptionality
Focus on Autism and Other Developmental Disabilities
Focus on Exceptional Children
Journal of Applied Behavior Analysis
Journal of the Association for Persons with Severe Handicaps
Journal of Autism and Developmental Disabilities
Journal of Developmental and Physical Disabilities
Journal of Early Intervention
Journal of Special Education
Journal of Special Education Technology
Journal of the Association for Persons with Severe Handicaps
Mental Retardation
Remedial and Special Education
Topics in Early Childhood Special Education

ticles. A manual search was then conducted of the table of contents of the journals listed in Table 1 followed by an ancestral search of the reference lists of the identified articles.

In order to be included in the review, studies met the following criteria:

1. Use of experimental design
2. Publication in peer-reviewed journal
3. Evaluation of assistive technology for self-management
4. Participants were diagnosed with an intellectual disability

Although assistive technology has been shown as an effective tool for teaching new skills (Hagiwara & Myles, 1999; Mechling & Gast, 1997; Norman, Collins, & Schuster, 2001), studies which used trainer-directed cues or instructional prompts were not included in this review which focused on use of assistive technology as an independent prompting device, used by the person alone, rather than a tool for presenting instruction. Nor were studies included which focused on the effects of assistive technology on aberrant behaviors (Alberto, Taber, & Fredrick 1999), social skills (Shabani et al., 2002) and communication skills (Taylor & Levin, 1998).

Results

Forty studies (see Table 2) were identified in addition to one literature review by Post and Storey (2002). The literature review focused on the use of auditory prompting. The technology was primarily visual, auditory, and tactile in nature and devices included: (a) picture prompts (17 studies); (b) audio cassette players (11 studies); (c) hand held computer-based systems (palmtop personal computers) (11 studies); and (d) vibration (1 study).

Identified studies measured the effects of assistive technology on: (a) independent performance of tasks (task completion) (25 studies); (b) task engagement (5 studies); (c) on-task behavior (4 studies); (d) accuracy of task performance (3 studies); (e) initiation of tasks (2 studies); (f) transitioning between tasks (2 studies); and (g) fluency of work performance (1 study).

The review found assistive technology to be effective in teaching task initiations and completion to persons with disabilities. Students were taught to self-operate devices to guide their own behaviors independent of instructor prompts. The first part of the paper reviews each of the identified studies and results of the strategies used while the discussion section addresses questions raised from the current research and suggestions for future research.

Picture Prompts

Pictures as visual supports were the most frequently evaluated form of antecedent prompts (17 studies) and reported to be the most commonly used and economic material (Lancioni, O'Reilly, & Oliva, 2001). Visual supports may provide aids to maintain attention, understand spoken language, sequence events, organize environments, or increase independent task performance by persons with disabilities (Hodgdon, 1995). As defined by Quill (1997), visual cues as environmental prompts, are available to persons with disabilities after external physical, gestural, or spoken adult prompts are faded and may become a permanent reference for completing tasks (Browder & Shapiro, 1985).

Use of picture cues to prompt initiation and completion of tasks can be divided into two

subgroups according to Lancioni and O'Reilly (2001): those which target multi-step tasks and those which sequence activities through a schedule.

Picture cued multi-step tasks. Eight studies were identified using picture cues to prompt students to complete multi-step tasks. Each step of a task analysis is depicted in a picture or photograph and presents the sequential steps comprising a single task (Allen, White, & Test, 1992). Students then look at each photograph prior to or during completing of a step. Picture prompts were demonstrated as effective in increasing vocational or job tasks (6 studies), daily living (1 study), and meal preparation (1 study).

Picture referencing in a study by Martin, Mithaug, and Frazier (1992) provided five students with moderate intellectual disabilities the necessary prompting to independently assemble a 13-step, 31 piece chair. Four of the five students further completed a more complex assembly of a love seat and settee using picture referencing. Students were able to look at a picture prior to attempting a step and self-correct using line drawings.

Use of a photograph task analysis permitted a 40-year-old man with profound mental retardation and atypical psychosis to perform vocational chores (dusting tables, setting a table, and vacuuming) independent of the instructor and to maintain this behavior for six months (Steed & Lutzker, 1997). Johnson and Miltenberger (1996) likewise found that pictures were effective in prompting three workers with mild to moderate mental retardation to complete packaging tasks which were changed daily while Copeland and Hughes (2000) found photographs to be effective prompts for two high school students with severe disabilities to initiate and complete job tasks. Agran, Fodor-Davis, Moore, and Martella (1992) found one of three participants in their study unable to respond to peer delivered instruction until picture prompts (paired with instructor prompts) were added to the task of taking customer orders and preparing a sack lunch. In a comparison study, photographs and line drawings for completing steps of a vocational assembly task were found to be more effective than physical demonstration for students with moderate intellectual disabilities. No difference was found for students

with severe and profound intellectual disabilities (Martin, Mithaug, & Burger, 1990).

