

Personal digital assistants as cognitive aids for high school students with autism: Results of a community-based trial

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Abstract. *Objective:* The purpose of this study was to examine the efficacy of personal digital assistants (PDAs) as task management tools in a sample of transition-age high school students with autism.

Method: The group included twenty-two high school students selected from locales across the Commonwealth of Virginia, all of whom carry a diagnosis of autism and exhibit difficulties in performing everyday tasks due to cognitive-behavioral problems. Participants were trained by an occupational therapist to use PDAs as task management tools and participants and their parents completed self-assessments of occupational performance (using the Canadian Occupational Performance Measure (COPM)) before training and eight weeks after training concluded. At the post-assessment, PDAs were examined for recorded appointments and other entries, as evidence of participants' usage, and participants were asked to demonstrate programming the PDA for reminder alarms and other functions, as a measure of their retention of training.

Results: Eight weeks after completion of training, the group demonstrated statistically significant improvement on COPM occupational performance and satisfaction with occupational performance scores, all PDA calendars showed reminder alarms scheduled for each day of the week across the eight week post-training period and all participants demonstrated the ability to respond to reminder alarms appropriately. Also, eight weeks after training, most participants (18 of 22 or 82%) were able to program device software, as trained, demonstrating retention of training and suggesting everyday use of the device. All participants attested to everyday device use and said that the device had improved their independence in performing functional activities.

Conclusion: A brief training intervention utilizing PDAs as cognitive aids is associated with improved self-ratings of performance and satisfaction in everyday life tasks among a group of high school students with autism. This group also demonstrated retention of training when reassessed eight weeks later, and their devices showed calendar entries across the eight weeks that suggest everyday use.

Keywords: Autism, personal digital assistant, PDA, cognitive aid, assistive technology, transition to work

1. Introduction and background

People with autism often experience difficulty with executive function-related tasks involving prospective memory, organization, planning, and goal-direction. Though these individuals may be intelligent and artic-

ulate, they can perform poorly at home, at school and in the community, because of their inability to independently initiate and complete scheduled tasks [12]. Efforts to solve these problems have included the use of written or pictographic activity schedules [2, 8, 18], sometimes utilized on desktop computers [16]. While helpful, these techniques typically require the supervision of an adult for consistent use, since students with executive dysfunction may forget to refer to their schedules. Accordingly, investigators have researched a variety of prompting techniques – such as verbal, ges-

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tural or tactile cues – which seem to help some students stay on task [6, 9, 19].

Using a multiple baseline design, one research team has investigated the use of personal digital assistants (PDAs), finding that an adolescent boy with Asperger's Syndrome (AS) markedly increased his recording of accurate homework assignments in three mainstream classes while using a PDA [11] and that PDA use by another adolescent with AS reduced reliance on adults to complete tasks at home and school [5]. This research seems promising, since PDAs, which were designed to be used as electronic task organizers, can be readily programmed to include quite complex activity schedules, with each task linked to a reminder alarm. Entry-level, inexpensive PDAs also include other features that may be helpful to students with task management problems, including electronic sticky notes, address books, PDA-to-PDA message beaming, to do lists and photo albums. More expensive PDAs and smart phones may include cameras, video recorders, wireless connectivity and GPS features that may prove useful to people with executive dysfunction at home and in the community.

The use of PDAs as task management aids may be especially appropriate for students at transition age. These popular consumer devices carry no "assistive technology" stigma, teens are often quite adept at the use of portable gaming devices, and so might readily adopt these similar products, and as research has shown, students with autism may prefer instruction by computers to that offered directly by teachers [3, 21]. As students navigate the transition to adulthood, many of the supports afforded them in public schools are lost [7, 20]. Adoption of a PDA as a cognitive aid may assist them in functioning more independently during their school years, while preparing them for the use of such aids during work exploration and employment activities.

2. Purpose

The purpose of this study was to examine the efficacy of PDAs as cognitive aids in a sample of high school students with autism. Three hypotheses were proposed; eight weeks after the conclusion of training, participants will demonstrate: (1) significantly improved self-estimates of occupational performance in everyday life tasks and satisfaction with their performance, as measured on the COPM, (2) participants will demonstrate retention of training and (3) students' PDAs will include evidence of everyday use, including calendar entries and reminder alarms.

