CELLreviews
Center for Early Literacy Learning
2012 ■ Volume 5 ■ Number 7

Assistive Technology and the Communication and Literacy Development of Young Children with Disabilities

Carl J. Dunst
Carol M. Trivette
Deborah W. Hamby

The effectiveness of different types of assistive technology for promoting the early communication and literacy abilities of young children 30 to 87 months of age was the focus of a meta-analysis. The synthesis included 36 studies of 687 children with disabilities or delays. The assistive technology that was the focus of use with the children included different types of speech generative devices (e.g., VOCA, CheapTalk, MINISPEAK) and various types of computer software and devices (e.g., computer-based instruction, adapted keyboards). Results showed that both types of assistive technology were effective in terms of promoting the children's communication and literacy-related behavior, and that the nature of the relationships were much the same regardless of any child or intervention moderator variable. Implications for practice are described.

The manner in which the use of assistive technology influenced the communication and literacy behavior of young children with developmental disabilities was the focus of the meta-analysis described in this *CELLreview*. Assistive technology includes "devices ranging from simple (e.g., adapted spoons and switches) to [those that are more] complex devices (e.g., computers, augmentative communication systems, environmental control devices, electric wheelchairs)" (Wilcox, Guimond, Campbell, & Moore, 2006, p. 33). The assistive technology that was the focus of this meta-analysis included a variety of devices specifically designed to influence improvements in the communication or literacy skills of the study participants.

Although there are a number of literature reviews on the effectiveness of assistive technology with preschoolers with disabilities (Campbell, Milbourne, Dugan, & Wilcox, 2006; Floyd, Canter, Jeffs, & Judge, 2008; Mistrett & Lane, 1995), none were meta-analyses of the studies included in the reviews nor did the investigators attempt to identify the differential effectiveness of the use of different devices varying in complexity with children who differed in their diagnoses or severity of delays. We located only one literature review of assistive technology studies with young children where the investigators employed different effect sizes for evaluating the use of the devices, but the effect sizes were not subjected to a meta-analysis (Branson & Demchak, 2009).

The meta-analysis described in this paper was guided by a framework that focused on the manner in which different types of assistive technology influenced the children's communication or literacy development (Dunst & Trivette, 2009). The research synthesis differed from meta-analyses of the efficacy of an intervention by going one step further by attempting to *unpack* and *disentangle* the practice characteristics that matter most in terms of child benefits (Dunst & Trivette, 2012; Dunst, Trivette, & Cutspec, 2007; Lipsey, 1993). The result was expected to be a better understanding of the conditions under which assistive technology was most effective with young children with disabilities.

Search Strategy

Studies were located using "*assist** and *technolog**" or *assist** *technolog** or "*assist** and *device*" or "*adapt** and *modification*" or *adapt** or *modification* AND *disabilit** or *disabled* or *handicap* AND *infant** or *toddler* or *preschool* AND *study* or *research* or *research stud** or *research report* as search terms. Both controlled vocabulary and natural language searches were conducted (Lucas & Cutspec, 2007).

CELLreviews are a publication of the Center for Early Literacy Learning (CELL) funded by the U.S. Department of Education, Office of Special Education Programs (Grant #H326B060010). CELL is collaboration among the Orelena Hawks Puckett Institute, the American Institutes for Research, and the PACER Center.

ERIC (Educational Resources Information Center), Psychological Abstracts (PsychInfo), MEDLINE, Academic Search Elite, Academic Search Premier, Dissertation Abstracts International, and REHABDATA were searched. These were supplemented by searches of Ingenta, Google Scholar, Scirus, and the Cochrane Databases, as well as a search of an EndNote library maintained by our Institute. Hand searches of the reference sections of all retrieved articles, book chapters, books, dissertations, and other reports were examined to identify additional studies. We also examined papers included in previous literature reviews of assistive technology to identify any missed studies (e.g., Alper & Raharinirina, 2006; Campbell et al., 2006; Dunst, Trivette, Meter, & Hamby, 2011; Mistrett et al., 2001; Mistrett & Lane, 1995). Studies were included if some type of assistive technology was used with young children with disabilities or developmental delays, child verbal or nonverbal communication abilities or literacy-related outcomes were the focus of investigation, and sufficient information was included in the research reports to compute effect sizes for intervention vs. nonintervention conditions.

Search Results

Nineteen studies were located that included 27 samples of children or samples of children evaluated at different ages. The 19 studies included 687 children. Appendix A shows the background characteristics of the child participants. The child participants ranged in age from 30 to 87 months (Mean = 54, SD = 15). All but two samples of children had identified disabilities. The children's estimated severity of delay (based on information in the research reports) ranged from profound/severe to typically developing.

Appendix B includes a description of the types of assistive technology used to promote the early communication or literacy skills of the children. The largest majority were some type of speech-generative devices or computer applications. The speech generating devices included, but were not limited to, Tech/Speak, DynaVox, Minispeak, VOCA, and MiniMo. The computer software assistive technology all provided interfaces for the child to acquire either communication or literacy skills.

