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ORIGINAL PAPER

Using a Personal Digital Assistant to Increase Completion of Novel Tasks and Independent Transitioning by Students with Autism Spectrum Disorder

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Abstract The purpose of this study was to evaluate the use of a Personal Digital Assistant with multiple prompt levels to increase completion of novel task boxes and transitioning within and between tasks. The study used a multiple probe design across three sets of task boxes replicated with three students with a diagnosis of autism spectrum disorder. Results indicated that: task completion was higher for two of the students compared to baseline conditions using a picture-based task strip; all students were able to complete a greater number of between task transitions using the PDA; students performed within task transitions equally as well using the PDA and the task strip; and one student began to self-fade use of more intrusive prompt levels.

Keywords Personal digital assistant · Video prompting · Hand held self-prompting system · Autism · TEACCH

Introduction

A critical skill for students with autism spectrum disorder (ASD) is the ability to function independently throughout the day which includes moving from one location to the next and completing tasks within those locations (Carnahan et al. 2009). However, movement towards independence and away from adult prompting has been shown to be problematic for children with ASD (Hume 2004). Researchers and practitioners continue to explore strategies to increase the ability of persons with disabilities, including ASD, to establish independence including completion of tasks and following daily routines (Mechling 2007). Antecedent self-management strategies or self-operated procedures are one means for increasing independence while decreasing the need for external prompting by others. When used independently, these antecedent self-management strategies, also referred to as self-operated prompting systems or personal support technologies (PST), (Braddock et al. 2004; Larkin and Turnbull 2005), may be used to: (a) prompt completion of a multiple step task such as preparing a recipe; or (b) follow a sequence of separate tasks (i.e., daily job or school schedule) and transition between those tasks (MacDuff et al. 1993). Schedules for completing daily activities are typically referred to as activity schedules and include a string of photographs, images, drawings, or text representing the routine and are sequentially arranged on some form of display (i.e., notebook, wall, desk, or computer) (Banda and Grimmett 2008). These visual displays provide concrete and permanent examples that may be particularly beneficial to persons with ASD who may have difficulty processing auditory information and therefore respond more positively to a visual system (Quill 1995). These systems may be used by an instructor or caregiver to visually direct a person with ASD or followed independently by the user without external adult prompting.

Traditionally, activity schedules and visual task analysis have been in the form of light tech, picture-based systems presented in a small notebook or desk top schedule (Banda and Grimmett 2008; Banda et al. 2009; Bryan and Gast 2000; Carson et al. 2008; Dettmer et al. 2000; Dooley et al. 2001; Lee 2006; MacDuff et al. 1993; Massey and Wheeler 2000; Mechling 2007; Pierce and Schreibman 1994; Spriggs et al. 2007) although some reports and research

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exist whereby computers and video-based systems have been used to present schedules (Dauphin et al. 2004; Kimball et al. 2004; Rehfeldt et al. 2004; Stromer et al. 2006) and multiple step tasks (Cannella-Malone et al. 2006; Graves et al. 2005; Mechling et al. 2008; Mechling and Gustafson 2008; Norman et al. 2001; Sigafoos et al. 2005).

Recently, researchers have begun to evaluate use of portable digital assistants (PDAs) as self-prompting devices for transitioning within (Cihak et al. 2007; Davies et al. 2002, 2003; Furniss et al. 1999; Mechling et al. 2009, in press; Riffel et al. 2005) and between tasks (Cihak et al. 2008). Between-activity schedules facilitate task-to-task movement such as between each activity of the day or travel between learning centers, while within-activity schedules facilitate a student's actions during the task (i.e., answer the first, second, and third question on a worksheet or completion of each step of a cooking recipe) (Banda et al. 2009; Lee 2006). Researchers have further begun to evaluate the inclusion of video on these portable self-prompting systems to support independent task completion by persons with disabilities. Taber-Doughty et al. (2008) as well as Van Laarhoven et al. (2007) used video modeling procedures (watching a video recording of the entire task followed by immediate performance of the task) to prompt task completion by students with disabilities while Mechling et al. (in press) and Mechling et al. (2009) used video prompts to present information to students on a PDA. In comparison to video modeling, video prompting provides a prompt (i.e., picture or video clip) of one step of a task analysis or activity and the student performs that step before returning to the system to receive information for the next step or cluster of steps. In the two studies by Mechling and others, the PDA provided a combination of photographs, video clips, and photographs + auditory prompts to promote independent completion of cooking recipes.

Similar to Mechling et al. (2009, in press), the current study sought to evaluate a combination of prompt levels, however it did so when students were presented with novel tasks within the TEACCH framework (Treatment and Education of Autistic and Communication Handicapped Children) (Mesibov et al. 2005). The TEACCH program has been reported in the literature as an effective strategy for working with students with ASD (Carnahan et al. 2009; Hume 2004; Hume and Odom 2007; Mesibov et al. 2005; Panerai et al. 1997, 2002) across a range of: cultures [i.e., China (Tsang et al. 2007) and Greece (Siaperas and Beadle-Brown 2006)]; environments [i.e., residential facilities (Siaperas and Beadle-Brown), homes (Ozonoff and Cathcart 1998), and job sites (Keel et al. 1997)]; activities [i.e., meal time, personal care, and outdoor activities (Siaperas and Beadle-Brown) and toileting (Boswell and Gray 1999)] and ages [i.e., adults (Siaperas and Beadle-Brown) and children (Rao and Gagie 2006)].

This study sought to extend previous research by combining the use of photographs, video, and auditory prompt levels on a portable PDA to prompt both within and between task transitions and task completion within a TEACCH, structured teaching setup using novel structured work tasks. Although other studies have evaluated use of each of these individual components within the domain of a visual schedule, no study to date has been conducted using combined prompts on a portable system to promote independent task completion and transitions both within and between tasks.

Within the realm of "task boxes" teachers may find themselves limiting variability across tasks in order to promote independence. For example, teachers may use the same file folder activities repetitively because students understand the format of the particular task and they seek to minimize prompts during independent work time. In contrast, use of novel tasks, with only a picture-based system, may require demonstration of new tasks by the teacher in order for students to understand how to approach the task. Although students may have mastered a concept (i.e., color matching), they may not understand the format of the task when variability and novelty is provided (i.e., sorting color disks into compartments of a box compared to stacking pegs by color). Therefore, a further purpose of the current study was to investigate the effect of a PDA with video, pictures, and pictures + audio prompt levels on completion of *novel* tasks.

Data from previous studies suggest that students may be able to complete more steps independently correct when using video prompting compared to static picture prompts whereby use of video has been shown to provide more information to students and to promote independent task completion without teacher instruction (Mechling and Gustafson 2008, 2009; Mechling and Stephens 2009). Further, researchers have reported the importance of providing a range of prompting options rather than resorting to one single prompt level or system (Mechling and Stephens 2009; Taber-Doughty et al. 2008; Van Laarhoven and Van Laarhoven-Myers 2006). With a combined system, students may initially use more intrusive levels of prompts for unfamiliar tasks or difficult task steps and self-fade these levels of prompts (i.e., video to photos) as they become more familiar with a task. Students may also re-institute use of more intrusive prompt levels with tasks performed infrequently. Indeed, Mechling et al. (2009, in press) found that students self-adjusted the level of prompts that they used on a PDA when video, picture + auditory, and picture only prompts were available.

For the current study the primary research questions were:

1. Using a PDA with multiple prompt levels within the TEACCH frame work of structured teaching, will students with moderate ASD independently: (a) transition from work station task box to task box (*within* task); (b) transition from an independent work station to another activity (*between* tasks); and (c) complete novel tasks; and
2. Will students self-adjust or choose the level of prompting needed when using the PDA with multiple prompt levels?

