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REVIEW

Assistive technology effects on the employment outcomes for people with cognitive disabilities: a systematic review

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Abstract

Purpose. This systematic review examines the effects of assistive technology (AT) use on employment outcomes for people with cognitive disabilities (CD). AT is a necessary tool for gaining and maintaining skills for people with CD. Research suggests that AT can assist this population in performing tasks with greater ease and independence.

Method. A literature search was conducted to examine the evidence supporting AT use in the workforce. Search criteria included: subjects with CD, use of an AT tool or device and participation in a vocational training program or active employment. The search results yielded nine articles focused on AT interventions used in vocational settings for people with CD.

Results. AT interventions demonstrated positive outcomes on job performance. Positive outcomes were measured as a higher rate of accuracy and task completion, increased independence and generalization of skills. We found a trend in the literature over the past 25–30 years, moving from low- to high-tech visual and auditory cuing systems.

Conclusion. Future research should focus on producing evidence to support the use of AT tools for this population, and provide guidelines for incorporating them in vocational training programs in schools and community settings.

Keywords: *Employment, vocational, assistive technology, transition planning, cognitive disabilities, developmental disabilities, job performance*

Introduction

Background

In 1975, congress passed Public Law 94–142 [1], the Education of All Handicapped Children Act. Prior to this law, individuals with cognitive disabilities (CD) were excluded from public education. As this population has become integrated into school and work programs, research has demonstrated that they are capable of learning to perform many jobs in the community [2]. Significant research has been devoted to training for improved accuracy and independence [2]. Professionals working with this population should be aware of the research on effective vocational training practices in preparation for future employment placements or supports [3].

Assistive Technology (AT) has the potential to assist people with CD in performing a variety of tasks accurately and independently [4,5]. Research supports that this population requires assistance and training to increase job skills and employability [6], as well as AT to promote success in the workforce [7]. However, this research is limited and demonstrates the need for further empirical evidence [8].

AT tools and devices are defined as 'any item, piece of equipment or product system, whether acquired commercially off the shelf, modified or customized, that is used to increase, maintain or improve functional capabilities of a child with a disability' [9]. The cueing systems in the reviewed studies match the above definition and are considered AT for the purpose of this systematic review.

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Purpose

The purpose of this systematic review is to examine the use of AT by individuals with CD in the work place. We ask two primary research questions. First, what are the employment outcomes of adults with CD who use AT in the workplace? Second, which AT interventions are documented to have a positive impact on employment outcomes in this population? These primary inquiries lead to two secondary research questions. Owing to AT interventions on the job, is this population more successful or employable? If so, what are the reported indicators of success on the job? A search for indicators of success included: accuracy, independence, higher pay, greater reports of job stability or reports of greater job satisfaction by employees or employers due to the use of AT on the job.

Therefore, the aims of this study were: (1) To systematically review and describe the effects of AT use on the employment outcomes for individuals with CD, (2) To evaluate trends of current AT interventions and the strength of the outcomes to determine future implications in vocational training and (3) To provide recommendations for AT practices and future research.

Rationale

Based on the authors' past clinical and teaching experience with individuals with CD, a disproportionate amount of AT tools and devices were available, compared to the amount of evidenced-based interventions currently documented. The AT marketplace is flooded with products and vendors. A search on Google for AT vendors yielded 170,000 entries [10]. Owing to the lack of research with this population in general, as well as within the workforce [11], it is difficult for professionals in this field to determine how many of these products are based on empirical research versus marketing.

We were interested in exploring this topic in order to improve our AT practices in school settings based on current research findings. We hope that better AT practice in the school settings will improve this population's performance in the workforce.

Method

Literature search

To begin our literature search we had three key terms: (1) cognitive disability, (2) AT and (3) employment. We expanded these key terms (see Table I), and completed our initial search using the following electronic databases (all years included):

- ERIC
- CINHAL
- PUBMED
- Web of Science

Additional searches were completed after reviewing the references from the articles obtained from the above databases. See Figure 1 for details of search methods.

Study selection

The two authors reviewed and summarized the selected studies. The findings and results of each study were examined and discussed to determine whether they should be included in the systematic review. In the event of uncertainty, both authors assessed the study in question to determine eligibility. Nine studies were included in the systematic review. See Figure 1 for a complete list of inclusion and exclusion criteria. As stated within the inclusion criteria, we included articles with all levels of evidence.

The Cochrane Collaboration Hierarchy of Evidence [12] was used to assign a level of evidence to each study. A description of this grading scale can be seen in Table II.

Data extraction

Study characteristics from each article were extracted and summarized in Table II, which provides an overview of each study. More detailed information can be located in Table IV. This will provide numerical data and a synopsis of results for each study.

Results

The selected nine studies generated a total sample size of 358 subjects, with 154 using AT. Of the 154 subjects, 40 were part of quasi-experimental studies. The remaining 114 subjects took part in a survey in which they indicated a self-reported 'mental limitation' and used AT as a workplace accommodation

Table I. Search terms.