The types of research designs, the length of the interventions, number of sessions, and the settings where the interventions occurred are shown in Appendix B. The research designs included single participant design studies (N = 11), between group or between conditions comparison studies (N = 3), and pretest-post test comparison studies (N = 13). The settings where the interventions took place included preschool classrooms, the children's homes, university clinics, and various combinations of these settings. The number of intervention sessions varied from one to 16 (Mean = 5, SD = 3) and hours of intervention varied from less than one to 40 (Mean = 20, SD = 17).

The outcomes in the studies included mostly investigator-development measures of either communication (verbal or nonverbal) or literacy-related (e.g., phonemic awareness, letter knowledge, reading) skills. Only two studies included literacy-related scales and instruments as the outcome measures (Mathisen, Arthur-Kelly, Kidd, & Nissen, 2009; Regtvoort & van der Leij, 2007). With only a few exceptions, observations of the children's communication or literacy behavior were the primary method used to obtain the outcome measures (see Appendix D).

Cohen's *d* effect sizes were used to determine the influence of using assistive technology on the child outcomes (Dunst & Hamby, 2012). Appendix D shows the comparisons that were made to evaluate the effects of the assistive technology interventions on the child outcomes. The average effect sizes and the 95% confidence intervals for the averages were used for substantive interpretation. A 95% confidence interval not including zero indicates that the average effect size is statistically at the $p < .05$ level (Shadish & Haddock, 1994).

Preliminary analyses were performed to determine if the effect sizes for the studies using different research designs yielded similar or different sizes of effect. The different group design studies yielded similar sizes of effect but the average effect sizes differed from those computed from single participant design studies. The results, therefore, are reported separately for both types of designs.

Synthesis Findings

Table 1 shows the findings for the communication and literacy-related outcomes obtained from the analyses of the effect sizes for the two different types of research designs. The results show that the assistive technology was effective in improving both types of child outcomes as evidence by both the sizes of effect and confidence intervals not including zero. The pattern of results was the same for both types of research design although the assistive technology was some-

Table 1
Average Effect Size and 95% Confidence Intervals for the Influences of the Assistive Technology on Child Communication and Literacy Outcomes

Types of Study/ Outcomes	Number of Effect Sizes	Average Effect Size	95% Confidence Intervals
Single Participant Studies			
Communication Outcomes	24	2.73	2.19-3.28
Literacy Outcomes	7	1.75	1.71-1.79
Group Studies			
Communication Outcomes	7	1.62	1.03-2.20
Literacy Outcomes	21	1.09	.70-1.48

what more effective in improving the children's communication behavior compared to the children's literacy-related outcomes as evidenced by the difference between the effect sizes for the two types of outcomes.

The relative effectiveness of the two types of assistive technology constituting the focus of investigation is shown in the Table 2. The speech generating devices proved effective in promoting the children's communication or literacy behavior in both the single participant and group design studies. The various types of computer devices were also effective in promoting the children's communication or literacy-related behavior. In the group design studies, the two types of assistive technology were similarly effective in terms of changes in the child outcome measures.

Table 3 shows the effects of the interventions for the study participants according to differences in child age. The pattern of results were very much the same for both types of research designs. The assistive technology interventions were most effective for the youngest compared to the oldest children in the studies. The findings, however, are partly confounded by differences in the children's severity of delay. For both types of designs, children in the oldest groups tended to have more profound/severe delays whereas the children in the youngest groups tended to have mostly moderate/mild delays.

The conditions under which the effects of assistive technology influenced the study participants' outcomes were examined by moderator analyses. The interventions differed according to length of the interventions, number of intervention sessions, and the settings in which the interventions took place (see Appendix C). The children who were the study participants also differed in terms of their diagnoses and severity of delay. Table 4 shows the extent to which these variables moderated the relationships between the assistive technology interventions and the child outcomes. All of the average effect sizes except for two differed significantly from zero as evidence by confidence intervals not including zero. There were very few large differences in the sizes of effects for within moderator group comparisons.

Table 2

Average Effects and 95% Confidence Intervals for the Influence of Different Types of Assistive Technology on the Child Outcomes

Type of Study	Number of Effect Sizes	Average Effect Size	95% Confidence Intervals
Single Participant Studies			
Speech-Generating Devices	30	2.53	2.07-2.99
Computer Devices	1	1.96	–
Group Studies			
Speech-Generating Devices	13	1.27	.74-1.80
Computer Devices	15	1.19	.73-1.64

Table 3

Average Effect Size and 95% Confidence Intervals for the Relationship Between the Assistive Technology Interventions and Child Outcomes as a Function of Differences in Child Age

Study Design/Child Age	Number of Effect Sizes	Average Effect Size	95% Confidence Intervals
Single Participant Studies			
30-48 Months	10	3.46	2.28-4.65
49-69 Months	7	2.64	2.11-3.17
70-87 Months	14	1.77	1.74-1.79
Group Studies			
30-48 Months	12	1.34	.81-1.86
49-69 Months	9	1.36	.78-1.94
70-87 Months	6	.70	.25-1.66

Discussion

Results showed that both types of assistive technology constituting the focus of investigation in the primary studies were effective in terms of improving the children's communication and literacy-related outcomes, and that the interventions were similarly effective for children differing in their diagnoses and severity of delays. Results also showed that the different contextual variables (setting, hours of intervention, number of sessions) we were able to analyze did not differentially influence the effectiveness of the assistive technology interventions.