Method

Participants

Three middle school students (two males and one female) with a diagnosis of autism spectrum disorder (ASD) participated in the study. Each student met the school system's diagnostic criteria for a diagnosis of ASD and eligibility for special education services. Each received special education services in a separate classroom setting for students with ASD and were selected based on their need to follow the elements of structured teaching under the TEACCH model. In addition, middle school age students were the focus of the study due to their need to work independently. Because of their age, diagnosis, and special education placements, each had prior experience using picture-based systems. Each student utilized an individualized picture-based activity schedule to prompt transitions between activities and task strips to prompt independent task completion. The systems had been in place for 3 years in the current placement for each student and had been introduced during elementary school. Students were reported and observed to have mastered fine motor and cognitive skills required of the task boxes. These included: (a) pincer and palmer grasps; (b) the ability to lift, squeeze, twist, insert, stack, and release objects; (c) color, letter, and number matching; (d) one-to-one correspondence; (e) patterning; (f) basic math skills (i.e., counting objects, matching numeral to set and set to numeral). In addition to these pre-requisite skills, parental permission was obtained for each student prior to inclusion in the study.

Daryl was a 14 year, 4 month old male diagnosed with autism at the age of 4 years, 3 months and a moderate intellectual disability (IQ 45, Wechsler Intelligence Scale for Children–Third Edition (WISC-III): Wechsler 1991; Adaptive Behavior Composite Score 71, Vineland Adaptive Behavior Scales: Sparrow et al. 1984). His score on the Childhood Autism Rating Scale (CARS) (Schopler et al. 1988) was 45. He spoke clearly in complete sentences and continued to add new verbs and nouns to his vocabulary. For example, he was observed making the following statements which correctly related to the context: "Where are you going after this?" "Do you like the computer?" and "I like working with you." He followed one and two step directions, requested materials, and recently began to ask questions when he didn't understand something. He enjoyed group activities and served as a role model for other classmates. He was very observant of others' actions and loved to talk about things going on around him and about pets. He was described as being kind, eager to please, and friendly towards adults who he often approached and asked about their pets. He followed a written schedule throughout the school day which he typed on a computer using a hunt and peck procedure. He was also able to type personal information such as his birthday, social security number, and phone number. He read using sight word recognition strategies rather than phonetic skills and was able to read on a 2nd grade level. Daryl could rote count and identify numerals to 100 and add and subtract using a calculator. He was also able to identify names and values of coins and bills. His gross motor and fine motor skills were described as functional for his academic environment and he was independent in dressing, toileting, and eating at school. He completed file folder activities and assembly tasks in his independent work area. He continued to need improvement with receptive and expressive language skills, to verbally answer wh questions, and to follow oral and written directions with up to 8 steps during a structured group activity. His needs also included counting coin combinations up to $1.00 and counting up to twenty dollars using one, five, and ten dollar bills. His needs in math also included counting by fives and using a number line to identify numerals which were more or less. He was working on reading and spelling basic sight words using a monthly 10 word spelling list, completing fill-in-the blank reading comprehension questions, and reading a modified newspaper and lunch menus. Socially his needs included describing the moods and feelings of others and himself.

Alison was a 14 year, 10 month old female diagnosed with autism at the age of 5 years and a moderate intellectual disability (IQ 47, Wechsler Intelligence Scale for Children–Third Edition (WISC-III): Wechsler 1991; Adaptive Behavior Composite Score 40, Vineland Adaptive Behavior Scales: Sparrow et al. 1984). Her score on the Childhood Autism Rating Scale (CARS) (Schopler et al. 1988) was 34.5. She used a voice output, augmentative communication device with multiple levels for oral communication, but attempted to vocalize some familiar words and phrases that were displayed on her device. The augmentative communication device contained up to 12 icons per overlay and she was able to navigate between two levels and to understand and use abstract symbols on the overlays. She independently followed up to three step directions and

was eager to please, friendly and cooperative. She possessed a good sense of humor and liked to laugh with others and receptively understood jokes and humor. Overall she preferred solitary activities and sometimes pushed away materials if frustrated or upset. She required a picture/word schedule for following classroom routines and a structured/organized classroom. She could write her first and last name and copied personal information using a template for spacing and letter size. She matched sight words to corresponding word pictures, and was able to identify letters a–g, color words, and days of the week in print. She was able to match numerals 1–10 to objects and objects to numerals. She used the restroom by herself and dressed independently including fasteners. She completed simple work tasks without prompting in her independent work area. Alison's needs included answering wh questions (who, when, where) using her augmentative communication device and following a multi-step work task with visual directions. Needs further included identification of letters h–z, identifying 50 new sight words, placing numbers on an analog clock, identifying minute and hour hands, telling time on the hour, identification of coins and dollar bills (1, 5, 10, 20), and counting from 0–20 using her AAC device. She further needed to increase the complexity of tasks she completed independently and length of time she worked alone.

Denny was a 14 year, 11 month old male diagnosed with autism at the age of 7 years and a moderate intellectual disability (IQ 54, Wechsler Intelligence Scale for Children–Third Edition (WISC-III): Wechsler 1991; Adaptive Behavior Composite Score 35, Vineland Adaptive Behavior Scales: Sparrow et al. 1984). His score on the Childhood Autism Rating Scale (CARS) (Schopler et al. 1988) was 36. He also had a diagnosis of AD/HD and took the medications Clonidine, Concerta, and Risperdal. Of the three study participants, Derek exhibited the most challenging behaviors. He demonstrated aggressive outbursts towards staff and students, non-compliant behaviors, and became quickly upset. His recent functional behavior analysis determined that refusal behaviors occurred in community or school environments when he was directed to do something he didn't want to do or understand and that these behaviors escalated into unsafe behaviors. Due to behavioral concerns he was on a reduced school day. His attention span varied depending on the activity, noise level, and frequency of distractions, but he was described as being easily distracted with poor concentration skills. He also engaged in sensory seeking activities, liked hugs, vacuum cleaners, cleaning, helping around the classroom and school, and looking at sales flyers containing vacuum cleaners. He was able to speak in complete sentences although he frequently perseverated on a topic. For example, he was observed making the following statements which correctly related to the context: "I want to work with you today" and "There's the picture of me" however, he made statements such as, "Do you like hotdogs?" and "I'm scared of the dog" which were out of context and perseverative in nature. Receptively he could follow one and two step directions if his attention to the speaker and task was gained. He was able to read simple sight words, functional words, and safety symbols. He wrote using an adapted pencil grasp and weighted pencil, but could write and type his first name independently. He was able to match and identify colors, shapes, and numbers. His gross motor skills were delayed and evident by difficulty with coordination, hopping, skipping, and climbing. Likewise, his fine motor skills were delayed and evident by difficulty with letter formation, manipulative skills, and bilateral hand writing activities. He could zip, tie his shoes, use the bathroom, and eat lunch independently. He used a picture and word schedule to follow daily routines, required an organized, structured classroom and structured work system, calm space, and sensory breaks. In addition to his behavioral skills, his needs included following 1 and 2 step directions, answering wh questions with 1–4 word responses, and improving listening skills. His academic needs included writing his first and last name, increasing his sight word vocabulary up to 100 words, choosing correct pictures from a field of three to answer comprehension questions, counting objects and matching objects with written numerals, and functionally using money. He further needed to increase his independence during work time and to follow written or verbal direction to complete tasks.

Setting and Instructional Arrangements

Pre-training, probe, and intervention sessions were conducted in a self-contained, middle school classroom for students with low to moderate functioning ASD. The classroom modeled the Division TEACCH program of structured teaching and included visual schedules, independent task completion (work time) with structured work systems, and one-to-one instruction of new skills. Students completed independent work sessions in blocks of 30 min, one time per day (morning and/or afternoon).

During structured independent work sessions, students were seated in individual desks with a wall in front of the desk, a bookcase with work materials to their left, and the back of a bookshelf to their right. Materials were placed in separate task boxes labeled with random numerals 2–29. Each student worked individually and completed four task boxes per session. Students used individual picture-based activity schedules, which were already in place prior to the study, to prompt them to the work area and to the next activity following completion of receiving reinforcement after the four work tasks were completed. The instructor

and reliability data collector (when present) sat behind the student desks.

Materials and Equipment

Commercially designed, structured task boxes used in the study were selected from *SHOEBOX TASKS* (Larson 2009), *Academic Work Activities, and Pre-Voc One* (Attainment Company 2005–2009). Tasks were selected which required skills previously mastered by each student, yet were novel (not attempted or seen) to each. The selected tasks (Table 1) included: color, number, shape, and letter matching; assembly; packaging; sorting; fine motor skills for using tongs, stretching, lacing, sliding, lifting, squeezing, inserting, stacking, and twisting; one-to-one correspondence; matching amount to numeral; and patterning. Twelve tasks were divided into three sets, four tasks per set. Four work tasks were completed per session in keeping with the format already established in the classroom when completing structured tasks.

