CELL reviews
Center for Early Literacy Learning
2011 ■ Volume 4 ■ Number 2

Tactile and Object Exploration Among Young Children with Visual Impairments

Carl J. Dunst
Ellen Gorman

The relationships between variations in object and surface features and tactile and object exploration were examined in nine studies including 82 preschool children with visual impairments. The types of exploratory behavior that were investigated have been hypothesized to be precursors of Braille readiness. Results showed that objects and surfaces that were more complex in feel and provided children more feedback were associated with greater amounts of exploratory behavior. Implications for practice are described.

It is generally assumed that the ability to read and understand Braille is dependent, in part, on a child's exploration or recognition of similarities and differences in the objects and materials provided a child (Lewis & Tolla, 2003). According to Drezek (1999), "Developing Braille readiness... is concerned with using the body--particularly the hands--effectively, with meaning that comes only from engaging in the world and investing in interaction, communication, and problem-solving" (p. 104).

The extent to which young children with visual impairment were able to differentiate between surfaces and objects that had contrasting conditions and features was the focus of this meta-analysis. No research synthesis, to the best of our knowledge, has been undertaken to empirically evaluate the long standing contention that tactile and object exploration and the ability to detect differences in surfaces or objects, are important experiences preparing young children with visual impairments to read Braille (e.g., Cziker, 2006; Lamb, 1998; Olson, 1981).

The focus of analysis was the tactile and object exploration of surfaces and material that differed in texture or manipulative qualities. The ability to differentiate between surfaces and objects that varied in contrasting features was viewed a necessary but not sufficient condition to support the hypothesis that surface and object exploration is a prerequisite for learning Braille. The meta-analysis was conducted using a characteristics-consequences framework where differences in the characteristics of experiences afforded a child are related to differences in the consequences of those experiences (Dunst & Trivette, 2009, in press).

SEARCH STRATEGY

Studies were located using "tactile AND exploration" OR "object AND exploration" OR "surface AND exploration" OR "haptic AND exploration" OR "tactile AND manipulation" OR "tactual AND manipulation" OR "object AND manipulation" OR "object AND tactual" OR "tactile OR touch" AND "visual AND impair*" OR "vision disorder" OR "vision impair*" OR "partial vision" OR "low vision" OR "blind" AND "infant OR toddler OR preschool" as search terms. ERIC, PsychInfo, MEDLINE, Education Research Complete, and Academic Search Premier were searched. The reference sections of all retrieved journal articles, book chapters, and books were examined to identify additional studies. Studies were also located by Google, Google Scholar, and Ingenta searches, as well as a search of

This research synthesis was prepared as an activity of the Center for Early Literacy Learning (CELL) funded by the U.S. Department of Education, Office of Special Education Programs (Grant #H326B060010). The opinions expressed however are those of the authors and are not necessarily endorsed by the funder. Appreciation is extended to Glinda Hill for her comments and suggestions on an earlier version of the paper.

an extensive EndNote library maintained by our Institute. Studies were included if the study participants had a visual impairment, the majority of the children were five years of age or younger, and information was included in the reports to be able to compare the effects of contrasting surface or object conditions and features on tactile or object exploration.

SEARCH RESULTS

Nine studies were located that meet our inclusion criteria. Appendix A includes the background characteristics of the study participants. The studies included 82 children 6 to 82 months of age whose average ages ranged between 8 and 72 months. About half of the participants were males (N = 42) and about half were females (N = 40). All of the children had visual impairments or were diagnosed as having congenital blindness. Eight of the children had some residual vision and five children had secondary conditions (either hearing impairments or cerebral palsy).

Appendix B includes the types of material (surfaces and objects) that were the focus of comparative analysis, the type of child exploratory behavior, the settings where the investigations were conducted, and the children's position where the exploratory behavior was observed or measured. The contrasting conditions shown in Appendix B were established on an *a priori* basis where the surfaces, material, and objects in italics were expected to be associated with more exploratory behavior. The type of manipulative exploratory behavior included shaking objects to produce sound (e.g., maraca), exploring novel objects, and dropping or rotating different shaped objects. The types of tactile exploratory behavior included touching sandpaper, exploring gradient textured surfaces, and examining surface differences. The particular surfaces, material, and objects that were expected to be related to greater exploratory behavior were ones that provided a child more feedback (e.g., sound) or were more complex in their texture or feel (e.g., sandpaper).

Cohen's *d* effect sizes for the difference between the measures of exploratory behavior for the contrasting conditions and features was used as the size of effect for testing the synthesis hypothesis. The effect sizes for the exploratory behavior were examined in a number of ways to identify the conditions under which exploration was maximized. The 95% confidence intervals were used for substantive interpretation of the results. A confidence interval not including zero indicates that the average effect size is significantly different from zero at the 0.05 level (Shadish & Haddock, 2009).

SYNTHESIS FINDINGS

The effect sizes for the different comparative conditions are included in Appendix C. The average effect size for all the comparisons was 1.48 (95% CI = 0.93–2.03), indicating that the children demonstrated more exploratory behavior with objects and surfaces that were either more complex or provided differential types of feedback.