3. Method

3.1. Design

This quasi-experimental study utilized a pre- and post-assessment design. The intervention consisted of providing a participant with a PDA and training her/him in its use as a cognitive aid during four home-based training visits, conducted over no more than a 14-day period. Following this training period, participants were asked to use their PDAs as trained for an eight-week period, during which the investigator did not contact them. Follow-up assessment was then conducted.

3.2. Participants

Volunteers were recruited with fliers posted in public high schools across the Commonwealth of Virginia. The study was approved by the Virginia Commonwealth University Institutional Review Board, and all volunteers assented to participate, with parental consent. In order to participate, volunteers needed to: (1) have a diagnosis of autism and a current Individualized Education Plan (IEP); (2) be at least 14 years of age; (3) attend a public high school in the Commonwealth of Virginia; (4) demonstrate sufficient dexterity to manipulate a stylus used to interact with the PDA; (5) have functional vision and hearing; (6) have a family member or caregiver willing to participate in the assessment element of the study; and (7) have a working home personal computer for backup of PDA data. Additionally, participants (or their parents) needed to describe everyday occupational deficits related to executive dysfunction on the COPM. The only compensation for taking part in the study was that participants were allowed to keep their PDAs, even if they chose not to complete trial participation.

4. Measurement tools

The study used two measurement instruments:

1. *The Canadian Occupational Performance Measure (COPM)*. A semi-structured interview assessment, the COPM is used across disability categories by occupational therapists. Test-retest reliability has been rated at 0.89, and internal consistency at 0.71 [1]. Researchers have demonstrated criterion validity in comparison with "spontaneous client-identified problems" and con-

struct validity in comparison with the Satisfaction with Performance Scaled Questionnaire (SPSQ) and the Reintegration to Normal Living and Life Satisfaction Scale [10]. A pair of studies support convergent and divergent validity of the COPM [4, 15]. The COPM is a unique client-centered instrument, in that it allows a participant to determine his/her own areas of need, providing information that cannot be obtained with other standardized health measurements. Each participant self-determines five areas of disability in everyday life tasks, rating performance and satisfaction on a 1 to 10 scale. Scores are averaged by the rater. On follow-up, the participant reviews these items and self-determines his/her current rating after treatment. Average scores on initial and follow-up assessments may then be compared.

2. *The Functional Assessment Tool for Cognitive Assistive Technology (FATCAT)*. The FATCAT was designed by the investigators as a post-treatment questionnaire to assess participant satisfaction with the intervention, and as a checklist for assessment of how well participants could demonstrate use of a handheld computer's functions, and how many entries participants logged on their handheld computers. As such the tool examines retention of training, everyday use of the handheld computer, and likelihood of participants continuing to utilize the device after the study's conclusion. Reliability and validity measures for this new instrument have not been established.

All assessments were conducted by the study investigators. The COPM was administered collaboratively with the participant and a parent, and COPM choices were agreed to by both. During the COPM interview, five self-generated occupational task deficits in everyday life were identified. Each Participant-parent dyad then assigned a number from 1–10 to each task, rating how well that task was performed (1 = not at all, 10 = independently) and how satisfying that level of performance was (1 = very unsatisfied, 10 = completely satisfied). The same procedure was followed on post-assessment conducted eight weeks after the conclusion of training. The FATCAT was administered during the post-intervention assessment interview, and involved: (1) counting the number of data entries on participants' PDA calendars across the eight-week post-training period, (2) observing the participant programming calendar reminder alarms, to do list entries, and address book entries (in order to measure proficiency in device

use), and (3) having the participant complete the Likert-scaled PDA usage questionnaire.

5. Procedure

The independent variable in this study was the training intervention in the use of a PDA as a task management tool. The theoretical basis for this intervention included principles drawn from occupational therapy, person-centered practice and *diffusion of innovations* theory [17]. Accordingly, the intervention was conducted in participants' homes and proceeded in a stepwise fashion intended to provide repetition, reinforcement and ongoing facilitation as participants learned to use the PDA to assist in performing everyday life tasks. The intervention built on participants' familiarity with personal computers and their awareness of other organizational strategies. One-on-one home-based training was conducted by the study director, an occupational therapist, verbally and by demonstration. Instructional literature was provided to accommodate varied learning styles.