Reinforcing stimuli were identified through teacher interviews and observation of students prior to the study when stimuli were used to reinforce task completion and correct responding. Students were observed interacting with sensory (i.e., tactile, light, sound) manipulatives during their completion of academic (i.e., rote counting, sight word reading) and fine motor tasks (i.e., writing name, cutting) with the classroom teacher. Based on task completion and accuracy, reinforcers were selected which provided similar sensory input to those used during one-on-one instruction with the classroom teacher. Photographs were taken of the reinforcing items and activities using a Cannon ZR 830 digital video camcorder and placed on the task strip and the multi-level prompting PDA as described below. Reinforcers were novel to the student and had not been used as reinforcement prior to the study.

During the probe condition, a task strip was placed at the top center of the student desk, with 2 in. numerals cards, in black font, velcroed to the strip to indicate the tasks to be completed. A photograph of a pre-selected reinforcer was velcroed at the end of the schedule (Fig. 1). Students used the task strip in a left-to-right format in which number cards were removed from the strip and placed on a velcro strip on the front of each corresponding task box (Carnahan et al. 2009).

Table 1 Task box descriptions by set

Set A	Set B	Set C
Color match sequence[a]	Closure[a]	Match, Assemble, Package[a]
Positive attraction[a]	Stretch[a]	Pipettes[a]
Lacing[a]	Money packaging[b]	Clock setting[b]
Pencil packaging[b]	Highlight pen packaging[b]	Plastic pipe assembly[b]

[a] ShoeboxTasks

[b] Attainment Company

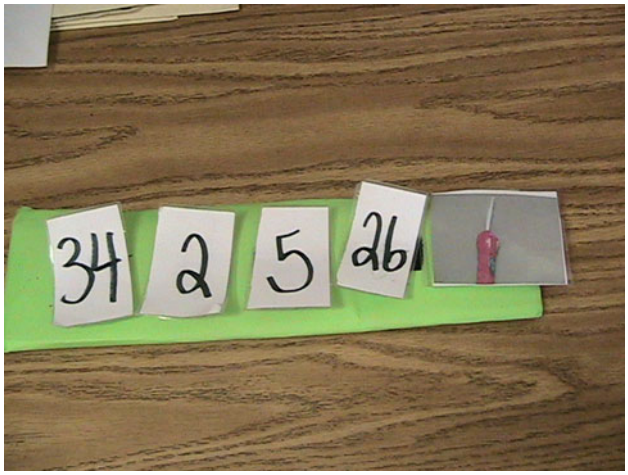

Fig. 1 Picture-based task strip

A Cannon ZR 830 digital video camcorder was used to make all video recordings and still photographs. Video recordings for the task boxes (within task transitions) were made showing only the hand of an adult model demonstrating how to perform each task box. Video recordings for transitioning to the reinforcement area (between task transitions) were made using a first person perspective or subjective point of view as if the student watching the video was locating the reinforcer (Shipley-Benamou et al. 2002). During video recordings, a voice over procedure was used to record directions (verbal prompts) provided by the person operating the camera.

During PDA intervention sessions, the PDA was positioned at the top center of the student's desk. *The Cyrano Communicator TM* (Pidion BM-150R with pre-installed software by One Write Company) was the PDA used in the study. Although the primary function of the PDA and software was to serve as a portable augmentative communication device, the pre-installed software allowed for importing of pictures and video directly onto available templates, hyper linking of slides, and recording of auditory prompts directly onto a slide. Except for the first and last slides, the template selected for the current study contained four blocks (Fig. 2) and students activated blocks by touching them with a stylus. The first slide on the PDA contained two blocks (Fig. 2). A photograph of the pre-selected reinforcer was placed on the slide along with a forward arrow icon pointing to the right and an auditory prompt which said, "next" when the block was touched. This block was positioned in the bottom right corner and linked to the next presentation slide (first task box).

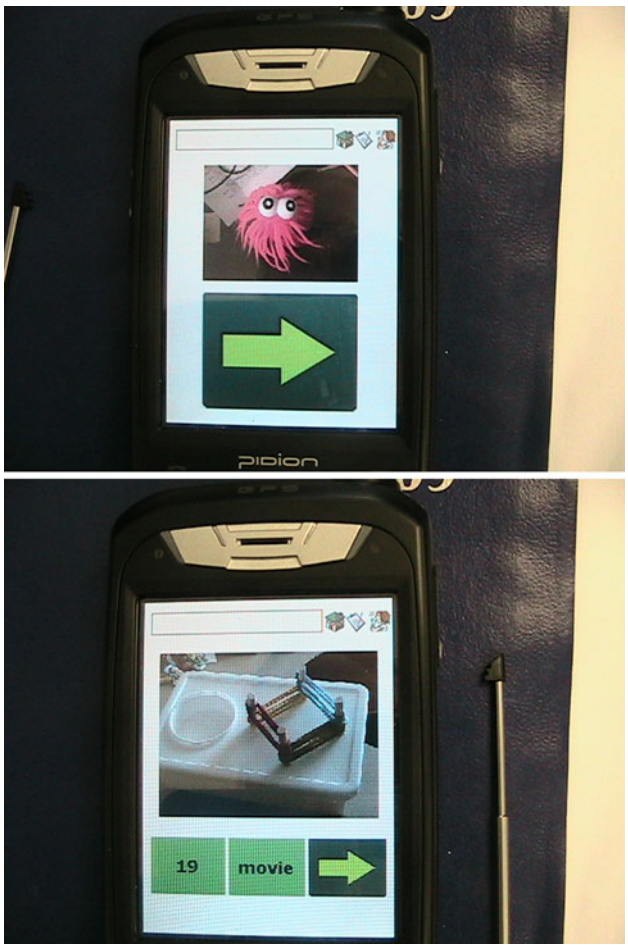

Fig. 2 Example of first slide of PDA with reinforcer and sample prompting page on the Cyrano Communicator™ PDA

On the next four slides, the top block was the largest block and contained a photograph showing a completed task box. An auditory prompt was recorded directly onto the block and played when the picture block was touched by the student (i.e., "match the colors"). The left bottom block contained a numeral icon corresponding to the target task box. An auditory prompt was recorded directly onto the block and played when the numeral icon was touched by the student (i.e., "Get the number ____ box"). The middle bottom block contained a video icon and linked to a video clip demonstrating completion of the task box. The video caption played immediately when the icon was touched, using TCPMP Movie Player. After the video caption was completed, the video stopped and the program automatically returned to the presentation slide. The right bottom block contained a forward arrow icon pointing to the right and an auditory prompt which said, "next" when the block was touched. This block also linked to the next presentation slide which contained prompts for completing the next task box. Four tasks were completed in this format. A student could refer back to a picture prompt, touch a picture on a page to hear the auditory prompt repeated, or touch the video block and replay the video recording as often as needed until the task was completed. The fifth presentation slide was linked to the last (sixth) slide which prompted the student to transition to the next activity area (*between* task transition). The sixth (last) slide presented on the PDA contained two blocks. The top block contained a photograph of the reinforcing item, pictured in its designated area, to be received by the student. An auditory prompt, "Finished, get the ____" was recorded directly onto the picture block and played when the block was touched by the student**.** The bottom block contained a video icon and linked to a video clip of the camera (first person perspective) locating the reinforcer. This slide did not contain an arrow block. Instead, after completion of the reinforcing activity the teacher prompted the student to, "Check your schedule," to return to the classroom picture-based activity schedule.

Experimental Design

A multiple probe design across three sets of novel structured work tasks (4 tasks per set) and replicated with three students was used to determine the effects of a PDA with multiple levels of prompts (video, picture + auditory, and picture prompts) on transitioning between and within tasks and the completion of *novel* tasks (Gast 2009). The PDA was operated individually by each student and used to deliver all prompts for task completion. One set of work tasks was performed during each session and only one session was conducted per day in the morning 4–5 days per week. Experimental conditions occurred in the following sequence: pre-training use of the PDA, probe without the PDA using a task strip (three sets of work tasks), PDA prompting (first set of work tasks), probe without the PDA using a task strip (three sets of work tasks), PDA prompting (second set of work tasks), PDA prompting probe (first set of work tasks), probe without the PDA using a task strip (three sets of work tasks) and so on. Subsequent probe sessions with the PDA and the task strip for previously introduced sets of work tasks were conducted to evaluate maintenance.