Three students with autism were successfully able to use pictures to self-manage their behaviors to complete daily living skills (i.e. setting a table, making a bed) in the absence of an instructor, generalize their behavior across settings and tasks, and maintain behaviors after two months. Color photographs of steps of the task analysis were inserted in a photo book, one picture per page, with a "smiley face" sticker on the last page to prompt self-reinforcement (Pierce & Schreibman, 1994).

In the only study evaluating picture prompts for food preparation, Singh, Oswald, Ellis, and Singh (1995) used a picture based cookbook to prompt three adults with mental retardation to independently prepare a dessert within community-based settings. Follow-up checks spread over 6 months indicated maintenance of task performance using the picture prompts and generalization to a novel setting.

Picture cued activity schedules. Picture activity schedules sequence different daily activities or tasks familiar to the student in order to increase engagement, participation, and independent transitioning from one activity to the next (Lancioni & O'Reilly, 2001). A sequential series of pictures or photographs may further illustrate multiple tasks for completing a more complex activity (Copeland & Hughes, 2000). Persons may follow a preset activity schedule or participate in determining what they want to do and the order in which they will do it (self-scheduling). Nine studies were identified which used picture schedules to increase on-task, task engagement (7), transitioning between activities (1), and task initiation (1).

During classroom center activities, on-task and on-schedule behaviors of four children with high functioning autism improved when a picture activity book was present and decreased when the book was removed during a study by Bryan and Gast (2000) using an A-B-A-B design.

Within both home and school settings, Irvine, Erickson, Singer, and Stahlberg (1992) used picture schedules as a self-management tool to prompt four high school students with moderate to severe mental retardation to ini-

tiate behavioral tasks. Visual daily schedules were used to facilitate transitions for two children with autism at home and in the community using both photographs and line drawings. Portable activity schedules in the form of a photo album and strip of foam board attached to an automobile dashboard resulted in decreased latency between presentation of instruction and time to begin a task and decreased teacher-delivered verbal and physical transitioning prompts (Dettmer, Simpson, Myles, & Ganz, 2000). Likewise, photographic activity schedules were used by MacDuff, Krantz, and McClannahan (1993) to teach four boys with autism to self-initiate leisure activities within a group home setting. Photographs were placed in a three ring binder and participants repeated the steps of turning a page, initiating and completing an activity until three tasks were completed.

An auditory feature was added to a set of picture cards by Lancioni, Brouwer, Bouter, and Coninx (1993). A watch, worn by two adults with intellectual disabilities, emitted an auditory cue at prescheduled times to prompt participants to take a card from a box and perform the scheduled activity. Results indicated that the combination of auditory cues for initiating activities and picture cards describing the activities were effective in increasing activity engagement for both participants.

Parents and classroom assistants have also been taught to use activity schedules to increase the independence of persons with disabilities. Parents successfully implemented photographic schedules within home settings to increase sustained and independent participation of their children with autism in a study by Krantz, MacDuff, and McClannahan (1993) while teacher assistants decreased their use of prompts to encourage three students with varying disabilities to follow photograph activity schedules (Hall, McClannahan, & Krantz, 1995).

Rather than learning to follow an existing schedule, Brown (1991) addresses the importance of designing daily activity schedules with regard to a person's preferences and individual life style including the choices of what to do, what not to do, and when to do it. Two studies evaluated the effects of self-scheduling when using picture activity schedules. In a group home setting, Bambara and Ager

TABLE 2

Overview of Assistive Technology as a Self-Management Tool

<i>Reference</i>	<i>Participants</i>	<i>Self-Management Skill (Dependent Variable)</i>	<i>Design</i>	<i>Results</i>
<i>Picture Cued Multi-Step Tasks</i>				
Agran et al. (1992)	<i>n</i> = 3 CA = 14–16 yrs Moderate, Severe ID	Complete job task at school: make sack lunch	Multiple baseline across participants	2 of 3 students made sack lunches in correct sequence. Generalization across novel customers.
Copeland & Hughes (2000)	<i>n</i> = 2 CA = high school Severe ID	Initiate and complete job task in high school faculty dining room: clean & set tables, sweep	Multiple baseline across participants	Independent task initiations increased. Task completion increased for 2 of 3 students.
Johnson & Miltenberger (1996)	<i>n</i> = 3 CA = adults Mild, Moderate ID	Complete job task in vocational training center: vocational assembly	Multiple baseline across participants and tasks	Photographs effective for 2 of 3 adults. Verbal training alone effective for 1 adult. Generalization & maintenance of self- management strategies & task performance.
Martin et al. (1990)	<i>n</i> = 20 CA = 13–17 yrs Mild, Moderate, Severe, Profound ID	Complete job task in classroom: vocational assembly	Latin Square	Mild, Moderate: photo- graphs more effective than demonstration. Severe, Profound: no difference between photographs and demonstration.
Martin et al. (1992)	<i>n</i> = 5 CA = 15–20 yrs Moderate ID	Complete job task in school room: furniture assembly	Multiple probe across tasks, replicated across students	Picture & video refer- encing more effective than assembly photographs. Picture referencing effective in 13 step assembly task. 4 of 5 students completed more complex tasks with picture referencing.
Pierce & Schreibman (1994)	<i>n</i> = 3 CA = 6–9 yrs Autism	Complete daily living skills in clinic: setting table, making bed, laundry, making lunch	Multiple probe across behaviors, replicated across children	Independent task completion. Generalization across settings & tasks. Maintenance of performance.
Singh et al. (1995)	<i>n</i> = 3 CA = adults Profound ID	Meal preparation in apartment setting: e.g. pineapple mousse	Multiple baseline across subjects	Acquisition and maintenance of multi- step meal preparation.
Steed & Lutzker (1997)	<i>n</i> = 1 CA = 40 yrs Profound ID	Complete vocational chores in com- munity & day center: dusting, setting table, vacuuming	Multiple probe across tasks	Picture prompts effective across vocational tasks.