The intervention included: (1) a 90-minute study enrollment home visit by the study director, (2) a 90-minute assessment visit, (3) a 90-minute initial training visit, and (4) three 60-minute follow-up training visits. Following assessment, all training was conducted over no less than ten days and no more than fourteen days. A final 90-minute post-intervention assessment visit was conducted eight weeks after the conclusion of training. On the initial visit, the participant was provided with a Palm® Zire 31 PDA [13] and shown how to enter data using the stylus. (This device was chosen, because it was the most basic and affordable PDA then on the market, providing essential task organization features in a compact package.) The investigator then loaded Palm® Desktop software onto the participant's home computer and showed both the participant and a parent how to enter calendar and alarm entries on the pc-based Palm® Desktop. Each participant and her/his parent were then shown how to transfer this information to the PDA via a USB-mediated operation called a "hot-sync". On subsequent visits, each participant and her/his parent were taught how to enter appointments directly onto the PDA and how to use the address book feature called "Contacts" and the To Do list feature called "Tasks". Each participant was encouraged to transfer appointments, medication schedules, homework assignments, home chore schedules and other items from paper-based calendars to the PDA, appending a reminder alarm to

each. Additionally, participants were trained in the use of any additional feature they wished to learn (e.g., playing Solitaire on the PDA or downloading digital photos to the PDA).

During the eight-week post-training period, participants were allowed to contact the investigator via phone or email with trouble-shooting questions, as needed, but the investigator did not initiate any contact with participants.

5.1. Data analysis

All twenty-two participants completed the study. Findings were entered into PASW 17[®] for PC [14] and statistical comparisons were conducted to determine if a significant change in COPM scores may have occurred during the trial.

6. Results

Participants comprised eighteen males and four females ranging in age from fourteen to eighteen at time of entry into the study (mean years 16.5), all of whom lived with a parent or parents. All students were supervised during the school day by a teacher's assistant and attended a mix of mainstream and non-mainstream classes. With supervision from teacher's assistants, all students utilized a scheduling book for organizing school tasks. All participants reported prior knowledge of being able to use computers for word processing and web-surfing. None had prior experience in the use of a PDA.

The following sections describe the findings for each hypothesis.

6.1. Learning to operate a PDA

To determine whether participants had learned to operate their PDAs, they were asked to demonstrate independent operation of the device after training was completed. On the final day of training, all participants demonstrated the ability to independently make calendar entries, set reminder alarms and repeating event reminders, and make address book entries. Eight weeks after the conclusion of training, 18 participants (82%) were independent in performing these PDA data entry functions. Two (9%) required a single verbal cue to set repeating calendar alarms and two others (9%) were unable to accurately program their devices. These two had been relying on a parent to enter data on the PDA.

In these cases, the student and parent reported that the student was able to respond to PDA messages, and continued to use the PDA as a task organizer as programmed by a parent.

6.2. Actual usage of a PDA

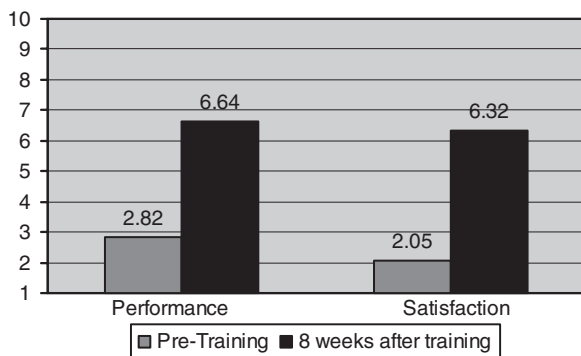
Frequency of use was determined by counting calendar events for each of the eight weeks after the conclusion of training. All PDAs showed calendar events recorded each week, a finding that supports successful retention of training and actual use of PDAs in everyday activities. Use of the calendar function, however, varied widely. For example, one participant averaged eleven calendar events per day over the eight week period, whereas another averaged only one.