Dependent Variables and Recording Procedures

Task Completion

Effects of the PDA intervention were evaluated through measures of task completion. Task completion was defined as completing the assigned structured tasks during the 20 min independent work session. Three dependent measures were used to monitor task completion: number of work tasks completed correctly during the work session,

duration time for completing the four work tasks, and the number of instructor prompts for redirecting off-task behaviors. Task boxes were recorded as being completed correctly when all pieces and parts were manipulated and/or placed in the appropriate location within 5 min (i.e., colored chips placed in the correct pattern) (Hume and Odom 2007). Duration was recorded by the instructor writing start and stop times on the data collection sheet. Start time was recorded when the student placed the first task box on the desk and stopped when the student placed the last task box in the "finished" area.

Because one of the purposes of the study was to evaluate the effectiveness of the PDA with multiple prompt levels to prompt students to independently complete novel tasks, no prompts or instructions were provided by the instructor for completing the task boxes during probe or intervention. Prompts were provided only for off-task behaviors. Using the system of least prompts, teacher prompting was defined as a verbal, gestural, proximal, or physical prompt used to direct a student back to the task (Hume and Odom 2007). Teacher prompting was used in response to a student's off-task behavior with duration of more than 5 s. Definition of off-task behavior was defined partially based on those of MacDuff et al. (1993) and defined as: (a) using task materials for purposes other than completing the task; (b) using any non-task related materials; (c) engaging in any self-stimulation, stereotypical, or tantruming behaviors; or (d) failure to use any materials or engage in the task. Five-seconds were allotted before a prompt was delivered to allow for minor distractions and to encourage students to self-direct back to the task. The instructor then used the system of least prompts to prompt the student back to the task. Procedures for delivering prompts were identical to those used to prompt within and between transitions with the addition of using a proximal prompt (movement towards the student) before applying a physical prompt. If a student failed to complete a task correctly within 5 min, the instructor stopped the task and placed the task box in the finished area and said to the student, "Finished with number ___."

Prompt Level on the PDA

The PDA prompt level used by students to complete each task box was also recorded in order to answer the research question, "Will students self-adjust or choose the level of prompting needed when using the PDA with multiple prompt levels?" Following the model of the system of least prompts (SLP) the student could touch and/or look at the numeral icon on the PDA corresponding to the task box, obtain the task box and complete it without further prompting from the PDA (independent), look at the photograph of the completed task on the slide and complete the task box (picture only), touch the photograph and hear an auditory prompt (i.e., "Put the water into the bottles") (picture + auditory), and/or touch the video block and watch a video caption of the task being modeled along with a verbal description of the task (video). Students could also repeat use of a prompt level. Data were recorded for the most intrusive prompt level used by the student during completion of the task box.

Within Task Transitions

Within task transitions were defined as those behaviors required for moving from one structured task box to the next task box. Event recording was used to record the number of times a student independently transitioned from task box to task box. An independent transition was recorded when a student physically started the next task box after completion of the previous task box without being prompted by the instructor. Completion of a task box was defined as initiating putting the task box in the finished area (box to the right of the desk) within 3 s after completing the task and placing the task box in the finished area within 5 s of its completion. Starting the next task box was defined as initiating within 3 s and removing the correct task box from the shelf within 5 s following picking up the numeral from the task strip (probe) or touching and/or looking at the numeral on the PDA (intervention). For the first task box an independent transition was recorded when the student removed the correct task box from the shelf and placed it on the desk following entering the independent work area and referring to the task strip (probe) or PDA (intervention) using the same time frames for initiation and completion. Teacher prompting was defined as a verbal, gestural, or physical prompt used to direct a student's completion of the transition (Hume and Odom 2007). The instructor began with a verbal prompt such as, "Get the number _____box" or "Put the number ___ box on the desk." After 5 s the instructor repeated the verbal prompt and pointed or motioned to the task box or desk (gesture). Failure to complete the task within 5 s resulted in the repetition of the verbal prompt paired with hand-over-hand or other physical prompts to direct the student to the task box or placement of the task box on the desk.

Between Task Transitions

Between task transitions were defined as those behaviors required for moving from the independent work station to receiving reinforcement for completion of the four structured work tasks. Event recording was used to record the number of times a student independently transitioned from the independent work station and located the reinforcer. An independent transition was recorded when a student

physically initiated movement to the location of the reinforcer within 3 s and located the reinforcer (different containers) within 5 s of removing the reinforcement picture from the task strip (probe) or touching and/or looking at a prompt on the PDA (intervention) and started interacting with the reinforcing activity or material without being prompted by the instructor. Using the system of least prompts procedure, instructor prompt levels and procedures were identical to those used for within task transitioning.

Pre-training Procedures

Students were already fluent with operation of the task strip (including reinforcement pictured at the end of the task strip) used during probe conditions and the picture-based activity schedule used to transition them to the independent work station. However, prior to the first probe session, students participated in pre-training sessions in order to learn how to operate the PDA with multi-level prompts. The self-prompting PDA followed the same format as that used during the intervention condition. Students were taught individually how to operate the different functions of the PDA using a stylus. These functions included: (a) touching and/or looking at the numeral block and selecting a corresponding folder; (b) looking at a picture prompt; (c) touching a photograph or icon to hear an auditory prompt; (d) touching the video block to watch the video prompt; and (e) touching the arrow block to advance to the next presentation slide. Pre-training, using a system of least prompts procedure, continued until a student was able to independently operate all functions of the device to complete 3 file folder coloring activities.

General Procedures

Independent work sessions were conducted identically to those already established prior to the study. Blocks of 30 min were scheduled one time a day for independent work sessions. Students used their individual picture-based activity schedules, already in place, for transitioning to the independent work station. Each student was presented with four work tasks to be completed independently within one work session. Students were presented with concepts they had mastered during one-to-one instruction with the classroom teacher, but had not attempted to complete during their independent work time (Table 1). Identical tasks were presented in each condition of the study and the order of task presentations varied within each session. Each task box was labeled with a different numeral placed on the front of the box. Target boxes, corresponding to numerals on the task strip (probe) or PDA (intervention), were removed from a bookshelf and placed on a desk by the student. Upon completion of the task box, students placed the box in a separate "finished" box to the right of the desk. Five minutes were allotted for completion of each task box (total of 20 min) with approximately 10 min remaining for interaction with the pre-selected reinforcing material. If a task box remained incomplete after 5 min, the instructor stopped the task, removed the materials, placed the task box in the finished area, and said, "Finished with number _____." Students were required to attempt completion of four tasks during independent work time prior to leaving the work station.

Probe Procedures

The first probe condition served to evaluate each student's ability to complete the three sets of work tasks prior to introduction of the PDA with multi-level prompts. Use of a task strip was already in place prior to the study. Because students were familiar and accustomed to use of light-tech organizational aids, they were not altered during baseline probes in order to evaluate each student's best performance on the tasks prior to intervention. Initial probe sessions were conducted individually with each student for a minimum of three sessions per set or until data stabilized. Subsequent probe conditions without the PDA system were conducted for one session per set immediately following use of the PDA with a particular set of tasks (Probes 2–4).

A tangible reinforcer was selected in advance, by the instructor, and the representative photograph was placed on the far right end of the task strip where the student could see it upon entering the work station (Fig. 1). The student started at the left of the task strip and: (a) removed the first numeral card; (b) matched it to the task box (placing the card on a Velcro strip on the front of the box); (c) removed the box from the shelf and placed it on the desk; (d) completed the task; and (e) placed the completed task box in the "finished" box to the right of the desk. When four tasks were completed in this manner, the student removed the photograph card of the reinforcer from the task strip and located the item which was placed in one of five locations.