The meta-analysis reported in this *CELLreview* differed from other syntheses and literature reviews of assistive technology interventions with young children with disabilities (e.g., Branson & Demchak, 2009; Campbell et al., 2006; Floyd et al., 2008) by (a) using effect sizes for judging the magnitude of the influences of the assistive technology on the children's communication and literacy outcomes, (b) investigating the effects of interventions for different research designs, and (c) examining the conditions under which the interventions were most effective. Our attempt to unpack and disentangle the interventions highlighted a major limitation of the original studies, and therefore the findings from meta-analysis of the studies; namely, the inclusion of only two quasi-experimental group design study (Hutinger et al., 1998) that permitted comparisons of intervention and non-intervention study participants.

Implications for Practice

A number of research syntheses that our colleagues and ourselves have completed on both the effectiveness of assistive technology and the conditions under which assistive technology is likely to be used by practitioners and parents include guidelines, suggestions, and procedures that can be

Table 4
Moderators of the Relationship Between the Assistive Technology Interventions and the Child Outcomes

Moderators	Number of Effect Size	Average Effect Size	95% Confidence Intervals
Single Participant Design Studies			
Child Severity of Delay			
Severe/Profound	24	2.56	1.99-3.12
Moderate to Typically Developing	7	2.35	1.77-2.92
Child Condition			
Physical Disabilities (e.g., Cerebral palsy)	12	2.20	1.85-2.55
Chromosomal Disabilities (e.g., Down syndrome)	4	1.76	1.68-1.85
Nonspecified (e.g., Developmental delay)	3	3.29	-.49-7.07
Intervention Setting			
Home/Home + Other	15	1.68	1.49-1.87
Clinic/School/Hospitals	16	3.29	2.65-3.93
Number of Sessions			
1-3	20	2.70	2.12-3.38
5-4	5	1.50	.76-2.24
Length of Intervention (hours)			
< 2	18	2.77	2.07-3.47
2.1-18	11	2.32	1.90-2.74
Group Design Studies			
Child Severity of Delay			
Severe/Profound	12	1.22	0.64-1.78
Moderate to Typically Developing	16	1.23	0.83-1.66
Child Condition			
Physical Disabilities (e.g., Cerebral palsy)	1	1.90	–
Chromosomal Disabilities (e.g., Down syndrome)	8	1.86	1.28-2.45
Nonspecified (e.g., Developmental delay)	7	1.33	0.96-1.70
Intervention Setting			
Home/Home + Other	5	0.95	.08-1.83
Clinic/Schools/Hospitals	23	1.28	.91-1.65
Number of Sessions			
1-3	6	.70	-.25-1.66
5+	16	1.64	1.32-1.96
Length of Intervention (hours)			
< 11	10	1.47	.85-2.08
30-40	10	1.57	1.05-2.08

used to incorporate assistive technology into early childhood intervention practices for young children with disabilities. (e.g., Dunst et al., 2011; Trivette, Dunst, Hamby, & O'Herin, 2010). One of the best sources of information on assistive technology for young children with disabilities is the *Tots 'n Tech Resource Institute* (www.tnt.asu.edu). The interested reader is referred especially to the *AT Research Briefs* on the *Tots 'n Tech* website where useful ideas are described in the various documents available for both practitioners or parents. *Resource Brief 5* includes both a model for using assistive technology with very young children with disabilities and a step-by-step process for individualizing the use of different kinds of devices.

Findings reported in this *CELLreview* indicate that different types of assistive technology are effective for promoting the communication and literacy skills of young children with disabilities. Research also indicates that despite the fact that assistive technology is effective with very young children with disabilities, the devices are generally not used by either practitioners or parents with children with disabilities, and

especially infants and toddlers with disabilities (Campbell, Milbourne, & Wilcox, 2008). As part of a research synthesis of the characteristics of training used to promote practitioner or parent use of assistive technology with young children with disabilities, (Dunst et al., 2011), we found that a failure to adopt and use assistive technology was mostly due to a failure to use effective training methods with practitioners or parents (see also Sawyer, Milbourne, Dugan, & Campbell, 2005). One of the products of that research synthesis was the development of an evidence-based checklist that includes the training methods and practices that were associated with practitioner and parent use of assistive technology (Dunst et al., 2011). The checklist can be used to ensure that training methods included those elements that will increase the likelihood of the adoption and sustained use of assistive technology. Attachment A includes a modified version of that checklist which includes the key characteristics of the training methods that were associated with use of assistive technology and other devices in both home and classroom settings.

References

Alper, S., & Raharinirina, S. (2006). Assistive technology for individuals with disabilities: A review and synthesis of the literature. *Journal of Special Education Technology, 21*(2), 47-64. Retrieved from http://www.tamcec.org/jset/

Binger, C., Kent-Walsh, J., Berens, J., Del Campo, S., & Rivera, D. (2008). Teaching Latino parents to support the multi-symbol message productions of their children who require AAC. *AAC: Augmentative and Alternative Communication, 24*, 323-338.