6.3. Change in COPM measures of performance and satisfaction

The COPM was administered prior to treatment and eight weeks after the conclusion of PDA training. During the COPM interview, each participant and parent dyad identified five functional deficits that most affected the participant's performance of everyday tasks. They then rated performance in each deficit area on a one-to-ten scale and rated satisfaction with performance on a one-to-ten scale. Though participants described individualized problems, upon examination the activities most often cited as occupational deficits fell into the following four general categories: (1) forgetting appointments, (2) managing household ADL and chores, (3) homework management, and (4) medication management.

In accordance with the COPM data registration protocol, the five self-identified task rating scores from the pre- and post-intervention assessments were averaged for each participant in "performance" and "satisfaction with performance" categories. Aggregate means across participants were then calculated using pre- and post-treatment individual mean scores.

Paired samples *t*-tests were conducted to compare the pre- and post-assessment aggregate means in both categories, showing statistically significant improvement in performance and satisfaction with performance of everyday life tasks following PDA training – pre-treatment performance mean = 2.82, post-training performance mean = 6.64 ($t = 10.317$, $p < 0.001$); pre-treatment satisfaction mean = 2.05, post-training satisfaction mean = 6.32 ($t = 7.865$, $p < 0.001$) (Fig. 1).

Fig. 1. COPM Scores ($n = 22$).

6.4. FATCAT survey observations

The FATCAT was designed as a Likert-scaled survey that asks a series of questions about using the PDA. All participants agreed or strongly agreed that “I use the device everyday”, “using a PDA has helped me improve performance in at least one area of my daily activities” and “I would like to continue using the device”. Asked to rate which PDA feature they found most useful, nine participants stated reminder alarms, six stated portability, four stated “to do” list, and three stated address book. The parents of nineteen participants stated that they did not need to assist their child in using the PDA at all. The three parents who did provide assistance provided less than one hour of assistance per week.

Other responses are indicated in Fig. 2.

The study was not designed to formally introduce PDA usage at school, but as Figure Two notes, some participants did use their PDAs there. Asked about this, ten participants said that the schools were allowing

them to use their PDAs as adjuncts to their scheduling notebooks, in order to record homework assignments, manage medication schedules and set other appointment reminders. Four students participated in the study during the summer, so it is not known whether they used their PDAs at school in the Fall. Three participants had tried to bring their PDAs to school, but school regulations forbade the use of handheld devices. Their parents stated that they were pursuing having the PDA included as an assistive technology on their children’s Individualized Educational Plan, in order to get around that rule, since it was apparent that the device might be useful in the school setting. Five students who participated in the study during the academic year had not tried to use their PDAs at school during the study period.

Most of the participants ($n = 16$, 73%) had misplaced their PDA at least once. Typically, they reported finding the device when an alarm reminder sounded, cueing them to its location. Thirteen reported that the device broke down during the trial. As noted below, one device was damaged irreparably and had to be replaced; the other “break downs” involved the battery running down or the device’s screen becoming unresponsive. Batteries were easily recharged without loss of data, and a simple reboot procedure restored screen function in cases of screen “freezing”.

6.5. Troubleshooting

During the eight-week post-training period, participants were allowed to contact the investigator via phone or email with trouble-shooting questions, as needed, but the investigator did not initiate any contact with participants. Seven participants did contact the investi-

Question	Strongly Agree/ Agree	Neutral	Strongly Disagree/ Disagree
I am able to program this device without help from another person.	16	4	2
I found that I was able to respond to reminder alarms almost every time one rang.	15	5	2
I primarily use the device to remind me to do things.	13	2	7
I use the device at school.	10	3	9
I misplaced the device at least once.	6	1	15
The device broke down at least once.	9	0	13
Using this device is just a waste of time.	0	0	22

Fig. 2. FATCAT responses ($n = 22$).

gator with questions; all of their troubleshooting issues (PDA screen freezing, for instance) were solved over the telephone. One participant lost his PDA; it was replaced. Another accidentally crushed the PDA screen by stepping on it; it was also replaced.