PDA Multi-Level Prompting Procedure

A photograph of the pre-selected reinforcer was placed on the first slide of the PDA which the student could view upon entering the work station area and prior to beginning the first task box (Fig. 2). The student then pressed the arrow block on the PDA to advance the program to the next slide (first task box). On the slide the student could see the number corresponding to the first task box to be completed. If touched, an auditory prompt was played (i.e., "Get number ___"). After placing the task box on the desk, the

student could look at the photograph on the slide and complete the task box, touch the photograph and hear an auditory prompt (i.e., "put the erasers on the pencils and put the pencils in the bag"), and/or touch the video block and watch a video caption of the task box being completed along with a verbal description of the task. The student could also complete the task box without referring to the prompts on the PDA. The student placed the task box in the "finished" box to the right of the desk upon completion of the task. The student then returned to the PDA, touched the right arrow block and preceded to the next task box. When four tasks were completed in this manner, the student advanced the program to the last slide (by touching the right arrow block on the last task box slide) which prompted the student to access the reinforcing material. Students could look at the picture of the reinforcer, touch the picture and hear an auditory description of the location of the item, or touch the video icon and view a video recording demonstrating where the item was located and how to access it. Sessions continued with a set of work tasks until criteria was reached (three tasks correctly completed with 100% accuracy for three sessions) or until data levels stabilized across three sessions. In addition, previously introduced sets were probed using the PDA during subsequent evaluation sessions to measure maintenance.

Social Validity

Following the last probe session, each student was taken to the work station area during the scheduled independent work time. The task strip and the PDA were both positioned on the desk and the instructor asked, "Which one do you want to use?"

Reliability

Data were collected simultaneously on student transitions within and between tasks, task completion, and PDA prompt levels used by the students (interobserver agreement) and on the instructor following condition procedures (procedural reliability). Data were collected on 25% of the sessions across all conditions (minimum of one session per condition) by the reliability data collector. Interobserver agreement was recorded by dividing the number of agreements of student responses (and instructor delivered prompts for off-task behavior) by the number of agreements plus disagreements and multiplying by 100. Task duration was recorded by the instructor and reliability data collector by writing start and stop times on the data collection sheet. Start time was recorded when the student placed the first task box on the desk and stopped when the student placed the last task box in the "finished" area. The reliability data collector and instructor used analog watches to record the times. Interobserver reliability estimates were reported by dividing the lower number of minutes by the greater number of minutes recorded by each and multiplying by 100.

Mean interobserver agreement for the number of task boxes completed independently correct was 100%. Mean interobserver agreement for student independent correct responses for transitioning within tasks was 95% across all students and conditions (range = 75–100%) and 100% across all students and conditions for transitioning between tasks. Mean interobserver agreement on task duration was 96.2% across all students and conditions (range = 85.7–100%) and 86.3% across all students and conditions (range = 80–100%) for the number of off-task directed prompts by the instructor. During the PDA prompting condition interobserver agreement for level of prompt used by the student was 95.8% (range = 75–100%)

Procedural reliability agreement was determined by dividing the number of observed instructor behaviors by the number of opportunities to emit the behavior, multiplied by 100 (Billingsley et al. 1980). Data were collected by the reliability data collector on the following instructor behaviors: (a) assuring that materials and equipment were in proper locations; (b) use of the correct prompting procedures for off-task behaviors; and (c) adherence to schedules and timelines for delivering tasks (5 min per task box) and reinforcement within the 30 min session time. Mean procedural accuracy was 95.3% (range = 88.2–100%). Errors occurred, for example, when two of the task boxes were not set up correctly, a fire drill was held during one of Alison's session, and the PDA emitted an incorrect auditory prompt.

Results

Task Completion

Graphic displays showing the number of task boxes independently completed by each student and independent task transitions within and between tasks are presented in Figs. 3, 4, 5. The use of the PDA with multi-prompt levels resulted in high levels of independent task completion for two of the three students across three sets of novel tasks, while Denny showed only modest gains for two of his three sets and was unable to complete any of the work tasks of his last set using the PDA. Levels of performance by the three students were maintained while using the PDA and students were able to complete tasks mastered with the PDA when they returned to using the task strip. Duration time to complete four tasks within each set across all students was higher when using the PDA across all conditions

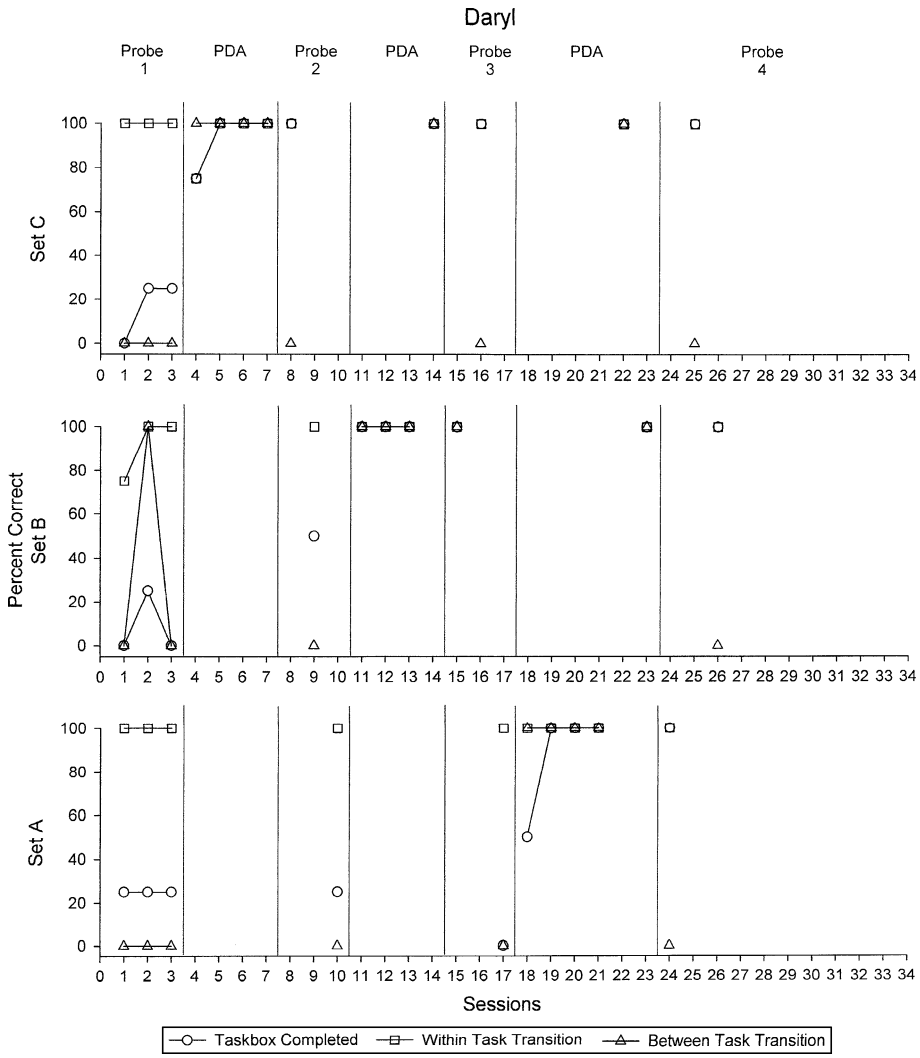

Fig. 3 Percentage of task boxes, within task transitions, and between task transitions completed independently correct by Daryl across the three sets. Probe sessions conducted with picture-based task strip. Subsequent PDA sessions, following mastery of a set, measured use of PDA over time (maintenance)

compared to use of the task strip following mastery of a set with the PDA. Mean completion times were: Daryl PDA 13.4 min, task strip 8.7 min; Alison PDA 13.1 min, task strip 8.67 min; and Denny PDA 17 min, task strip 15.2 min. As further addressed in the discussion section, increased levels of completion time when using the PDA was partially due to the time requirements for watching the video, touching pictures and listening to prompts, and advancing slides.

Figure 3 displays Daryl's independent task completion across the three sets of tasks during probe (task strip) and intervention (PDA) conditions. Although inconsistent, he was able to complete one task from Sets 1 and 3 prior to introduction of the PDA and two task boxes prior to the introduction of his second set. His correct performance upon introduction of the PDA rapidly increased across each set. He reached 100% correct on his first session with the second set and on the second session for Sets 1 and 3. He maintained his performance when the PDA was withdrawn and the task strip was re-introduced and upon re-introduction of the PDA. Overall, occurrences of off-task behaviors, measured by the number of teacher prompts, were low for Daryl when using both the task strip (mean of .5 prompts per session) and the PDA (mean of 1.4 prompts per session).