TABLE 2—(Continued)

<i>Reference</i>	<i>Participants</i>	<i>Self-Management Skill (Dependent Variable)</i>	<i>Design</i>	<i>Results</i>
<i>Picture Cued Activity Schedules</i>				
Anderson et al. (1997)	<i>n</i> = 3 CA = adults Moderate, Severe ID	Engagement in group home daily activities	Alternating treatment	Greater participation for 2 of 3 adults when self-scheduling available.
Bambara & Ager (1992)	<i>n</i> = 3 CA = 31–57 yrs Moderate ID	Engagement in home & community leisure activities	Multiple probe across participants	Increased participation in self-directed leisure activities and diversity of activities using self-scheduling.
Bryan & Gast (2000)	<i>n</i> = 4 CA = 7–8 yrs Autism	On-task & on- schedule for classroom center activities	A-B-A-B withdrawal	Student performance rose with graduated guidance and visual schedule package. Performance main- tained with visual schedule and dropped without it. Performance gener- alized with schedule to novel activities.
Dettmer et al. (2000)	<i>n</i> = 2 CA = 5, 7 yrs Autism	Transitions between activities in home or community	A-B-A-B withdrawal	Decrease latency to begin activities with visual schedule. Decrease in teacher verbal & physical prompts for transitioning with visual schedule for 1 student.
Hall et al. (1995)	<i>n</i> = 2 CA = 7, 8 yrs Fragile X Autism	Classroom aides prompting of students & student engagement in inclusive classroom	Nonconcurrent multiple- baseline	Decrease in multiple prompts used by aides after instruction. Independent engagement improved for both students.
Irvine et al. (1992)	<i>n</i> = 4 CA = 15–18 yrs Moderate, Severe ID	Initiation of school tasks & completion of home chores	Multiple baseline across subjects, replicated across settings	Independent use of schedules at home & school. Maintained use of schedules across both settings.
Krantz et al. (1993)	<i>n</i> = 3 CA = 6–8 yrs Autism	Engagement in home living tasks in child's home	Multiple baseline across subjects	Parents were taught use of photographic schedules. Children's engagement increased with work & play materials

TABLE 2—(Continued)

<i>Reference</i>	<i>Participants</i>	<i>Self-Management Skill (Dependent Variable)</i>	<i>Design</i>	<i>Results</i>
Lancioni et al. (1993)	<i>n</i> = 2 CA = 35, 68 yrs Moderate, Severe ID	Activity engagement in institutional setting	Multiple baseline across subjects	Auditory cues from watch plus box of picture cards increased frequency of independent participation for 1 student. Visual cues introduced for 2 nd student who did not respond to auditory watch.
MacDuff et al. (1993)	<i>n</i> = 4 CA = 9–14 yrs Autism	On-task & on-schedule after school activities	Multiple baseline across participants	Sustained engagement, independent activity change. Generalization to new photographs & group home settings.
<i>Tactile Prompts</i>				
Lancioni et al., (1991)	<i>n</i> = 3 CA = 13–16 yrs	On-task behaviors, “breaks in performance”	Multiple treatment	Breaks in performance reduced for 2 of 3 students.
<i>Auditory Prompts</i>				
Briggs et al. (1990)	<i>n</i> = 4 CA = 14–19 yrs Moderate, Severe ID	Multiple step task completion in home living suite & school gym- nasium: e.g. laundry, cleaning	Multiple baseline across settings & tasks	Independent use of self- operated audio prompting system. Generalized use to new setting. Maintenance of task performance.
Davis et al. (1992)	<i>n</i> = 3 CA = 16–20 yrs Severe ID	Fluency of vocational task performance in community food preparation site	Multiple baseline across participants	Musical tapes with interspersed performance cues increased vocational task fluency.
Grossi (1998)	<i>n</i> = 2 CA = 26, 28 yrs Severe ID	Accuracy of work performance, time spent working at community setting: e.g. cleaning	Reversal	Musical tapes with interspersed auditory prompts increased work performance for each employee.
Lancioni et al. (1995)	<i>n</i> = 2 CA = 13 yrs Mild ID Multiple Disabilities	Independent task performance (cooking) in school kitchen & work room	Alternating treatments	Auditory and pictorial prompting systems equally effective.
Lancioni et al. (2001)	<i>n</i> = 3 CA = 19–22 Mild ID Visual Impairments	Accuracy of task performance in center kitchen, multi-purpose, activity room: food preparation, assembly (wall decoration, table decoration)	Alternating treatments	Single step instructions effective in increasing task performance. Clusters of instruc- tions effective in maintaining high levels of perform- ance. Decrease in performance with removal of system.