Binger, C., Kent-Walsh, J., Ewing, C., & Taylor, S. (2009). Teaching educational assistants to facilitate the multisymbol message productions of young students who require AAC. *American Journal of Speech-Language Pathology, 19*, 108-120. doi:10.1044/1058-0360(2009/09-0015)

Branson, D., & Demchak, M. (2009). The use of augmentative and alternative communication methods with infants and toddlers with disabilities: A research review. *AAC: Augmentative and Alternative Communication, 25*, 274-286. doi:10.3109/07434610903384529

Campbell, P. H., Milbourne, S., Dugan, L. M., & Wilcox, M. J. (2006). A review of evidence on practices for teaching young children to use assistive technology devices. *Topics in Early Childhood Special Education, 26*, 3-13.

Campbell, P. H., Milbourne, S., & Wilcox, M. (2008). Adaptation interventions to promote participation in natural settings. *Infants and Young Children, 21*(2), 94-106.

Dunst, C. J., & Hamby, D. W. (2012). Guide for calculating and interpreting effect sizes and confidence intervals in intellectual and developmental disabilities research studies. *Journal of Intellectual and Developmental Disability, 37*, 89-99. doi:10.3109/13668250.2012.673575

Dunst, C. J., & Trivette, C. M. (2009). Using research evidence to inform and evaluate early childhood intervention practices. *Topics in Early Childhood Special Education, 29*, 40-52. doi:10.1177/0271121408329227

Dunst, C. J., & Trivette, C. M. (2012). Meta-analysis of implementation practice research. In B. Kelly & D. F. Perkins (Eds.), *Handbook of implementation science for psychology in education* (pp. 68-91). New York, NY: Cambridge University Press.

Dunst, C. J., Trivette, C. M., & Cutspec, P. A. (2007). *Toward an operational definition of evidence-based practices* (Winterberry Research Perspectives Vol. 1, No. 1). Asheville, NC: Winterberry Press.

Dunst, C. J., Trivette, C. M., Meter, D., & Hamby, D. W. (2011). Influences of contrasting types of training on practitioners' and parents' use of assistive technology and adaptations with infants, toddlers and preschoolers with disabilities. *Practical Evaluation Reports, 3*(1), 1-35. Available at http://practicalevaluation.org/reports/CPE_Report_Vol3No1.pdf

Durand, V. M. (1999). Functional communication training using assistive devices: Recruiting natural communities of reinforcement. *Journal of Applied Behavior Analysis, 32*, 247-267. doi:10.1901/jaba.1999.32-247

Floyd, K. K., Canter, L. L. S., Jeffs, T., & Judge, S. A. (2008). Assistive technology and emergent literacy for preschoolers: A literature review. *Assistive Technology Outcomes and Benefits, 5*, 92-102. Retrieved from http://www.atia.org/i4a/pages/index.cfm?pageid=3305

Hutinger, P., Bell, C., Beard, M., Bond, J., Johanson, J., & Terry, C. (1998, May). *The early childhood emergent literacy technology research study* [Final report]. Macomb, IL: University of Illinois. (ERIC Document Reproduction Service No. ED418545).

Hutinger, P., Bell, C., Johanson, J., & McGruder, K. (2002, August). *LitTECH interactive outreach: Final report*. Macomb, IL: Western Illinois University, Center for Best Practices in Early Childhood Education. (ERIC Document Reproduction Service No. ED469844).

Kent-Walsh, J., Binger, C., & Hasham, Z. (2010). Effects of parent instruction on the symbolic communication of children using augmentative and alternative communication during storybook reading. *American Journal of Speech-Language Pathology, 19*, 97-107. doi:10.1044/1058-0360(2010/09-0014)

Kent-Walsh, J. E., & Light, J. C. (2002, November). *Evaluation of an AAC in-service program: Case studies* [Powerpoint presentation]. Presentation made at the annual convention of the American Speech-Language-Hearing Association, Atlanta, GA.

Koppenhaver, D. A., Erickson, K. A., Harris, B., McLellan, J., Skotko, B. G., & Newton, R. A. (2001). Storybook-based communication intervention for girls with Rett

syndrome and their mothers. *Disability and Rehabilitation, 23*, 149-159. doi:10.1080/09638280150504225

Koppenhaver, D. A., Erickson, K. A., & Skotko, B. G. (2001). Supporting communication of girls with Rett Syndrome and their mothers in storybook reading. *International Journal of Disability, Development, and Education, 48*, 395-410. doi:10.1080/10349120120094284

Lipsey, M. W. (1993). Theory as method: Small theories of treatments. *New Directions for Program Evaluation, 57*, 5-38. doi:10.1002/ev.1637

Lucas, S. M., & Cutspec, P. A. (2007). *The role and process of literature searching in the preparation of a research synthesis* (Winterberry Research Perspectives Vol. 1, No. 10). Asheville, NC: Winterberry Press.

Mar, H. H., & Sall, N. (1993, May). *Applications of technology in the communication training of children with deaf-blindness: A programmatic approach* (Technical report). New York: Saint Luke's/ Roosevelt Hospital Center, Developmental Disabilities Center. (ERIC Document Reproduction Service No. ED360795).

Mathisen, B., Arthur-Kelly, M., Kidd, J., & Nissen, C. (2009). Using MINSPEAK: A case study of a preschool child with complex communication needs. *Disability and Rehabilitation: Assistive Technology, 4*, 376-383.