Cognitive disability: cognition, cognitive disabilities, developmental disabilities, mental retardation, impaired IQ, Down syndrome and autism.
Assistive technology: assistive technology, technology, devices and assistive technology devices.
Employment: employment, jobs, sheltered workshops, supported employment, vocation and vocational training.

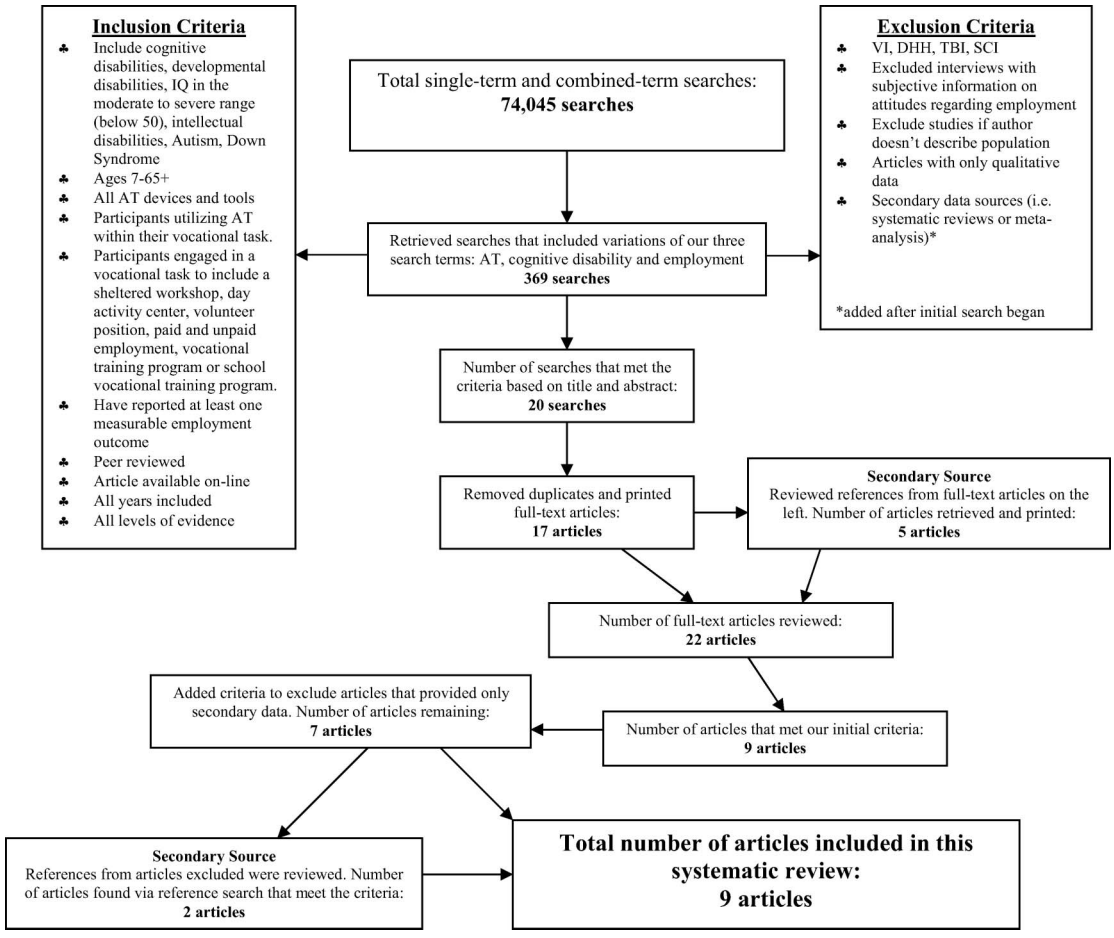

Figure 1. Search method.

Table II. CRD hierarchy of evidence.

Level	Description
1	Experimental studies (i.e., RCT with concealed allocation)
2	Quasi-experimental studies (i.e., studies without randomization)
3a	Controlled observational studies
3b	Case–control studies
4	Observational studies without control groups
5	Expert opinion based on theory, laboratory research or consensus

[13]. As summarized in Table III, this study showed mixed results compared to the other studies. These results were determined to be 'mixed', as only 36% of survey respondents indicated the use of an AT tool. The majority of respondents indicated that they did not use any accommodations and did not report their 'mental limitations' to their employers.

Study characteristics for the nine articles are summarized in Table III, and the success indicators are detailed in Table IV. Overall, the results of AT use are positive for helping our selected population become more successful on vocational tasks. 83% of articles studied accuracy, 63% of articles studied independence and 38% studied generalization.

The authors initially anticipated finding information on higher pay, employer satisfaction and employee satisfaction with the use of AT, but that was reported in 0%, 38% and 38% of the articles, respectively. See Table V for comprehensive information on interventions outcomes and results. Information about improvement in the areas of accuracy, independence and generalization can be found on Table IV. The authors noted no significant difference in the levels of accuracy and independence between low- and high-tech devices. However, articles that were comparing the use of low- and high-tech AT indicated that subjects completed job tasks up to 50% faster using the high-tech devices.