TABLE 2—(Continued)

<i>Reference</i>	<i>Participants</i>	<i>Self-Management Skill (Dependent Variable)</i>	<i>Design</i>	<i>Results</i>
Mechling & Gast, (1997)	<i>n</i> = 4 CA = 10–13 yrs Moderate ID	Completion of daily living tasks in school setting	ABAB across two behaviors & 4 students	Combination audio & picture prompting system led to increased number of steps completed independently.
Mitchell et al. (2000)	<i>n</i> = 3 CA = 14–16 yrs Mild ID	Accuracy of vocational task performance completed in bathroom of self-contained classroom: cleaning mirror, sink, toilet	Multiple probe across behaviors, replicated across 3 students	Prompting device used to complete tasks & generalization to novel (faculty) bathroom. Mixed results for maintenance of skills when auditory prompting faded.
Steed & Lutzker (1999)	<i>n</i> = 2 CA = 37, 48 yrs Mild ID Schizophrenia	Task completion in day program setting: making coffee, washing dishes, watering garden	Multiple baseline across behaviors, replicated across 2 adults	“Dramatic” increases in independent task completion. Generalization to untrained settings & maintenance of performance.
Taber et al. (1998)	<i>n</i> = 5 CA = 16–18 yrs Moderate ID	Transition through job tasks at community retail pet store and church	Alternating treatments, multiple probe across settings, with embedded withdrawal	Comparison of single & multiple word prompts produced no significant differences. Both strategies effective in increasing independent task initiations.
Taber et al. (1999)	<i>n</i> = 1 CA = 12 Autism Moderate ID	On task behavior, teacher prompts during classroom writing activity & school cafeteria vocational task	Multiple probe across settings, embedded withdrawal	Significant decrease in # of teacher-delivered prompts. Generalization across settings.
Trask-Tyler et al. (1994)	<i>n</i> = 3 CA = 17–21 yrs Developmental Disability Visual Impairment	Completion of cooking skills within 2 on campus kitchens	Multiple baseline across behaviors	Students completed steps using tape recorded recipes. Generalization to untaught recipes.
<i>Palmtop Personal Computers</i>				
Davies et al. (2003)	<i>n</i> = 40 CA = 18–54 yrs Mild, Moderate, Severe ID	Completion of order-fulfillment tasks at software developers’ office	Beta testing, two-group, within subjects design	<i>Pocket Compass</i> with audio & picture cues effective tool for increasing independence and accuracy on vocational tasks.

TABLE 2—(Continued)

Reference	Participants	Self-Management Skill (Dependent Variable)	Design	Results
Davies et al. (2002a)	n = 12 CA = 19–46 yrs Mild, Moderate ID	Completion of 8- item schedule within software developers' company	Two-group, within subjects design	Palmtop PC with <i>Schedule Assistant</i> software more effective than written schedule for increasing independent performance of vocational & daily living tasks.
Davies et al. (2002b)	n = 10 CA = 18–70 yrs Mild, Moderate, Severe ID	Completion of vocational tasks: pizza box assembly, software packaging	Beta testing, two group, within subjects design	Palmtop PC with <i>Visual Assistant</i> software using audio & picture cues effective tool for improving task accuracy & decreasing external adult prompting.
Ferguson et al. (2005)	n = 1 CA = 14 yrs Asperger Syndrome	Time Management & completion of routine daily tasks at school & home	Multiple baseline across settings	<i>Personal Digital Assistant</i> with alarm & calendar effective in prompting student to complete tasks.
Furniss et al. (1999)	n = 6 CA = 31–47 yrs Severe ID	Completion of packaging & assembly jobs in community work settings	6 single case experiments	<i>VICAID</i> (simplified Palmtop PC) with audio reminder and pictorial line drawings supported higher levels of work accuracy & pace than picture prompt systems.
Hersh & Treadgold (1994)	n = 8 CA = 21–49 yrs Traumatic Head Injury	Completion of tasks at home (take out trash, yard main- tenance), attending meetings, taking apartment key to work, taking medication	AB	<i>Neuropage</i> with vibration text messages effectively provided reminders for participants to complete routine tasks.
Lancioni et al. (2000)	n = 6 CA = 23–47 yrs Severe Develop- mental Disability	Completion of tasks at day program: cleaning, table setting, food preparation	Alternating treatment	Palmtop PC with vibration, auditory prompts, & picture cues was more effective than picture cards as measured by percentage of steps performed correctly.
	n = 3 Selected based on 90% maintenance performance from Study 1	Completion of tasks from Study 1	Alternating treatment	Clustering of picture instructions on Palmtop PC effective for maintaining task performance.