Mistrett, S. G., Hale, M. M., Diamond, C. M., Ruedel, K. L. A., Gruner, A., Sunshine, C., Berman, K., Saunders, J., & McInerney, M. (2001, February). *Synthesis on the use of assistive technology with infants and toddlers (birth through two)*. Washington, DC: U.S. Department of Education, Office of Special Education Programs. Retrieved January 4, 2008, from http://www.fctd.info/webboard/files/AIR_EI-AT_Report_2001.pdf

Mistrett, S. G., & Lane, S. J. (1995). Using assistive technology for play and learning: Children from birth to 10 years of age. In W. C. Mann & J. P. Lane (Eds.), *Assistive technology for persons with disabilities* (2nd ed.). Bethesda, MD: American Occupational Therapy Association.

Olive, M., Lang, R. B., & Davis, T. N. (2008). An analysis of the effects of functional communication and a Voice Output Communication Aid for children with autism spectrum disorder. *Research in Autism Spectrum Disorders, 2*, 223-236.

Regtvoort, A. G. F. M., & van der Leij, A. (2007). Early intervention with children of dyslexic parents: Effects of computer-based reading instruction at home on literacy acquisition. *Learning and Individual Differences, 17*(1), 35-53.

Romski, M. A., & Sevcik, R. (1996). *Breaking the speech barrier: Language development through augmented means*. Baltimore: Brookes.

Romski, M. A., Sevcik, R. A., Robinson, B. F., & Bakeman, R. (1994). Adult-directed communications of youth with mental retardation using the system for augmenting language. *Journal of Speech and Hearing Research, 37*, 617-628.

Rosa-Lugo, L. I., & Kent-Walsh, J. (2008). Effects of parent instruction on communicative turns of Latino children using augmentative and alternative communication during storybook reading. *Communication Disorders Quarterly, 30*, 49-61.

Schepis, M. M. (1996, March). *A comprehensive evaluation of the effects of voice output communication aids on the communicative interactions of students with autism*. Washington, DC: U.S. Department of Education. Retrieved from ERIC database. (ED461203)

Schepis, M. M., Reid, D. H., Behrmann, M. M., & Sutton, K. A. (1998). Increasing communicative interactions of young children with autism using a voice output communication aid and naturalistic teaching. *Journal of Applied Behavior Analysis, 31*, 561-578. doi:10.1901/jaba.1998.31-561

Sevcik, R. A., & Romski, M. A. (1995). Adult partner-augmented communication input to youth with mental retardation using the System for Augmenting Language (SAL) [Electronic version]. *Journal of Speech and Hearing Research, 38*, 13-24. Retrieved from http://jslhr.highwire.org/

Sevcik, R. A., Romski, M. A., & Adamson, L. B. (2004). Research directions in augmentative and alternative communication for preschool children. *Disability and Rehabilitation, 26*, 1323-1329. doi:10.1080/09638280412331280352

Shadish, W. R., & Haddock, C. K. (1994). Combining estimates of effect size. In H. Cooper & L. V. Hedges (Eds.), *The handbook of research synthesis* (pp. 261-281). New York, NY: Russell Sage Foundation.

Skotko, B. G., Koppenhaver, D. A., & Erickson, K. A. (2004). Parent reading behaviors and communication outcomes in girls with Rett syndrome. *Exceptional Children, 70*, 145-166. Retrieved from http://journals.cec.sped.org/ec/

Thunberg, G., Ahlsen, E., & Sandberg, A. D. (2007). Children with autistic spectrum disorders and speech-generating devices: Communication in different activities at home. *Clinical Linguistics and Phonetics, 21*, 457-479.

Trivette, C. M., Dunst, C. J., Hamby, D. W., & O'Herin, C. E. (2010). Effects of different types of adaptations on the behavior of young children with disabilities. *Research Brief (Tots n Tech Research Institute), 4*(1), 1-26. Retrieved September 8, 2010, from http://tnt.asu.edu/files/Adaptaqtions_Brief_final.pdf

Wilcox, M. J., Guimond, A., Campbell, P. H., & Moore, H. W. (2006). Provider perspectives on the use of assistive technology for infants and toddlers with disabilities. *Topics in Early Childhood Special Education, 26*, 33-49.

Williams, C., Wright, B., Callaghan, G., & Coughlan, B. (2002). Do children with autism learn to read more

readily by computer assisted instruction or traditional book methods? A pilot study. *Autism: The International Journal of Research and Practice, 6*, 71-91.

Authors

Carl J. Dunst, Ph.D., and Carol M. Trivette, Ph.D., are Co-Principal Investigators of the Center for Early Literacy Learning and Co-Directors of the Orelena Hawks Puckett Institute in Asheville and Morganton, North Carolina. Deborah W. Hamby, M.P.H., is a Research Analyst at the Puckett Institute.