Discussion

Research question #1

This systematic review investigated the employment outcomes of adults with CD who use AT in the workplace. As documented in Table IV, all studies

Table III. Study characteristics.

Reference	Level of evidence	Number of subjects, n = total	Number of subjects used AT, n = total	Sex: F = female; M = male	Ages, r = range; m = mean	Type/severity of disability	Type of AT	Type of employment	Type of task	Results	Retrieval site
Connis [14]	Level 2	$n=4$	$n=4$	$F=1$ M = 3	r: 21–24 m: 22.8	– Mental retardation –IQ: 35–50	Picture cues (photographs) were taped in the correct sequence on a clearly visible wall in the subjects work area and were combined with self-management procedure	Vocational Training Program	– Dishroom work – Washing pots and pans	Positive	Reference search
Wacker and Berg (1983)	Level 2	$n=5$	$n=5$	$F=3$ M = 2	r: 18–19 m: 18.6	– Moderate and severely retardation – IQ between 30 and 38	Picture prompts (books)	Work activity program	– Black value assembly (18 steps) – Circuit board assembly (30 steps) – Double red valve assembly (43 steps) – Packaging task (41 steps)	Positive	Reference search
Wacker et al. [15]	Level 2	$n=3$	$n=3$	$F=1$ M = 2	r: 13–19 m: NR	– Severe or profound mental retardation – IQ less than 26	– Picture prompts (book)	School	– Dust table – Clean window – Conduit-assembly task – Folding laundry – Envelope stuffing – Set-up board game	Positive	Reference search
Steed and Lutzker [16]	Level 3b	$n=1$	$n=1$	$F=0$ M = 1	r: 40 m: 40	Profound mental retardation and atypical psychosis	Picture prompts (photographs)	Local Senior Center and Day Program for adults with DD	– Setting table – Vacuuming – Dusting – Dusting – Emptying trash	Positive	Reference search
Tabor et al. [17]	Level 2	$n=5$	$n=5$	$F=1$ M = 4	r: 16–18 m: 17.4	– Moderate mental retardation – IQ ranged from 40 to 43	– Auditory prompts (delivered via tape recorder and headphones)	– Community-based vocational instruction (CBVI) site – High School Vocational Program – Settings: church and pet store	– Vacuum – Dust – Sweep – Clean mirrors – Straighten pew – Straighten pew – Assemble pet carrier – Straighten cans – Hang one strip	Positive	Reference search

(continued)

Table III. (*Continued*).

Reference	Level of evidence	Number of subjects, n = total	Number of subjects used AT, n = total	Sex: F = female; M = male	Ages, r = range; m = mean	Type/severity of disability	Type of AT	Type of employment	Type of task	Results	Retrieval site
Furniss and Ward [2]	Level 2	$n=6$	$n=6$	$F=1$ M = 5	r: 31–47 m: 38	– Cognitive disability – Vineland percentile scores 15–40	– Picture cues (drawings) in a book – Computer-aided support system: palm-top computer – Prompt devices: audio and vibrating – Supervisor call unit (carried by job coach or supervisor)	– Attend day center – Participated in unpaid work in a regular work environment ½ day/week	– Assembly: nut/bolt/washer – Assembly: boxes – Preparing clock cars – Assembly: aqualung pillar valve	Positive	CINHAL
Lancioni et al. [18]	Level 2	$n=6$	$n=6$	$F=3$ M = 3	r: 23–47 m: 37	– Severe developmental disability – Vineland age equivalencies from age 2–6.5 years on daily living skills and 1–2.5 years on socialization skills	– Palm-top computer (pictorial instructions, prompting and latency conditions) – Auditory output device and vibration for prompting – Smiling faces were used as reinforces	– Day activity centers	– Cleaning (hall, meeting room or living room, toilet area) and setting the table – Food preparation (pudding, soup, cookies, fruit dessert)	Positive	CINHAL and PUBMED
Davies et al. [19]	Level 2	$n=10$	$n=10$	$F=2$ M = 8	r: 18–70 m: 41.9	– Mental retardation – Intelligence testing (WAIS-R): Range: 39–72 mean = 54.8	– 'Visual Assistant' on a palm-top computer with audio and digital pictures	– Community-based vocational support program – School district community-based program for student with MR ages 18–21	– Pizza box assembly – Software assembly task	Positive	Reference search
Williams et al. [13]	Level IV	$n=320$	$n=114$	NR	r: 18–65+ m: NR	Self-reported mental limitation	– Talking clock – Checklist of steps – Reminder devices – Computer – Alarms	– Not delineated for individuals with self-reported mental limitations compared to other respondents		Mixed	ERIC
Total	Level 1: 0 % 2: 78% 3: 11% 4: 11% 5: 0%	$n=358$	$n=154$	*F = 30% *M = 70%	r: 7–65 *m: 30.8	– – – – – –	– – – – – –	– – – – – –		Positive = 89% Mixed = 11% Negative = 0%	Databases = 33% Reference Search = 67%

NR, not reported; F, female; M, Male; n = sum.
*Based on number reported.

Table IV. Success indicators.