TABLE 2—(Continued)

<i>Reference</i>	<i>Participants</i>	<i>Self-Management Skill (Dependent Variable)</i>	<i>Design</i>	<i>Results</i>
Lancioni et al. (1999)	<i>n</i> = 4 CA = 19–39 yrs Severe ID	Completion of tasks at day program: cleaning, food preparation, table setting	Alternating treatment	Palmtop PC with auditory prompts & step-by-step picture instructions effective for task com- pletion. Presenting instruction in clusters effective for main- taining high levels of performance.
Lancioni et al. (1999)	<i>n</i> = 4 CA = 18–23 yrs Severe ID	Completion of multi-step activities at day program	Alternating treatment	Palmtop PC with auditory prompts, vibration, & pictures resulted in greater % of steps performed correctly, & fewer adult prompts than picture system
Lancioni et al. (1998)	<i>n</i> = 3 CA = 20–36 yrs Severe ID	Completion of tasks at day program: cleaning, table setting, food preparation	Alternating treatment with reversal	Palmtop PC with auditory prompts, vibration, & pictures resulted in significantly higher levels of correct performance on tasks compared to picture card system.
Riffel et al. (2005)	<i>n</i> = 4 CA = 16–20 yrs Moderate, Severe ID Autism Prader Willi Syndrome	Task completion, productivity, & independence on transition related tasks: setting table, rolling silverware in napkins, laundry	Multiple probe across students	Palmtop PC with Visual <i>Assistant</i> software (digital pictures and auditory directions) effective in increasing # of steps completed. Decrease in # of instructor prompts. No change in amount of time to complete tasks.

(1992) used picture schedules of recreational activities each week with three adults with moderate intellectual disabilities. Adults choose picture cards of preferred activities and placed them in a sequenced activity book for each day. All participants learned to self-schedule their own leisure activities, participate in a wider variety of activities, and maintained their performance for up to 6 months after training. Anderson, Sherman, Sheldon, and McAdam (1997) took color photographs of three adults with mental retardation partic-

ipating in housekeeping, personal care, and recreational activities within a group home setting. Adults made active choices about what to put on their schedules. Engagement time increased for participants when schedules were available.

In summary, picture cues as a form of light tech assistive technology, can increase skills for independently participating in activities whether it involves: (a) performance of a multi-task behavior; (b) initiation, participation, or sustained participation in an activity;

(c) participation in a wider variety of activities without reminders or prompts from others; or (d) decreased dependency on adults. Use of picture activity schedules have been shown to: (a) increase understanding of routines and expectations; (b) increase engagement time; (c) promote transition from one activity to the next; and (d) provide opportunities to make choices, and increase control over their daily lives.

What does not appear to be as clear from the available literature is whether the type of picture and/or form of presentation influence these behaviors. Although the majority of studies used color photographs of actual steps or activities (Johnson & Miltenberger, 1996; Pierce & Schreibman, 1994; Steed & Lutzker, 1997) line drawings were also reported as effective tools (Irvine et al., 1992; Martin et al., 1992; Singh et al., 1995). Digital photography and the ability to download images directly to print programs or edit them via personal computers make this form of imagery competitive with the ease of drawing pictures by hand. If there is a possibility that some students may not understand line drawings or may receive more concrete information from photographs, the use of color photographs may begin to dominate the field.

Assuming photographs are the visual image of choice for presenting pictures to students with disabilities a second question is whether photographs should depict finished products or individual steps of a task analysis. Martin et al. (1992) was the only identified study that addressed this issue. Results indicated that video and picture referencing to both be effective tools compared to photographs of completed items. A further question is who should be in the photographs and whether students respond better to seeing themselves performing a task or engaged in an activity (Anderson et al., 1997).

Picture cues have been organized onto poster board (Johnson & Miltenberger, 1996), binders (Steed & Lutzker, 1997), booklets and photograph albums (Copeland & Hughes, 2000), folders, and single sheets of papers with little attention to whether one system may be more effective than another. Questions remain as to how many pictures should be on one page and whether a more active response (touching a picture or turning a

page) may have differing effects than looking at stationary pictures. While Irvine et al. (1992) required students to mark off pictures of completed steps, Johnson and Miltenberger found it necessary for one of three participants to touch photographs in addition to looking at them. Copeland and Hughes found that requiring students to touch the photograph increased initiation of a task step, but not completion of the task. Turning over the picture, however, resulted in greater task completion for both students in the study. Agran et al. (1992) likewise found turning over photographs to be an effective strategy while others (MacDuff et al., 1993) found placing photographs in binders and turning pages to be useful for keeping track of completed steps.