Figure 4 displays Alison's independent task completion across the three sets of tasks during probe (task strip) and intervention (PDA) conditions. She was unable to complete any of the task boxes during probe sessions for Sets 1 and 2 and completed one task box prior to introduction of the PDA with Set 3. Her correct performance upon introduction of the PDA rapidly increased across each set and she reached 100% correct on the first session with the second and third set. Alison did not display any instance of off-task behavior lasting more than 5 s when using either the task strip or PDA.

Figure 5 displays Denny's independent task completion across the three sets of tasks during probe (task strip) and intervention (PDA) conditions. Although he was unable to complete any task boxes prior to introduction of the PDA,

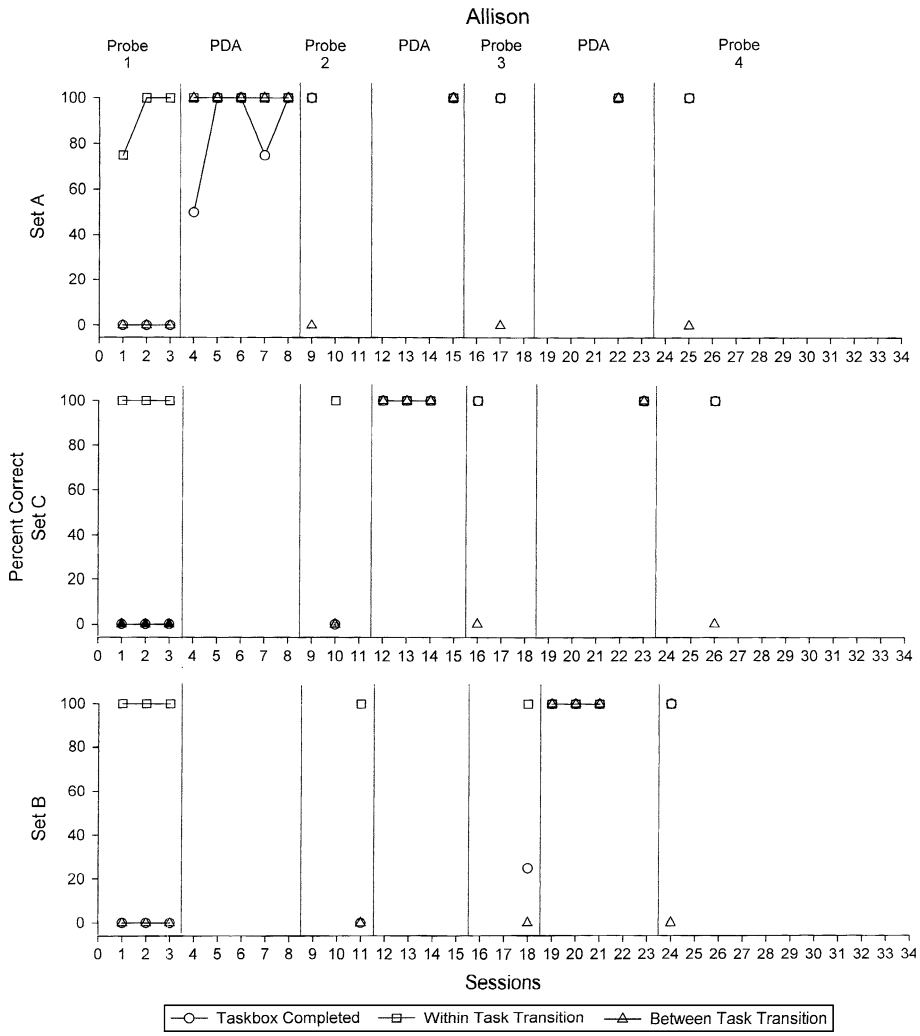

Fig. 4 Percentage of task boxes, within task transitions, and between task transitions completed independently correct by Alison across the three sets. Probe sessions conducted with picture-based task strip. Subsequent PDA sessions, following mastery of a set, measured use of PDA over time (maintenance)

he was only able to complete two task boxes using the PDA with Set 1 and one task box with Set 2. He was unable to complete any of the task boxes in Set 3. Sessions were discontinued across each set when his data stabilized across three sessions and showed no further progress. When comparing performance under probe conditions (task strip) and use of the PDA, instance of off-task behavior was greater with the PDA (mean of 6.4 prompts per session) than the task strip (mean of 4.78 prompts per session). A remediation condition was added after the final probe condition to examine whether an adult model would improve his performance on task completion. Two of his three sets were unaffected while he was able to complete one additional task box from his second set.

Prompt Level on the PDA

Figure 6 provides information about the level of prompt used by each student during each PDA prompting and maintenance sessions across the three sets of task boxes. Denny was the only student who completed some task boxes without looking at the PDA picture (independent) and the only student to use the picture only prompt. He used the following percentage of prompt levels across all task boxes: video 77.3%, picture + auditory 4.5%, picture 11.4%, and independent 6.8%. Daryl and Alison used the video prompt (Daryl 87.5%; Alison 96.4%) to complete the majority of the task boxes with minimal use of the picture + auditory prompt level (Daryl 12.5%; Alison 3.6%) and neither student used the picture prompt or completed any of the task boxes without use of the PDA. Although they were verbally reminded that they did not have to watch the video, each indicated a preference for using the most intrusive level of prompt with Daryl saying, "I need to watch the movie." It should be recognized that each was able to complete all of the task boxes when the PDA was unavailable and the task strip was re-instated. Daryl did begin to fade his use of video prompts on his third set of task boxes and increased his use of the picture + audio prompt level on his second and third sets.

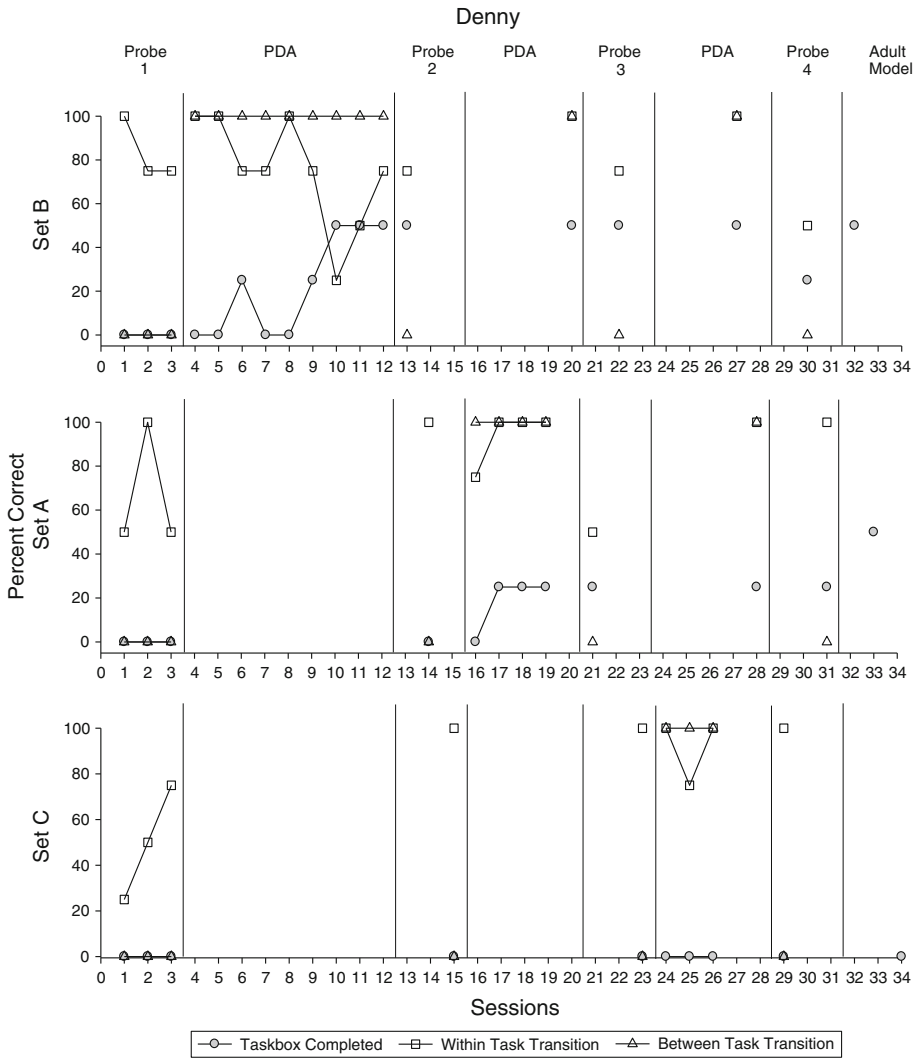

Fig. 5 Percentage of task boxes, within task transitions, and between task transitions completed independently correct by Denny across the three sets. Probe sessions conducted with picture-based task strip. Subsequent PDA sessions, following mastery of a set, measured use of PDA over time (maintenance)

Denny also began to fade his use of video prompts with his second set of task boxes and during the last session with his first set, but increased his use of video prompting with his third set of task boxes.