Appendix A

Characteristics of Child Study Participants

Study	Sample Size	Age (Months) Mean	Age (Months) Range	Child Conditions	Severity of Delay[a]	Type
Binger et al. (2008) (Study 2)	2	42	35-49	Phonological processing disorder Cleft palate	S/P[b] M/M[c]	Disability
Binger et al. (2009)	3	66	54-76	Developmental delay Developmental delay Dysarthria, cerebral palsy	DD[d] DD S/P	Disability
Durand (1999) (Studies 2 & 3)	2	54	42-65	Cerebral palsy, cognitive disability Cerebral palsy, cognitive disability	M/M S/P	Disability
Hutinger et al. (1998)	151	NR[b]	36-72	Mild to moderate disabilities	M/M	Disability
Hutinger et al. (2002a) (Year 2, Early Childhood/Special Education)	33	36	NR[c]	Mild to moderate disabilities	M/M	Disability
Hutinger et al. (2002a) (Year 2, Pre-Kindergarten)	72	48	NR	Mild to moderate disabilities	M/M	Disability
Hutinger et al. (2002a) (Year 2, Inclusive)	28	48	NR	Mild to moderate disabilities	M/M	Disability
Hutinger et al. (2002a) (Year 2, Pre-Kindergarten/ Kindergarten)	16	60	NR	Mild to moderate disabilities	M/M	Disability
Hutinger et al. (2002a) (Year 2, Kindergarten/ 1st Grade)	12	66	NR	Mild to moderate disabilities, typically developing	M/M TD[e]	Mixed
Hutinger et al. (2002a) (Year 3, Early Childhood/Special Education)	42	36	NR	Mild to moderate disabilities	M/M	Disability
Hutinger et al. (2002a) (Year 3, Pre-Kindergarten)	41	48	NR	Mild to moderate disabilities	M/M	Disability
Hutinger et al. (2002 b) (Year 2)	36	48	36-60	Developmental delay, speech and language impairment	DD	Disability
Hutinger et al. (2002 b) (Year 3)	36	48	36-60	Developmental delay, speech and language impairment	DD	Disability
Hutinger et al. (2002 b) (Year 4)	58	48	36-60	Developmental delay, speech and language impairment	DD	Disability
Hutinger et al. (2002 b) (Year 5)	68	48	36-60	Developmental delay, speech and language impairment	DD	Disability
Kent-Walsh & Light (2002)	2	60	60[g]	Cerebral palsy	S/P	Disability
Kent-Walsh et al. (2010)	5	78	60-99	Cerebral palsy Down syndrome Cerebral palsy Cerebral palsy Down syndrome	S/P S/P S/P S/P S/P	Disability
Koppenhaver et al. (2001a); Koppenhaver et al. (2001b); Skotko et al. (2004)	4	63	43-84	Rett syndrome	S/P	Disability
Mar & Sall (1993)	1	40	–	Cerebral palsy, cortical visual impairment, bilateral hearing impairment	S/P	Disability
Mathisen et al. (2009)	1	46	–	Cerebral palsy, congenital heart disease, microcephaly	S/P	Disability
Olive et al. (2008)	1	48	-	Autism Spectrum Disorder	S/P	Disability
Regtvoort & Leij (2007)	57	70	NR	At-risk for reading impairment	TD	At-risk
Romski et al. (2010)	41	30	21-40	Down syndrome, seizure disorder, cerebral palsy	M/M	Disability

Appendix A, continued.

Study	Sample Size	Age (Months) Mean	Age (Months) Range	Child Conditions	Severity of Delay[a]	Type
Romski et al. (1994); (Romski & Sevcik (1996); Sevcik & Romski (1995)	4	87	74-105	Not specified Reye syndrome Unknown Autism	M/M S/P S/P M/M	Disability
Rosa-Lugo & Kent-Walsh (2008)	2	81	80-82	Congenital speech impairments Developmental delay, congenital speech impairments	S/P DD	Disability
Schepis et al. (1996); Schepis et al. (1998)	4	48	36-60	Autism	S/P	Disability
Sevcik et al. (2004)	1	48	–	Severe developmental delay, seizure disorder	S/P	Disability
Thunberg et al. (2007)	4	75	66-90	Autism, mild cognitive disability Autism, moderate cognitive disability Pervasive developmental disorder Pervasive developmental disorder	M/M M/M S/P S/P	Disabilit
Williams et al. (2002)	8	55	37-69	Autism	M/M	Disability

[a]Estimated based on information included in the research report.
[b]Severe to profound disabilities.
[c]Mild to moderate disabilities.
[d]Developmental delay.
[e] Not Reported.