7. Discussion

Among the 22 participants, this study demonstrates significantly improved self-estimation of occupational performance in everyday life tasks and in satisfaction with performance, while also demonstrating retention of all trained procedures for twenty participants (91%) and routine use of the PDA as a task management tool over an eight-week post-training period for all participants. Accordingly, these findings support the use of a brief, participant-centered and home-based training intervention and the use of consumer-level PDAs as cognitive aids for high school students with autism, providing evidence that teenagers with autism-related executive dysfunction can learn to operate off-the-shelf PDAs as assistive technology, and improve their self-estimation of functional performance in everyday life tasks by doing so.

When examining a broad construct such as executive dysfunction it may be helpful to determine exactly what everyday activities were impacted by the intervention. The COPM is a useful tool for addressing this question, because it requires individuals to self-identify specific occupational difficulties. The problems most often cited by participants – managing upcoming appointments, routine activities of daily living, household chores, homework, and medication routines – may be the problems most impacted by this intervention, and clinicians are encouraged to consider PDA training for clients who present with these issues. Further research is recommended to further refine the occupational performance areas best addressed with this approach.

This study focused on training in the use of basic PDA task organizational features (reminder alarms, to do lists and address books). PDAs and smart phones often include many other features that may benefit people with autism, such as video recorders, Internet connectivity and Global Positioning Satellite (GPS) functionality. Though basic task management features appeared to work for the study participants, it is possible that other PDA functions may offer benefits unexamined here. Future investigators are encouraged to explore these promising capabilities as assistive technology for people with autism.

This study shows that occupational performance gains can be demonstrated for at least eight weeks after training, as measured on the COPM. Future investigators may wish to follow participants beyond eight weeks post-treatment to determine more accurately the lasting impact of this intervention. They may also wish to utilize tools or methodologies that allow objective observation of occupational performance change, rather than relying on participant and parent self-measurements.

All participants in this study used a cognitive aid prior to enrollment, their school scheduling notebook. Using a PDA significantly increased self-ratings of occupational performance above that observed when using the scheduling notebook, suggesting that PDAs may be a useful adjunct to low-tech pen-and-paper calendars, especially in the home setting, where such notebooks are not typically used.

8. Limitations

It is important to note that the study sample was neither randomized nor representative of the autism population as a whole. Because the sample consisted of public high school students with intact vision, hearing and dexterity, each of whom attended a mix of mainstream and non-mainstreamed classes with teaching assistant supervision, who were computer users, and who lived with parent(s) at home, the results should be applied cautiously for other factions of the autism population. Future researchers may wish to utilize a randomized, controlled trial with a larger, more inclusive sample.

The assessment measures utilized in this trial, the COPM and FATCAT, are both self-assessment rating scales. Scores for both measures were agreed to by each participant and a parent. Including a parent in the assessment was intended to provide a degree of objectivity to necessarily subjective self-ratings. Counting calendar events that had been recorded during the eight-week trial and observing actual usage of the PDA at the conclusion of the trial helped to verify routine usage and retention of learning. The large change in scores on the COPM, however, may indicate a placebo effect, which may be mitigated in future studies by the use of a placebo-treated control group or by separate external observer ratings to verify self-rating estimations. Threats to scoring bias may also be reduced by having assessment and training administered by separate people.

9. Conclusion

The effort to develop ecologically valid research on the use of assistive technology for people with autism is still in its infancy, and much work needs to be done. This study confirms previous investigations into the efficacy of portable organizers as cognitive aids and points the way to work that may further clarify the benefits that may be expected from these devices. The intervention described herein is brief, straightforward and inexpensive. This study may provide a guideline for occupational therapists, speech and language pathologists, special education teachers and vocational counselors to pursue in helping their clients with autism function more independently at home and in the community.

All of the students in this study were supervised during school hours by teaching assistants, who helped them manage school-based tasks. As students transition away from the classroom, this human support will be lost. Learning to use a PDA as a task management tool may help these students in making that transition, by providing self-directed electronic task management support for vocational and nonvocational activities. Further research using PDAs as task organizers for people with autism during the transition to community and work settings is recommended.

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