Within Task Transitions

Graphic displays showing the percentage of independent transitions from task box to task box are presented in Figs. 3, 4, 5 for each student. As shown in the figures, each student demonstrated high levels of transitioning within tasks when using both the task strip and the PDA. Students were familiar with the picture-based task strip system prior to the study and therefore the system was continued during baseline conditions. They were further familiar with the structured teaching arrangement in which their tasks were kept on the bookcase and the manner in which the system operated. Daryl and Alison required only one prompt during the initial baseline condition and no further prompts for the remainder of the study regardless of the condition. Denny's independent within task changes was slightly higher when using the PDA (85.5%) compared to the task strip (75%). When using the task strip he selected a box number on the strip which was further down the sequence (i.e., the last task box to be completed) rather than the correct task box in sequence. When using the PDA he was unable to see the next task box number in the sequence until the corresponding task slide was displayed on the device.

Between Task Transitions

Independent transitions between tasks are displayed graphically in Figs. 3, 4, 5 for each student. Independent task changes were recorded at the completion of the last task box as students transitioned to location of their reinforcement and engagement in the new activity. Each student had difficulty transitioning to the reinforcing activity

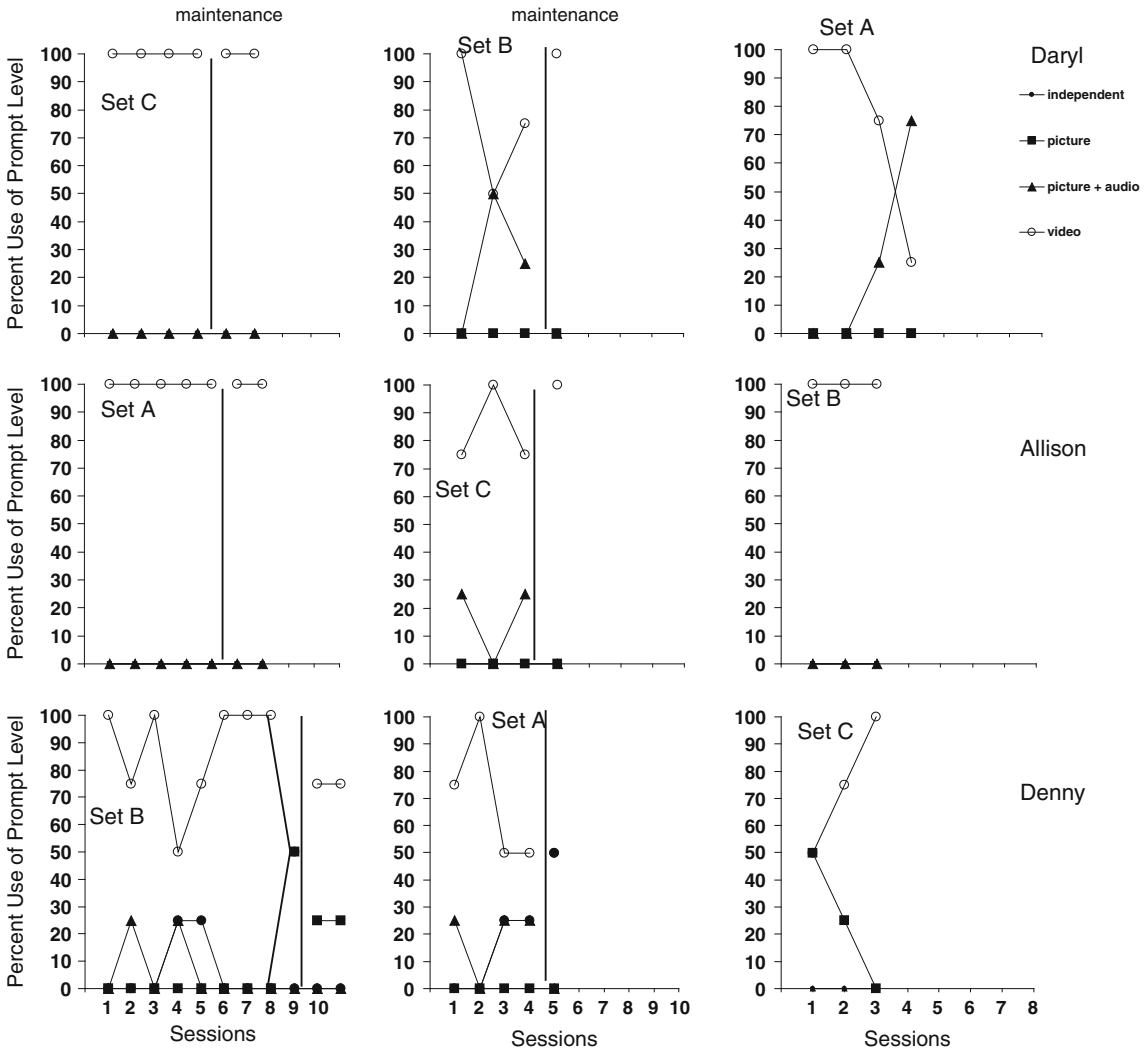

Fig. 6 Prompt level used by each student across tasks

when using the picture-based task strip. Information on the task strip was limited to a photograph of what was to be received whereby the student could receive information on where the item was located (picture + auditory) and how to locate it (video) if needed when using PDA. Daryl's independent task changes were 16.7% when using the task strip and 100% when using the PDA. Alison and Denny were unable to complete any of their task changes independently with the task strip and completed 100% of the transitions without assistance when using the PDA.

Social Validity

Each of the students responded to the preference question by pointing to the PDA. Alison also smiled and touched the video button when asked what she would like to use. When she was then asked if she would like to use the PDA she touched "yes" on her voice output communication device. Daryl verbally answered that he wanted to watch the video when asked why he wanted to use the PDA.

Discussion

The purpose of this study was to evaluate the effects of using a PDA with multi-level prompts (picture, picture + auditory, and video) on students' abilities to complete novel tasks and to transition both within and between tasks. The study further evaluated students' abilities to self-adjust the level of prompting used on the PDA. Results of the current study indicated that: task completion was higher for two of the three students compared to baseline conditions using a picture-based task strip; all students were able to complete a greater number of between task transitions using the PDA; students performed within task transitions equally as well using both the PDA and the task strip; and

one student began to self-fade use of more intrusive prompt levels (video prompting).

Results help expand the limited database available on the use of technology based systems as means for providing activity schedules and systems for prompting students with autism. Results support those of previous studies on the effectiveness of using portable hand-held devices for self-prompting (Cihak et al. 2007, 2008; Davies et al. 2002, 2003; Furniss et al. 1999; Riffel et al. 2005), the use of video on hand-held devices (Taber-Doughty et al. 2008; Van Laarhoven et al. 2007), and in particular, the use of a PDA which can provide multi-level prompting options to students on each screen (Mechling et al. 2009, in press). Results of the study demonstrated a functional relationship between the use of the PDA and students' abilities to independently transition between tasks (moving from the structured work station to reinforcing activities) and to complete novel tasks independent of adult prompting, while their ability to independently transition within tasks (moving from one task box to the next) was high regardless of the system used.