Reference)	Accuracy	Independence	Generalized skills	Higher pay	Employee satisfaction	Employer satisfaction
Connis [14]	NR	↑	NR	NR	NR	NR
Wacker (1983)	↑	NR	↑	NR	NR	NR
Wacker et al. [15]	↑	↑	↑	NR	NR	NR
Steed and Lutzker [16]	↑	↑	↑	NR	NR	NR
Tabor et al. [17]	↑	↑	NR	NR	NR	↑
Furniss and Ward [2]	↑	NR	NR	NR	↑	↑
Lancioni et al. [18]	↑	NR	NR	NR	↑	↑
Davies et al. [19]	↑	↑	NR	NR	↑	NR
Williams et al. [13]*	NR	NR	NR	NR	NR	NR
Total # of studies (N)	7	5	3	0	3	3

*Williams et al. [13]: did not present appropriate experimental data in any of the indicators.

demonstrate a trend towards positive effects, including increased accuracy, independence and generalization of skills.

Research question #2

AT interventions and the positive effects on employment outcomes were also considered. The articles examined illustrated the use of cuing systems as an effective training tool. The cuing systems utilized in these studies explored many ways to deliver prompts, including: task analysis illustrated on picture or photo cue cards, verbal cues recorded onto a tape player and computer-aided devices that combined a variety of visual and auditory cues.

Research demonstrates that these types of cuing systems are effective in teaching individuals with CD in both school and vocational settings [14]. Connis (1979) summarized the early research in the area of cuing systems beginning with the use of picture cues in academic settings for students with CD [15]. His findings cited examples of the positive effects of picture cues to teach vocational skills [20].

The number of studies using picture cues in vocational settings increased and showed a trend moving from low- to high-tech applications. Early studies involved the use of line drawings or photos either posted on the wall near work areas or presented in book format. The complexity of these cues and technology increased with later studies. Studies in the 1980s and 1990s introduced the delivery of auditory cues via a portable tape player (i.e., Walkman). Tabor et al. [17] stressed the superiority of this type of device as it was widely used in the mainstream population and therefore non-stigmatizing. They were also more portable than picture cuing systems utilized in early studies. Popular culture continued to dictate the next and most current trend towards the use of hand-held, computerized devices as Personal Data Assistant (PDA) devices became more readily available and cost effective. These devices generally utilize a combination of prompts such as video, photos, vibration and recorded verbal cues. These devices engage users through many modalities and are easy to individualize for a variety of different tasks. Auditory or tactile (vibration) cues can be programmed to alert users that fail to complete steps in a timely manner [17]. This promotes errorless learning, which is a major benefit of these devices over picture cues alone.

Research question #3

This study also examined whether AT use increases success or employability due to the use of AT. Eight out of nine studies support the beneficial effects of AT tools in the workplace. These articles reported increased accuracy, independence and generalization of skills following the implementation of AT. The results of the survey by Williams et al. [13] was included in our initial data analysis as they reported the use of AT in the workplace. However, it was not experimental data and was not included in the results table (Table V), as it did not report specific information about subjects.

Research question #4

The final question was to discover the indicators of employment success. The initial assumption was that success would be measured as a higher rate of pay or job stability. We also expected to find reports of increased job satisfaction by employers or employees, as a result of AT use. The most frequently reported indicators of success on the job were increased rates of accuracy, independence and the ability for workers to generalize skills to additional tasks or settings, as outlined in Table IV. None of the studies we reviewed reported information on rates of pay or job stability. Three of the studies reported employer satisfaction, stating that the workers with CD appeared to be busier

Table V. Results table.