Tactile Prompting

The use of vibration as a self-management tool to prompt persons with disabilities to independently complete tasks has received minimal attention in the literature. Only two such studies were identified. A vibrating pager was used to prompt a student to read a message on the pager and complete daily tasks in a study by Epstein, Willis, Connors, and Johnson (2001) however, the study was conducted with a student with a diagnosis of AD/HD rather than an intellectual disability which is the focus of this review. Lancioni et al. (1991) used a small vibrator connected to a hearing aid ear mold to decrease the number and length of breaks in performance made by three persons with severe intellectual disabilities. The vibrator was wireless and activated by a computer system that registered inactivity. The only other identified studies using tactile prompting with students with intellectual disabilities (autism) focused on verbal initiations (Taylor & Levin, 1998) and social initiations (Shabani et al., 2002). The potential of this form of assistive technology as an antecedent self-management strategy may warrant more attention as either stand alone systems or to prompt students to use a visual prompting system.

Auditory Prompting

Post and Storey (2002) define auditory prompting as any prerecorded antecedent cue

(single or multiple word phrases), which increases the probability that a desired behavior will occur. In their review of the literature they identified nine studies between the years 1990-1999 using auditory prompting by persons with moderate to severe disabilities. In addition to these, three additional articles were identified in the current review (Lancioni et al., 2001; Lancioni, Klaase, & Goossens, 1995; Mitchell, Schuster, Collins, & Gasaway, 2000). Of the eleven identified studies, ten used auditory prompts recorded on portable cassette players with an attached headset worn by the participant. One used a combination of recorded speech and picture overlays on an augmentative communication device to provide visual and auditory prompts (Mechling & Gast, 1997). The majority of the studies (seven) evaluated self-instruction using a task analysis and recorded step-by-step prompts for completing a task. For example, Briggs et al. (1990) recorded a verbal script of 22 steps for operating a washing machine and used a bell tone to signal when to stop the cassette player and perform a step.

Three studies used recorded music interspersed with verbal prompts such as "Keep working," and "Are you working?" to encourage participants to remain on task and complete vocational tasks (Davis, Brady, Williams, & Burta, 1992; Grossi, 1998; Taber, Seltzer, Heflin, & Alberto, 1999). Although only one student participated in the Taber et al. study, results have implications for the use of auditory prompts by persons with autism who are traditionally described as being stronger visual learners.

Taber, Alberto, and Fredrick (1998) compared single- and multiple-word prompts through an alternating treatment design. No significant difference between independent task performance was found however, when workers used multiple-word prompts they had a slightly shorter duration time for transitioning between tasks and more independent task changes than when following single-word prompts. A study by Lancioni et al. (2001) also supports the use of multiple word prompts on auditory systems. They found that self-operated audio systems could successfully present single word instructions corresponding to each step of a task analysis as well as clusters of instructions (i.e. two task steps presented in

succession when "play" was selected on the audio cassette player).

In an interesting comparison study, Lancioni et al., (1995) found no significant difference between the use of picture prompts and auditory prompts for presenting steps of cleaning and food preparation to two adolescents with multiple disabilities. One difference noted in the results was that one participant found manipulation of the picture system to be more difficult due to physical disabilities. Results highlight the importance of an auditory system for persons who may have motor delays. These devices have received only limited evaluation with persons who have visual impairments (Lancioni et al., 2001) or may be non-readers and thus find such a system to be an effective tool for presenting stimulus prompts without an emphasis on visual systems.

Limited concern has been presented about the amount of time to develop the auditory prompting system in comparison to creating line drawing picture systems (Lancioni et al., 1995). Others report ease in preparing auditory systems compared to photograph systems (Mitchell et al., 2000).

A point about the design of auditory systems was raised by Taber et al. (1999) concerning whose voice should be recorded on such systems and would authoritative figures, persons liked, or well known by the student, have differing effects on response. Trask-Tyler, Grossi, and Heward (1994) suggest that the student's voice (i.e. "Have I checked my___?") may be an effective prompt for some.

Another feature to consider is the ability of subjects to replay auditory prompts when needed. Some systems allow the cassette recorder to stop automatically after each prompt and repeat prompts (Lancioni et al., 1995) while less expensive cassette players may not have these features and may be more difficult for persons with severe intellectual disabilities to operate. Such systems may only present a "beep" to cue the student to stop the cassette player. Digital cassette players allow students to start and stop at specific points during the recording.

Mechling and Gast (1997) addressed this issue in their selection of an augmentative communication device to present both visual (photographs on paper overlays) and auditory

(voice recording) prompts on one device to teach multiple steps of home living skills to four students with intellectual disabilities. Students could concretely see which step to complete and hear additional information about how to perform the step. Students could also repeat presentation of information by repressing a photograph for any step of the task analysis and listening again to the information. This form of assistive technology closely resembles the benefits described in the next section, which reports the effects of handheld computers as an antecedent prompting system.