The most significant result of the study and implications for future use appears to be in the number of task boxes completed independently by students and the suggestion that provision of information through multiple prompt levels may increase task performance and the ability of students to complete novel tasks. While unable to complete the majority of the tasks using the traditional picture-based task strip, two of the three students were able to generalize concepts such as color matching, fine motor, and assembly skills to non-trained, novel materials without further adult instruction while the third student, Denny, was able to complete 33.3% of the task boxes when using the PDA. All information for the completion of tasks was provided through the multiple prompt levels on the PDA with no training by the instructor, therefore supporting a self-prompting device for promoting generalization of skills across new materials or environments.

The current investigation expands available data on use of video and multiple levels of prompts across different tasks used within the TEACCH model of structured teaching. In keeping with recommendations by Spriggs et al. (2007), the study sought to explore additional effective and efficient ways for students to use activity schedules. Components of the PDA appear to support practices of making expectations clear and explicit through the use of visual cues (Siaperas and Beadle-Brown 2006) while creating environments which promote independence and reduce the number of adult prompts (Hume 2004). In addition to supporting independent performance of novel tasks, use of such a multi-media prompting device holds promise when there is concern for maintenance of skills over time and in particular skills that may be used infrequently, yet are considered functional and useful. For such skills, using a PDA with multiple prompt levels may provide the support a person needs and persons with disabilities may reinstate higher levels of prompting when a task is performed less frequently (i.e., following a recipe to cook a turkey at Thanksgiving or shopping for a winter coat).

In addition to investigating task completion and transitioning using the PDA, one of the purposes of the current study was to determine if students with autism would self-fade or self-adjust the level of prompts used (from more intrusive to less intrusive) as they became familiar with the task boxes. Unlike the results of Mechling et al. (2009) who evaluated a PDA with multiple prompt levels to prompt cooking recipes, the two students who effectively used the PDA in the current study did not significantly adjust the level of prompts used over time. Although Daryl began to decrease his use of video prompts and to increase his use of picture + audio prompts during his second session with his second set of task boxes and during completion of his third set of task boxes, Alison continued to rely on watching the videos before attempting to complete a task box. However, they were clearly able to complete the tasks without this level of prompting as demonstrated by their 100% independent performance when the picture-based task strip was re-instated with each set of tasks. Denny's task completion remained low throughout the study regardless of the prompt level he used. He was the only student who attempted to complete some of the task boxes independently or by using the picture prompts. Students were reminded that they did not have to watch the video, but Allison continued to do so. Daryl commented to the instructor, "I have to watch the movie to know how to do it," and Alison was observed smiling and vocally imitating intonations of the directions provided by the voice over feature of the video recordings. A limitation of the study was that maintenance measures limited evaluation to a short period of time (maximum 30 days). Of interest would be whether students would continue to rely on the video or whether its use may have been due to novelty. It may also be possible that students' reliance on video prompts was not because they needed the more intrusive level of prompts to complete tasks, but because they found watching the video to be reinforcing.

Lack of fading of prompt levels may have contributed to the task completion time and the number of off task behaviors which showed a slight difference between the two systems in support of the task strip. Duration for completing tasks when using multi-level prompts may be explained by the cumulative time that it took to operate the different features of the system and prompt levels when more than one prompt was accessed per slide. When using the video prompt level, Daryl and Alison maneuvered

through all prompt levels on the PDA. Each looked at the picture, touched the picture and listened to the auditory prompt, and then touched the video icon and watched the task being performed. Further, manipulating the different features may have also accounted for the number of prompts delivered by the instructor to re-direct the students back to the task. Although researchers have reported the importance of providing a range of prompting options to students (Mechling et al. 2009, in press; Mechling and Stephens 2009; Taber-Doughty et al. 2008; Van Laarhoven and Van Laarhoven-Myers 2006) future research may need to investigate the difference in effectiveness and efficiency measures when allowing students to choose their level of prompting if it appears students are dependent upon a prompt level or distracted by the reinforcing value of video that they do not need in order to complete a task. Depending on the task and whether time to complete a task is critical, it may not be beneficial to provide a range of prompts to all students once they have mastered a task. Although the purpose of the current study was not to compare different systems, in light of the efficiency results, future research may also be needed which simultaneously compares the use of picture-based, light tech systems and high tech systems. It should also be recognized that picture-based systems were already being used by the students in the current study prior to the introduction of the PDA. Because students were older (middle school age) they already had a history with picture-based systems and therefore these systems were not taken away from them during baseline. Prior history with organizational aids may affect use of high tech systems. Future research with younger students without such prior experiences may produce very different results in addition to the direct comparison of systems.

Results of the current study also suggest that the skills and characteristics of learners with ASD may influence the appropriateness of hand-held devices to self prompt completion of tasks. Denny showed only minimal improvement in completing the task boxes when using the PDA. Although he possessed the pre-requisite skills (i.e., motor imitation and auditory and visual processing skills) it appears that his distractibility and short attention span may have affected his use of the PDA. It should also be noted that although he chose the PDA during measurement of social validity, he appeared not to like the PDA. He frequently hit the device with his hand, pushed it away, or advanced slides before he had completed a task box. Perhaps he was more comfortable with the task strip which was familiar to him and introduction of a new procedure was too difficult for him although his performance with the task strip was comparable to use of the PDA. An additional remediation condition was added at the end of the study to try to determine if adult modeling would be more effective for him than video modeling, but as demonstrated in Fig. 5, although implementation time was limited, this procedure had little effect on his task box completion. Results, although not conclusive for Denny, suggest that it may be important to allow students to choose their device and mode in which they are prompted.

It should also be recognized that the reinforcing value of the selected stimuli could have had affects on task completion time. Perhaps Denny's performance could have been positively affected had other, more powerful, reinforcers been identified and that the reinforcers selected were not strong enough to support his task completion. Although observations, in addition to teacher opinion, were used to select reinforcers, Logan and Gast (2001) found that researchers consistently recommend systematic preference assessments rather than relying on the opinion of others concerning what students prefer.

In addition to evaluating the use of multi-prompt levels, the current study expands the research on use of a PDA as a self-prompting device by evaluating its effect on both transitioning within and between tasks. Although results support use of the PDA to prompt transitioning between tasks, the design for measuring the transitions raises a limitation to the study. Transitions between tasks were those behaviors required to move from completing the last task box to locating and interacting with a reinforcing material. This reinforcing activity could be considered part of the task (within) rather than a new task (between). A further limitation was the use of only one activity and transition for measuring between task transitions rather than using the prompting system for multiple transitions throughout the day and across multiple tasks. Future investigations should consider evaluations of the PDA throughout the day and across environments which students are not familiar. In addition, the instructor was always present during the completion of the task boxes and was responsible for stopping tasks if they exceeded 5 min. If the PDA is to be evaluated as a true self-prompting device then students will need to use it without the presence of an adult. This could be readily evaluated in future studies along with timing features available on various PDAs which could serve as prompts when time limitations exist. Another feature of the PDA which was not utilized in the current study was that, unlike the task strip, students could only see one task at a time to be performed. The PDA can be programmed with a home page with all tasks visually presented and linked to subsequent slides showing the number of tasks to be completed in keeping with principles of structured teaching.

Another limitation of the study was that although tasks were considered novel, Daryl was completing 50% of his third set and Alison was completing 25% of her third set prior to introduction of the PDA. Because the task strip was

an integral part of the students' current visual support systems, its use was continued during baseline probes. It is possible that students were learning tasks during probes with the task strip, therefore, future research should isolate these variables by excluding the use of organizational aids during baseline conditions and/or use of an experimental design that allows for direct comparison of systems.

In summary, findings of this study advance applied practices by providing teachers, job coaches, and parents with a research-based strategy, keeping with technology advances, for providing greater independence to persons with ASD. Hand-held systems hold promise with speed, ease of use, flexibility, and advanced capabilities for prompting completion of new tasks, tasks which are infrequently performed, or those that change over time. Future research should consider evaluation of these features across a range of environments in addition to those found in school settings. Within community or job sites, persons with disabilities are often required to change from one task to the next without help or external adult prompting and it is important to provide them with a means to manage their own task change behaviors (Cihak et al. 2008). Therefore, it is recommended that future research continue to explore the use of portable devices and replication of the current results across other tasks and settings.

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