Study*	Intervention	Outcomes†	Results/conclusion
Connis [14]	*Comparison* Pre-test vs. post-pest for 'independent task change' with picture cue training. *Duration* Data were collected throughout work day (5 h/day) Data was collected over 90 vocational training days: Baseline: Data were collected over 18 vocational training days Picture-cue training: Data were collected over 18.5 (mean) vocational training days Post-training (daily checks)/Maintenance: Data were collected over 21.5 (mean) vocational training days Post-training (weekly checks)/Maintenance: Data were collected 1x/week over 6 weeks. This began on day 65 and ended on day 90. During post-training, subject could choose to use the picture cues or not use the picture cues	*Accuracy* Not reported *Independence* The % of independent task change: Baseline X = 57% Picture-cue training X = 96.5% Post-training (daily checks) X = 97% Post-training (weekly checks) X = 95% Frequency of picture use during post-training on day 70 and day 90, respectively: X = 49% *Generalization* Not reported	1. During self-recording and picture-cue training, the subjects completed an increased proportion of independent task changes 2. Subject demonstrated the ability to maintain skills over time with the use of picture cues 3. Self-recorded and the use of picture cues were shown to be an effective procedure for teaching mentally retarded adults to function more independently in a job setting 4. Observers informally observed a decrease in the use of pictures towards the end of the post-training phase. Subjects were either selective in marking the squares or marked several squares at once and then changed tasks correctly. Subjects continued high percentages of independent task changes, even though their frequencies of picture-cue use diminished over time, suggests that the high proportion of independent task changes may have maintained with total removal of the training package
Wacker and Berg (1983)	*Comparison* Pre-test vs. post-test for 'percent of correct steps', during a vocational task, while using pictures cues Maintenance effects Generalization of performance *Duration* **Training tasks** Mean number of sessions for black valve task ($n = 5$): Baseline: 5.6 sessions Training (step 3): 6.4 sessions Post-test 1: 3 sessions Post-test 2 (picture cue removed): 2 sessions Maintenance (2–4 weeks after post-training 2): 3.2 sessions Mean number of sessions for circuit board task ($n = 3$): Baseline: 5.6 sessions Training: 6 sessions Post-test 1: 3 sessions Post-test 2 (picture cue removed): 2 sessions Maintenance (2–4 weeks after post-training 2): not-reported **Generalization Tasks:** packaging and red valve assembly: Mean number of sessions for generalization tasks ($n = 3$): Baseline: 9.3 sessions Training: no training	*Accuracy* **Percent of steps completed correctly for black valve assembly ($n = 5$):** Baseline: range (approx) = 20%–55% Training: range = 40%–100% with all subjects at 100% for last two data points collected Post-test 1: 100% Post-test 2: 100% Maintenance: 4/5 subjects ranged from 98% to 100% and the last subject ranging from 65% to 100%. **Percent of steps completed correctly for circuit board assembly ($n = 3$):** Baseline: range (approx) = 0–70% Training: 100% Post-test 1: range (approx) = 98%–100% Post-test 2: 100% Maintenance: not reported *Independence* Not reported *Generalization* **Percent of steps completed correctly for generalization tasks ($n = 3$):** Baseline: range (approx) = 0–35% Training: no training Post-test 1: range (approx) = 50%–100%	1. Task training with picture prompts was effective in teaching all students to assemble the black valve. Following training and the use of picture prompts, all students were able to continue to perform the all steps, with 100% accuracy, with and without picture prompts. 4/5 subjects were able to maintain 98% accuracy or above during the maintenance period 2. Task training with picture prompts with the second training tasks (circuit board) with 2/3 subjects performed all steps with 100% accuracy and the third subject performing with 100% accuracy during 4/5 trials 3. During generalization tasks, all subjects improved their accuracy of performance substantially above their baseline numbers, but only one subject increased her performance to 100% accuracy. All subjects generalized their use of the picture books with each student turning the pages of the book correctly and independently 4. During the generalization tasks, a substantial decrease was noted when picture cues were removed, but increase again once picture cues were reinstated 5. Picture prompts can be effective in promoting generalization of tasks and in improving accuracy for complex vocational performance for adolescents with moderately to severely mental retardation 6. Subject was able to maintain higher levels of accuracy with the removal of picture prompts with the training tasks, but not with the generalization tasks 7. Once students are trained to use picture cues effectively, few training trials may be required on future tasks that also use picture cues

(*continued*)

Table V. (*Continued*).

Study*	Intervention	Outcomes†	Results/conclusion
	Post-test 1: 3 sessions Post-test 2: 2.3 sessions Post-test 1: 2.3 sessions Training (completed with 2/3 subjects with packaging task only): 3 sessions Post-test 1 (completed with 2 subjects that needed training on the packaging tasks): 2.5 sessions	Post-test 2: range (approx) = 0–80% Post-test 1: range (approx) 65%–100% Training (completed with 2/3 subjects owith packaging task only): % not reported during training Post-test 1 (completed with 2/3 subjects who needed training on the packaging tasks): 100%	
Wacker et al. [15]	*Comparison* Pre-test and post-test for 'percent of correct task steps' Percent of independence with page turning after training Generalization of skills to two 'generalization tasks', one similar to the training task and one dissimilar *Duration* **Mean number of session across training task and generalization tasks (2) for all participants:** Baseline: 8.3 sessions Training (step 3): 44 sessions Post-training (training task only): 4.3 sessions Probe (generalization tasks only): 2.3 sessions Maintenance: 3.1 sessions over 3–4 months	*Accuracy* Percent of correct task steps completed for all subjects and all tasks (mean): Baseline: > 55% Training: 72.2% Post-training (training task only): 93.8% Probe (generalization tasks only): 46.7% Maintenance: 74% *Independence* Percent of independence with page turning for all subjects and all tasks (mean): Baseline: not reported Training: 76.2% Post-training (training task only): 95% Probe (generalization tasks only): 73.4% Maintenance: 93.6% *Generalization* **Task 1 (task similar to training task):** Baseline: task steps: 26.7% Probe task steps : 62.8% page turning : 83.5 % Training task steps: 78.2% page turning: 85.6% Maintenance task steps: 86.3% page turning: 100%	1. All students required extensive training with initially training task (143, 79 and 83 sessions) 2. Following extensive training and the use of picture prompts (book), all the subjects performed at high levels of accuracy 3. All subjects generalized their skills to 'generalization tasks' without additional training 4. A substantial reduction of training was needed for both generalization tasks following the acquisition of the training task 5. All subjects maintain their skill on the training task and at least one of the generalization skills over a 3–4 month maintenance period. 6. All subjects demonstrated improved independence with page-turning skills.