Palmtop Personal Computers

Palmtop personal computers are portable handheld systems that employ features of a touch screen for input and multimedia capabilities (text, sound, digital photographs, and video clips) (Swan, Swan, Van Hover, & Bell, 2002) which have been used to promote self-management by persons with disabilities. Basic use of these devices has included only the features of text, sound, and light. A flashing light, and/or auditory "beep" have prompted students to look at the device displaying a text message. Messages reminded students to: complete tasks within a morning, school, or evening routine (Ferguson, Smith Myles, & Hagiwara, 2005); and attend a meeting or complete daily living skills such as taking out the trash (Hersh & Treadgold, 1994). Each increased independence while decreasing dependence on adult reminders. In a comparison study, Davies, Stock, and Wehmeyer (2002a) found a portable computer system with auditory prompts and text reminders to be more effective in prompting 12 students with mental retardation to perform tasks according to a schedule compared to a traditional written schedule.

Digital images have also been imported onto Palmtop personal computers to provide visual antecedent prompts. Furniss et al. (1999) used line drawings representing each step of a vocational task, along with auditory and vibration features, to prompt students. In addition to showing pictures, the Palmtop aid vibrated or emitted a recorded voice ("Press the key now") to prompt students to use the device or advance to a new step if they were idle for a

pre-determined amount of time. Lancioni, O'Reilly, et al. (1999) evaluated single pictures for each task step and multiple steps clustered into a picture. Step-by-step instructions presented in pictures were effective in prompting completion of tasks such as table setting, food preparation, and cleaning. Results of the second part of the study showed that students were able to maintain high levels of correct responding for these same tasks when instruction was clustered together under picture prompts.

Three separate comparison studies found pictures presented on a Palmtop personal computers to be more effective than pictures presented manually on cards as antecedent prompts for completing such tasks as table setting, food preparation, and cleaning (Lancioni, O'Reilly, Seedhouse, Furniss, & Cunha, 2000; Lancioni, Van den Hof, Boelens, Rocha, & Seedhouse, 1998; Lancioni, Van den Hof, et al., 1999). Students had a higher level of correct performance on task completion when using the portable handheld computer systems. Results were attributed to students mishandling cards and therefore skipping steps of the task analysis and failing to initiate steps when using the manual card system. The portable computer systems used in the studies also included auditory and vibrating features to prompt students to initiate the next step in the task sequence.

Additional information in the form of digital auditory and picture prompts have been delivered to study participants through Palmtop personal computers. Using touch screen features, participants accessed pictures corresponding to steps of a task analysis while hearing a description of how to complete the steps. Using these features, Riffel et al. (2005) decreased the need for external instructor prompts while increasing the number of steps students completed independently. Students further decreased the time for completing vocational and independent living tasks. Likewise, Davies, Stock, and Wehmeyer (2002b; 2003) incorporated digital images of each step of a task analysis and digital recordings of instructions corresponding to each step to prompt completion of vocational tasks. Each study incorporated features that allowed students to repeat auditory step directions when needed by pressing a "Play" or "Start" button

and moving to the next step by pressing a "Done" or "Next" button on the touch screen.

As a newly emerging technology, Palmtop personal computers presently represent the "highest tech" form of technologies used as antecedent prompts for self-management among persons with intellectual disabilities. These systems are commercially available and their use is becoming more prevalent in society, making them socially acceptable and less stigmatizing than systems developed specifically for a person with disabilities (Davies et al., 2002a). Unlike some technologies, the capabilities of Palmtop personal computers will continue to increase (Swan et al., 2002) including software that can be individualized to meet the needs of students.

Similar issues arise when using Palmtop personal computers as when using auditory or picture systems alone. Whose voice should be on the system? What images should appear on pictures? Lancioni et al. (2000) were able to reduce the number of instruction "occasions" by clustering multiple steps into one picture once students reached independent performance with individual steps presented on a Palmtop system. The ability to readily make adjustments in the complexity of antecedent prompts as the learner's performance improves or tasks change has further been described as an advantage to computer-based systems (Lancioni et al.).

The use of computer-based systems compared to paper-based systems such as picture cards, photograph albums, and lists, may hold some distinct advantages. As demonstrated by Lancioni, O'Reilly et al. (1999) and Lancioni et al. (1998) students may lose their place or mishandle manual systems. Computer-based systems may allow better coordination and completion of steps of a task analysis and may decrease the chances that a student becomes lost in the sequence of task (Furniss et al., 1999). Further, auditory cuing can be added to minimize loss of attention to the task (Lancioni & O'Reilly, 2001; Montgomery et al., 1996) by prompting students to initiate the next step or activity. Compared to traditional cassette players, handheld computer-based systems readily provide: (a) repetition of steps; (b) control over auditory and visual cuing (Davies et al., 2002b); and (c) task specific auditory instructions with addition of visual

supports through digital pictures or video clips specific to the task. These features may be important for persons who are not strong auditory learners.