Appendix B

Types of Assistive Technology Used in the Studies

Study	Device/Adaptation	Type
Binger et al. (2008) (Study 2)	AAC intervention to support shift from single to multiple symbol stage of language development	Speech-generating devices + other adaptations/Assistive technologies
Binger et al. (2009)	Speech-generating devices (MiniMo, Springboard)	Speech-generating devices
Durand (1999) (Studies 2 & 3)	Speech-generating device (Introtalker)	Speech-generating devices
Hutinger et al. (1998)	Interactive technology literacy curriculum (ITLC)—Focused on computers w/ switches, touch tablets, adaptive keyboards, AAC devices, alternative input devices, amplified sound, visual reinforcement	Computers/Assistive technologies
Hutinger et al. (2002a)	LitTECH Interactive Outreach project—Focused on teaching how to use technology to promote early literacy	Computers/Assistive technologies
Hutinger et al. (2002b)	Interactive Technology Literacy Curriculum (ITLC)—Focused on computers w/ switches, touch tablets, adaptive keyboards, AAC devices, alternative input devices, amplified sound, visual reinforcement	Computers/Assistive technologies
Kent-Walsh & Light (2002)	Speech-generating devices (Tech/Speak systems)	Speech-generating devices
Kent-Walsh et al. (2010)	Speech generating devices (DynaVox, Techspeak, DynaMyte)	Speech-generating devices
Koppenhaver et al. (2001a); Koppenhaver et al. (2001b); Skotko et al. (2004)	Light tech ACC systems (PCS, single-message Big-Mack, multi-message Four In-Line Cheap Talk, variety of stands)	Speech-generating devices + other adaptations/ assistive technologies
Mar & Sall (1993)	Computer, switches, adaptive keyboards, software	Computers/Assistive technologies
Mathisen et al. (2009)	Speech-generating device (Vanguard II with Unity 84 powered by MINSPEAK)	Speech-generating devices
Olive et al. (2008)	Voice Output Communication Aid (VOCA) (Four Button Touch Talk Direct)	Speech-generating devices
Regtvoort & Leij (2007)	Phonemic awareness training with computer	Computers/ Software/Technology
Romski et al. (2010)	Speech-generating devices (CheapTalk, Communication Builder, GoTalk, TechSpeak, TechTalk)	Speech-generating devices
Romski et al. (1994); Romski & Sevcik (1996); Sevcik & Romski (1995)	Microcomputer-based speech-output communication device (Words + Portable Voice II)	Speech-generating devices
Rosa-Lugo & Kent-Walsh (2008)	Computer-based voice-output communication system (Dynnamyte 3100)	Speech-generating devices
Schepis et al. (1996); Schepis et al. (1998)	Naturalistic training of Voice Output Communication Aid (Cheap Talk)	Speech-generating devices
Sevcik et al. (2004)	WOLF speech output communication device	Speech-generating devices
(Group 2, video)	Speech-generating device (Touch Talker)	Speech-generating devices
Thatcher (2009)	Speech-generating device (Vantage)	Speech-generating devices
Thunberg et al. (2007)	Speech-generating devices with symbols (Portable touch-screen computer, Clicker 3, TechTalk)	Speech-generating device + other adaptations/Assistive technologies
Williams et al. (2002)	Computer based instruction	Computers/ Software/Technology

Appendix C

Selected Characteristics of the Research Designs and the Intervention Procedures

Study	Research Design		Length of Training		Instructional Setting
	Type	Design	Hours	Number of Sessions	
Binger et al. (2008) (Study 2)	Single participant	Multiple baseline	2	NR	NR
Binger et al. (2009)	Single participant	Multiple baseline	2-3	NR	NR
Durand (1999) (Studies 2 & 3)	Single participant	Multiple baseline	18	3	NR
Hutinger et al. (1998)	Between group	Post test comparison	<1	NR	School, university
Hutinger et al. (2002a)	Within group	Pretest/post test	36	5	University, school
Hutinger et al. (2002b)	Within group	Pretest/post test	40	5	University
Hutinger et al. (2005); Hutinger et al. (2006)	Within group	Pretest/post test	36	10	School
Kent-Walsh & Light (2002)	Single participant	A-B design	30	6	School
Kent-Walsh et al. (2010)	Single participant	Multiple baseline	2	3	Home
Koppenhaver et al. (2001a); Koppenhaver et al. (2001b); Skotko et al. (2004)	Single participant	Multiple baseline	10	5	Hospital
Mar & Sall (1993)	Single participant	A-B design	NR	NR	Classroom
Mathisen et al. (2009)	Single participant	Pretest/post test	NR	NR	School, home
Olive et al. (2008)	Single participant	Multiple baseline	NR	10	Home
Panyan et al. (1991)	Within group	Pretest/post test	7	3	Schools
Puckett & Brozo (2004)	Within group	Pretest/post test	46	8	University
Regtvoort & van Leij (2007)	Between group	Post test comparison	NR	2	NR
Romski et al. (2010)	Within group	Pretest/post test	8	16	Home, university
Romski et al. (1994); Romski & Sevcik (1996); Sevcik & Romski (1995)	Within group	Pretest/post test	3	3	NR
Rosa-Lugo & Kent-Walsh (2008)	Single participant	Multiple baseline	5	5	Home
Schepis et al. (1996); Schepis et al. (1998)	Single participant	Multiple baseline	<1	1	School
Sevcik et al. (2004)	Single participant	A-B design	NR	NR	School, home
Thunberg et al. (2007)	Within group	Pretest/post test	4	1	Home
Williams et al. (2002)	Within group crossover design	Computer vs. no computer Book vs. computer	NR	NR	School

NOTE. NR = Not reported.