(*continued*)

Table V. (*Continued*).

Study*	Intervention	Outcomes†	Results/conclusion
		Task 2 (dissimilar from training task): Baseline task steps : 24.8% Probe task steps : 29.7% page turning : 60.1% Training task steps: 71.2% page turning: 84.4% Maintenance task steps: 61.5% page turning: 89.3%	
Steed and Lutzker [16]	*Comparison* Pre-test and post-test to look at 'percentage of steps completed' with the use of a picture book. Maintenance effects Ability to generalize skills *Duration* **Training and picture prompts** Baseline: range of 1–4 months Training: range of 1–2 months Post-training: range of 1–4 months Picture book removed: approximately 1 week Maintenance: Collected at 1, 3 and 6 months following initial training. **Generalization with picture prompts** Picture prompts only: approximately 1 month Picture prompts (book) removed: approximately 2–3 weeks Picture prompts (book) reintroduced: ranged from approximately 1–3 months	*Accuracy* Percent of steps completed accurately with training and picture prompts for three training tasks: Baseline: > 13% Post-training: < 87% Picture cues (book) removed: 0% Picture cues (book) reintroduced: < 87% Maintenance: 97% *Independence* Not reported *Generalization* **Percent of steps completed with generalization task** (dusting sofa wood); Picture prompts (no training): 92% Picture prompts (book) removed: 0% Picture prompts (book) reintroduced: 92% **Percent of steps completed with generalization task (emptying trash):** Picture prompts (no training): 100% Picture prompts (book) removed: 55% Picture prompts (book) reintroduced: 100%	1. Picture prompts represent an alternative to instructor assistance for task completion 2. Picture prompts were successful in increasing the percentage of steps completed for each of the tasks. However, practice was still needed to ensure the overall quality of the subjects' performance 3. Skill performance was maintained over time with continued use of picture prompts with this subject 4. Subject generalized the use of picture prompts to similar tasks with this subject

(*continued*)

Table V. (*Continued*).

Study*	Intervention	Outcomes†	Results/conclusion
Tabor, et al. [17]	*Comparison* Pre-test and post-test to look at the 'percent of independent task transition' for subjects using auditory prompts Single word prompts vs. multiple-word prompt Maintenance effects Withdraw effects *Duration* Mean number of session reported for all subjects across both settings: Baseline: 13.8 sessions Intervention: 13.4 sessions Maintenance: 10.5 sessions Withdrawal: 4 sessions	*Accuracy* Not reported *Independence* Mean number of independent task transition (max = 6): Baseline: 2 transitions Intervention: 5.8 transitions Maintenance: 6 transitions Withdrawal: – auditory prompts removed: 0.5 transitions – auditory prompts reinstated: 6 transitions *Generalization* Not reported	1. Found self-operated auditory prompts were helpful to control for desired behaviors (independent task transition) 2. Found self-operated auditory prompts effective for teaching workers with moderate mental retardation to manage their own task change behavior in vocational settings 3. Found auditory prompting system can be generalized across settings without additional training 4. Statistical analysis revealed a statistically significant difference between baseline and both auditory promptings systems in both vocational settings 5. Visual and statistical analysis of the data revealed no significant differences between lengths of verbal prompts. Therefore, single word and multi-word auditory prompts were found to be equally effective. Authors initially thought single work would be more effective
Furniss and Ward [2]	*Comparison* Pre-test and post-test for accuracy of 'task completion' with computer-aided device (palmtop) and picture cues (booklet) Maintenance effect of assistive technology Computer-aided device (palm-top computer) vs. picture cues (booklet) *Duration* – Participants were at their given site only one half-day pre-week. – The average work uninterrupted work time for all participates was 71 min. – Mean number of sessions for all subjects: Baseline: 1.7 sessions Introductory training (no data collected): 1.2 sessions Training: 6.7 sessions Maintenance: 18.7 sessions Withdrawal(¶)(**): 1.7 sessions	*Accuracy* Percent of accurate task steps completed (mean): Baseline: 25.2% Training: 84.1 % Maintenance: 79.9% Withdrawal (all or partial)§: 64.9% *Independence* Percent of time engaged on task (mean): 92.7% *Generalization* Not reported	Case Study 1: 1. After intensive training with the palm-top computer, this subject performed at 95% accuracy. He had an initial decline in the maintenance phase, but recovered in session four and five to 100% and 95%, respectively. When the palm-top computer was removed the subject dropped to 62.5%. He was able to recover over three sessions to end at 90.3% accuracy Case Study 2: 1. This study compared the use of the palm-top computer with instructions and prompts compared to instructions and no prompts. This subject improved from 14.7% accuracy at baseline to an average of 85.5% accuracy after intensive training. There was a decline with maintenance with an average accuracy of 68.7%. With the removal of prompts there was a further decline with an average accuracy of 53%. When the prompts were reintroduced the subject's accuracy improved to an average of 86.3%, with a high of 92% 2. In addition to decreased accuracy without the prompting device, the subject also required more time. The subject required 24.3 min without prompts and 19.8 min with prompts Case Study 3: 1. This study looked at accuracy of the palm-top computer device compared to picture cues (books). This subject's accuracy improved from 36% at baseline to 85.9% with the palm-top computer and 80.7% with the picture book. During maintenance, the subject's accuracy decreased slightly to 75.4% with the palm-top computer and 78% with the picture book. When all supports were removed, the subject's accuracy remained similar at 78% accuracy, which is inconsistent with the other case studies discussed in this article

(*continued*)

Table V. (*Continued*).