For persons with physical disabilities, computer-based systems may employ a touch screen or be accessed through single switch activation or other assistive devices. Alerting and reminding capabilities of computer-based systems can provide self-cueing, problem solving, and information storage for persons with memory or attentional difficulties associated with traumatic brain injury or intellectual disabilities (Hersh & Treadgold, 1994).

Argued disadvantages of hand-held computer-based systems are the cost and maintenance of devices, but with rapid change in technology, prices will continue to decrease (Davies et al., 2002a; Swan et al. 2002). These systems also require some basic computer skills to set up the devices and select the best system. Although more time is needed initially to set up the systems and personalize them (Davies et al., 2002a), the process of taking pictures and recording audio files is described as very "straightforward" by Davies et al. (2003).

Finally, although Kimball, Kinney, Taylor, and Stromer (2003; 2004) outline instructions on how to create computer-based activity schedules with photographs and video models using *Microsoft Power Point*, to date no research base exists to support this new and creative use of high tech systems in providing students with visual, auditory, and animated cues for following and transitioning between activities or use in other forms of self-management. The promising effects of video prompting for teaching new skills (watching a video segment, making an immediate response, and advancing or repeating a video clip on a computer-based program) (Mechling, 2005) sets the stage for using such a system to create self-management systems within a computer-based program.

Discussion

The purpose of this paper was to review the application of assistive technology to increase the independent, self-management skills of persons with intellectual disabilities through self-prompting devices. Each of the 40 identi-

fied studies reported positive results when using assistive technology as an antecedent prompt for eliciting a target response while reducing the need for instructor prompts. Permanent prompts, whether auditory, visual, or automated, provided the assistance and support needed for persons with intellectual disabilities to participate in everyday activities that they could not perform with total independence. Twelve studies reported generalized responding to new activities or tasks and fifteen reported prompting strategies that guided and maintained performance over time.

Research has shown that assistive technology can facilitate learning, increase access, and serve as a tool to compensate for specific challenges associated with a disability (McGregor & Pachuski, 1996). The question appears to no longer be whether assistive technology can benefit persons with disabilities, but rather how best to use it and how it can be improved. The challenge for many educators is to remain abreast of technology. Many interventionists remain unaware of the types of devices available (Wehmeyer, 1999) and the varying uses outside those identified by the manufacturer. Barriers to funding and lack of information prevent proper identification and use of devices (Wehmeyer) and teachers continue to express concern about equipment complexity and lack of support and training (McGregor & Pachuski). It does little good when assistive technology devices are kept on a shelf or in a closet because practitioners do not know how to use them. Since its early inception, technology has become smaller, cheaper, more powerful, and easier to use (Lewis, 1998), yet in spite of these benefits and steadily decreasing costs, persons with intellectual disabilities continue to underutilize assistive technology (Wehmeyer).

A continued challenge is to examine applications of various technologies to determine which properties are the most beneficial and suitable to different individuals (Lancioni & O'Reilly, 2001; Lewis, 2000). One system does not fit all and future research and application may need to examine students' characteristics that relate to the effectiveness of one procedure over others. For example, students with autism are characterized as being stronger visual learners (Quill, 1997) which supports the

use picture systems or automated systems incorporating digital images. Language or intellectual disabilities may hinder the use of strictly auditory systems while persons with attentional difficulties may require auditory cuing, and those with physical disabilities may have difficulty manipulating picture systems. Martin et al. (1990) found that while photographs and line drawings were effective self-management tools for persons with moderate intellectual disabilities, there were no differential effects between these systems and physical demonstration for persons with severe and profound intellectual disabilities. Multiple use and forms of assistive technology make it a promising avenue for meeting the individual and diverse needs of learners. Its potential for providing additional, animated information, incorporating video and multi-media features may further address the unique and multiple learning styles of persons with disabilities.

Just as one system does not fit all, even one system may not permanently fit each person. Even as a person's independence increases, it may not be appropriate to remove the system, yet it may not be appropriate to continue the identical system. A learner may need a more advanced system which can: (a) adjust with learning of a task; (b) provide fewer prompts; (c) cluster steps under one visual prompt (Lancioni, O'Reilly, et al., 1999); or (d) combine auditory prompts into multiple messages. Use of assistive technology as a form of antecedent prompting can address the need for systems to adjust as student needs change.

The nature of the task may also influence the effectiveness of one form of prompting over another. Nailos, Thomas, Whitman, and Maxwell (1994) found that students performed better with verbal-visual instructions when tasks were familiar to them, but visual cues alone were more effective when task stimuli were unfamiliar to the student. Attention needs to be paid to matching the most effective strategy to the task and the learner in order to promote independence across environments.

In conclusion, this review supports the current use of assistive technology as a self-management tool and recognizes the need for further expansion of its use as the field of technology continues to evolve. There ap-

pears to be a need for careful consideration of the capabilities of assistive technology as stimulus prompts that can be self-operated by individuals with disabilities. Creative applications should continue as persons with disabilities seek means to exert control over their lives, decrease dependence on others, and promote greater inclusion in community settings and daily activities.

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