Appendix D

Cohen's d Effect Sizes for the Child Outcome Measures

Study	Comparative Conditions	Measurement Method	Outcome Construct	Outcome Measure	Participants	Effect Size
Binger et al. (2008) (Study 2)	Intervention vs. baseline	Observation	Communication	Number of multi-symbol messages produced per 10 min session	P1 P3	4.85 2.35
Binger et al. (2009)	Intervention vs. baseline	Observation	Communication	Number of multi-symbol message produced per 10-minute session	P1 P2 P3	1.81 3.22 2.10
Durand (1999) (Studies 2 & 3)	Intervention vs. baseline	Observation	Communication	Percentage of intervals of unprompted communication (classroom)	P1 P3	3.17 2.91
	Intervention vs. baseline	Observation	Communication	Percentage of intervals of unprompted communication (community)	P1 P3	2.25 3.02
Hutinger et al. (1998)	Experimental vs. control post test	Observation	Literacy	Informal literacy assessment		1.79
Hutinger et al. (2002a) (Year 2)	Pretest vs. post test	Observation	Literacy	Informal literacy assessment—modified early childhood/special education		1.90
	Pretest vs. post test	Observation	Literacy	Informal literacy assessment—modified pre-kindergarten		.82
	Pretest vs. post test	Observation	Literacy	Informal literacy assessment—modified inclusive		1.31
	Pretest vs. post test	Observation	Literacy	Informal literacy assessment—modified pre-kindergarten/kindergarten		1.35
Hutinger et al. (2002a) (Year 3)	Pretest vs. post test	Observation	Literacy	Informal literacy assessment—modified early childhood/special education		1.17
	Pretest vs. post test	Observation	Literacy	Informal literacy assessment—modified pre-kindergarten		.97
Hutinger et al. (2002b) (Year 3)	Pretest vs. post test	Observation	Literacy	Informal literacy assessment		3.35
Hutinger et al. (2002b) (Year 4)	Pretest vs. post test	Observation	Literacy	Informal literacy assessment		1.32
Hutinger et al. (2002b) (Year 5)	Pretest vs. post test	Observation	Literacy	Informal literacy assessment		1.58
Kent-Walsh & Light (2002)	Pretest vs. post test	Observation	Communication	Frequency of communicative turns		1.90
Kent-Walsh et al. (2010)	Intervention vs. baseline	Observation	Communication	Number of communicative turns	P1 P2 P3 P4 P6	1.81 1.82 1.80 1.77 1.69
	Intervention vs. baseline	Observation	Literacy	Number of different semantic concepts	P1 P2 P3 P4 P6	1.73 1.78 1.78 1.72 1.76
Koppenhaver et al. (2001a); Koppenhaver et al. (2001b); Skotko et al. (2004)	Pretest vs. post test	Observation	Communication	Frequency of children's successful symbolic communication acts per phase with familiar storybooks		2.29
	Pretest vs. post test	Observation	Communication	Frequency of children's successful symbolic communication acts per phase with unfamiliar storybooks		1.91
	Pretest vs. post test	Observation	Literacy	Frequency of children's labels and comments per phase with familiar storybooks		1.57

Appendix D, continued.

Study	Comparative Conditions	Measurement Method	Outcome Construct	Outcome Measure	Participants	Effect Size
Koppenhaver et al. (2001a); Koppenhaver et al. (2001b); Skotko et al. (2004), continued	Pretest vs. post test	Observation	Communication	Frequency of children's labels and comments per phase with unfamiliar storybooks		1.13
	Pretest vs. post test	Observation	Communication	Percentage of VOCA during communication exchange use		1.75
Mar & Sall (1993)	Intervention vs. baseline	Observation	Communication	Ratings of level of achievement of communication goals	P1	1.96
Mathisen et al. (2009)	Pretest vs. post test	Standardized measure	Literacy	Preschool and Primary Inventory of Phonological Awareness (PIPA)		.13
	Pretest vs. post test	Individually administered test	Literacy	Sheffield Early Literacy Development Profile		1.16
Olive et al. (2008)	Intervention vs. baseline	Observation	Communication	Frequency of attention-getting requests	P1	.44
Regtvoort & Van der Leij (2007) (Groups 1&2)	Experimental vs. control post-test	Individually administered test	Literacy	Phonemic awareness		.59
	Experimental vs. control post-test	Individually administered test	Literacy	Letter knowledge		1.03
	Experimental vs. control post-test	Individually administered test	Literacy	Naming speed		.26
Romski et al. (2010)	Pretest vs. post test	Observation	Communication	Number of augmented words used per 30 minutes		1.92
Romski et al. (1994); Romski & Sevcik (1996); Sevcik & Romski (1995)	Pretest vs. post test	Observation	Literacy	Mean length of utterance		-.75
	Pretest vs. post test	Observation	Literacy	Mean number of lexigrams used per 30 minutes		1.94
Rosa-Lugo & Kent-Walsh (2008)	Intervention vs. baseline	Observation	Communication	Frequency of communicative turns	P1 P2	1.76 1.82
	Intervention vs. baseline	Observation	Literacy	Frequency of semantic concepts	P1 P2	1.69 1.80
Schepis et al. (1996); Schepis et al. (1998)	Intervention vs. baseline	Observation	Communication	Rate per minute of communicative interactions during snack time	P1 P2 P3 P4	4.03 3.12 3.61 3.25
	Intervention vs. baseline	Observation	Communication	Mean rate per minute of communicative interactions during leisure time	P1 P2	6.28 4.74
Sevcik et al. (2004)	Pretest vs. post test	Observation	Communication	Percent of the time child is engaged in activities or communicating in an activity in therapy and at home		.41
Thunberg et al. (2007)	Pretest vs. post test	Observation	Communication	Percentage of effective child responses with device to communicative partner		1.14
Williams et al. (2002)	Pretest vs. post test	Observation	Literacy	Number of words read correctly—computer group (15 minutes)		.21
	Pretest vs. post test	Observation	Literacy	Words recorded during two 30-minute direct observations—computer group		.13