Study*	Intervention	Outcomes†	Results/conclusion
			Case Study 4: 1. The use of a palm-top computer and picture book, with 81.3% and 87% accuracy, respectively, but the subject completed the task faster with the palm-top computer (10.1 min) compared to the picture book (20.7 min). 2. When the subject worked without the palm-top computer completed fewer tasks correctly (57.7%), confirming the palm-top computer was effective for this subject accuracy (85.3% before withdraw and 84.5% accuracy after withdraw). Case Study 5: 1. Comparing the use of a palm-top computer device and a picture booklet along with step-by-step instructions and 'clustered' instruction, the subject performed best with the palm-computer and 'clustered' instructions (100% accuracy) Case Study 6: 1. This study examined the long-term changes with the use of a palm-top computer. The subject started with a baseline average of 28.5%, increasing to 81.5% with intensive training. The subject's accuracy dropping initially, but averaging 71.3% with a final score of 85%, exceeding the average achieved during intensive training Overall: 1. Palm-top computers along with intensive training were effective in enabling these participants to perform work tasks with a high degree of accuracy 2. After intensive training by a job coach, there was an initial decrease in accuracy; however, over time 4/6 participants showed further improvements beyond what they achieved with intensive training 3. Accuracy difference between the use of palm-top computer or picture cues (book) and withdraw of devices was greater for tasks where most or all tasks steps were unique versus when the task steps were more repetitive 4. The overall difference between palm-top computer and picture cues (books) for these case studies seems to be in performance fluency rather than accuracy

(*continued*)

Table V. (*Continued*).

Study*	Intervention	Outcomes†	Results/conclusion
			5. Views from careers based on interview questions (questions given point values): – Overall benefit of palm-top computer device: extremely positive (mean = 20.6/24 points) – Relationship with fellow employees: positive (mean = 2.75/3 points) 6. Views from co-workers and employers base on interview questions (questions given point values): – Suitable work placement: positive (mean = 9/12 points) – Ease of social interaction: less positive (mean = 6/12 points) – Acceptability of palm-top computer device: moderately positive (mean = 15.5/24 points) – Job effectiveness: positive (17.7/27 points) 7. Computer-aided devices may offer considerable potential as tools to enable person with severe DD to maintain engagement with, and accurate completion of, complex vocational tasks
Lancioni, et al. [18]	*Comparison* **Experiment 1:** – Pre-test and post-test to examine 'number of correct steps with computer-aided device (palmtop) and picture cues (cards) coupled with verbal or vibratory prompts. – Cross-over test switch the device/tasks opposite that of the maintenance phase (i.e., task that was presented in the computer-aided system were presented in the card system and vice versa). **Experiment 2:** – Using the computer-aided device only with different levels of instruction: no instruction; clustered instructions; and omitted instructions *Duration* – Participants' only completed one tasks per session. – Participants' completed one to three sessions per day. **Experiment 1:** Mean number of sessions for all subjects: Baseline: 9 .3 sessions Introductory Training: 6 sessions Training: 20 sessions Maintenance: 23.7 sessions Cross-over test: 16 sessions **Experiment 2:** Mean number of sessions for all subjects: No instruction: 32 sessions Cluster instruction: 32 sessions Omitted instructions: 32 sessions	*Accuracy* **Experiment 1 (n = 6)** Percent of correct steps (mean)††: Baseline: 8.5% Training: 64% Maintenance: 93.5% Cross-test: 87.5% **Experiment 2 (*n* = 3)** Percent of correct steps (mean)‡‡: No instruction: 56.3% Cluster instruction: 85.3% Omitted instructions: 80.7% *Independence* Not reported *Generalization* Not reported	Experiment 1: 1. Overall percent of correct tasks were 10%–42% higher than with the card system 2. With the cross-over tests, participants had an improvement of 14%–36% with tasks transferred from the card system to the computer system, but showed a 9%–30% deterioration with tasks transferred from the computer system to the card system 3. Computer prompts occurred more frequently during the training phase (x = 5 prompts/session) compared to other phases 4. Participants preferred the computer system (x = 90%) over the card system Experiment 2: 1. The mean percentage for instructions organized with clusters was similar to the maintenance and crossover test of the first experiment 2. All three subjects had greater accuracy with the clustered instructions compared to when instructions were omitted 3. The computer system can be adjusted to in the way the instructions are delivered to meet the needs/level of the client. Overall 1. Although both computer-aided systems and card systems proved to be helpful in improving accuracy of task completion, the computer-aided systems were 10%–42% more effective than card system 2. Those subjects with lower levels of achievement showed a wider performance discrepancy between the computer system and the card system

(*continued*)

Table V. (*Continued*).

Study*	Intervention	Outcomes†	Results/conclusion
Davies, et al. [19]	*Comparison* Comparing outcomes for vocational tasks both with and without support from the portable visual/audio training and support provided with the 'Visual Assistant'. *Duration* Each participant completed each task (two tasks total), two times, once with the Visual Assistant and once without	*Accuracy* Number of errors made (mean): Visual Assistant: 0.75§§ No visual Assistant: 2.25§§ *Independence* Number of prompts required for each step: Visual Assistant: 1.05§§ No visual Assistant: 2.40§§ *Generalization* Not reported	1. The observed mean difference for errors per task was statistically significant ($p < .006$) 2. The observed mean difference for errors per task was statistically significant ($p < .032$) 3. Although preliminary due to the small sample size, the results support that a multi-media training, with a palm-top computer, can be effective in improving independence and accuracy for adults with MR performing community-based vocational tasks 4. The use of portable palm-top devices has the potential for reducing the need for human assistance for individuals with MR 5. Portable palm-top devices can be a useful adjunct to training and supports to promote community inclusion 6. Experiences with the Visual Assistant elicited comments positive comments from the participants (based on authors' observations)

*Williams et al. [13] not included in this table since experimental data was not collected.
†The numbers listed in the outcomes column are only approximate based on the readability of the graphs and tables presented in the articles.
‡1 session = 15 min.
§Only reported withdraw data for 5/6 subjects.
¶Only reported withdraw data for 5/6 subjects.
**Includes all or partial withdraw of assistive technology.
††numbers are approximate due to lack of specificity on figure/graph within the original article.
‡‡The 3 subjects from experiment 2 also participated in experiment 1.
§§Significant difference.

while using the AT intervention [2,17,18]. In two of the studies, employees were asked to report their preferred ATs. The workers selected the palm device more often than the picture cue books [2,18].

Limitations

Our literature search yielded a relatively small amount of studies that met the search criteria (see Figure 1). The present literature is limited to small sample size studies; no more than 10 participants were included in any of the experiments. Although the studies reported positive effects on the employment outcomes of workers with CD, it would be difficult to generalize such a small quantity of results to larger portions of this population. Another limitation is the length of the studies. Most subjects only participated in vocational training for a limited amount of time each week. The studies did not to measure long-term maintenance of skills gained with AT use. Maintenance of skills measured in these studies ranged from only 2 weeks to 6 months. Although the use of AT in these studies showed positive results, data may be stronger if vocational training was longer and if long-term maintenance was reported.

The information provided in the survey by Williams et al. [13] was included in this review because it provided quantitative information on AT tools used in the workplace. However, the term 'mental limitation' was not explicitly defined, as it was in the remaining studies, leaving the level of the cognitive disability unknown.

Relevance of studies

Regardless of the limitations, these studies could easily be replicated in other vocational or educational settings. In following the simple format used in these quasi-experimental studies, teachers or job coaches could collect pre- and post-AT intervention data in school or community settings. Baseline data could be collected using a task analysis and compared to data collected after implementing new AT interventions.

Most of these job tasks involved limited steps, simplifing the process of measuring success. The early studies included are still relevant today, as low-tech interventions of picture and audio prompts can be upgraded to higher tech tools (i.e., PDA) available today.

Conclusions

As a result of this systematic review of literature, we can conclude a number of important findings to improve our AT practices with this population. The evidence indicates that the AT cuing systems make this population more independent and assist in increasing job completion and accuracy [2,14–17 ,19]. The AT cuing systems examined also helped individuals with CD generalize job skills to other tasks and settings.

Recommendations

As AT is becoming less complicated and more cost effective, all of these factors will increase the possibility of AT tools being utilized in school and vocational settings. These cuing systems are examples of AT interventions that could be adapted to any budget or level of sophistication. Low-tech cuing systems, such as picture cue books, are easier and less expensive to make now that digital cameras are more prevalent. Conversely, high-tech palm devices are also less expensive and easier to use and are socially valid in mainstream settings. Any of these low- or high-tech cuing systems should be introduced in school settings to support students with CD as they transition into the vocational training stage of their education. AT support teams should increase funding and training for these tools. AT teams, adult service provider agencies and vocational professionals should work together to provide these tools and train teachers and job coaches.

Future research

The use of multiple prompts with PDA devices are currently being researched by AbleLink [21], a vendor based in Colorado. AT and vocational training professionals should be knowledgeable of this research to positively influence AT practices with this population. Continued research should focus on long-term maintenance of skills with AT, using larger sample sizes to increase the validity of the results. Future research should also focus on implementing these AT interventions earlier in school vocational programs to increase employability.

Finally, to improve our AT practices, AT professionals should work to promote continued research in our field and demand higher standards from manufacturers. Implementation of research-based AT practices in middle and high school settings can benefit this population as they transition to the workforce. Therefore, AT and vocational training professionals should begin working together to introduce AT approaches in transition and vocational training programs in the public school setting.

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