Table 1 shows the results for three different types of contrasting features and conditions. The results for type of exploratory behavior showed that both tactile and object exploration were greater when the children were provided objects that were more responsive to child actions or were materials or textures that were more complex in their feel. The children engaged in more exploratory behavior regardless of whether the type of child behavior was manipulation of objects or materials or the children demonstrated recognition of the differences in surface textures. The analyses of the three different comparative conditions also showed that the children demonstrated more exploratory behavior if the objects or surfaces were novel or dissimilar, multi gradient or provided feedback of some type. Taken together, the results

Table 1
Cohen's d Effect Sizes and 95% Confidence Intervals for Different Comparative Conditions and Features

Exploratory Measures	Number	Mean Effect Size	95% Confidence Interval
Type of Exploratory Behavior			
Object Exploration	15	1.48	0.85 – 2.12
Tactile Exploration	18	1.47	0.55 – 2.39
Type of Child Behavior			
Tactile Recognition	19	1.86	0.98 – 2.74
Manipulation	14	0.95	0.45 – 1.46
Comparative Conditions			
Familiar vs. Novel/Dissimilar	13	2.06	0.87 – 3.26
No Feedback vs. Feedback	3	1.52	0.52 – 2.51
Single Gradient vs. Multi Gradient	17	1.02	0.45 – 1.60

from all three sets of comparisons shown in Table 1 indicate that exploratory behavior was enhanced when surfaces and objects were more complex and provided a child opportunities to produce some type of environmental consequence.

The extent to which the relationships between variations in object and surface conditions or features and exploratory behavior were moderated by child characteristics and study conditions are shown in Table 2. The average effect sizes for all the moderator groups were significantly different from zero and all were larger than $d = 1.25$. The only noteworthy finding was the difference in the sizes of effect for severity of visual impairment. Children with residual vision engaged in more exploratory behavior compared to children with no residual vision.

DISCUSSION

Results showed that surface and object qualities were associated with differences in the exploratory behavior of young children with visual impairments and that infants as young as 6 to 12 months of age demonstrated differences in exploration of objects and surfaces. The more complex the surfaces and the more sensory feedback objects provided, the greater the amount of child exploration. The findings provide support for the contention that the kinds of materials provided young children with visual impairments matter in terms of object and surface exploration.

Erickson and Hatton (2007) noted that "Research supporting specific approaches [to intervention] for young children with visual impairments and blindness is limited" (p. 58). Although we were able to locate only nine studies including a relatively small number of participants, the findings from the meta-analysis of those investigations were particularly robust. The following are several of the more important findings. First, children as young as 12 months of age were able to differentiate between both objects and surfaces that varied in manipulative quality and texture. Second, in every study except one (Zimmerman, 1986), the study participants demonstrated more exploratory behavior regardless of type of contrasting objects or surfaces, type of child behavior, or type of comparative conditions. Third, the relationships between type of objects or surfaces and exploratory behavior were minimally influenced by differences in the characteristics of the children or investigations. Fourth, and especially important in terms of implications for practice, the results highlight the particular types of textures, objects, and materials that are most likely to engage young children with visual impairments in exploratory behavior (Appendix B).

Implications for Practice

Braille readiness experiences for infants, toddlers, and preschoolers with visual impairments are considered an important part of early literacy learning (American Foundation for the Blind & National Association for Parents of Children with Visual Impairments, 2009; Wright & Stratton, 2007). Those experiences include a range of activities that involve the use of the hands and fingers for exploring and identifying objects, material, textures, and surfaces that promote

Table 2
Moderators of the Relationships Between the Contrasting Conditions and Child Exploratory Behavior

Moderators	Number	Mean Effect Size	95% Confidence Interval
Sample Size			
1 - 2	13	1.33	0.67 – 1.98
3 - 20	20	1.58	0.73 – 2.42
Child Age (months)			
6 - 12	11	1.26	0.61 – 1.91
13 - 82	22	1.59	0.80 – 2.38
Severity of Visual Impairment			
No Vision	23	1.41	0.88 – 1.95
Residual Vision	7	2.34	0.25 – 4.42
Setting			
Child's Home	12	1.35	0.63 – 2.07
Non-Home Setting	15	1.88	0.82 – 2.93
Adult Assistance			
Some	19	1.14	0.61 – 1.67
None	11	1.44	0.55 – 2.33
Outcome Measure			
Frequency or Amount	13	1.29	0.39 – 2.19
Percentage or Proportion	20	1.60	0.85 – 2.35

recognition and discrimination (Drezek, 1999; Lamb, 1996, 1998).

Findings from the research synthesis in this *CELLreview* provide guidance about the kinds of experiences that may be important for Braille readiness. These experiences include opportunities for infants with visual impairments to interact with objects and toys that produce interesting and reinforcing consequences when explored and manipulated; opportunities for toddlers with visual impairments to interact with and identify familiar and novel objects and material; and opportunities for preschoolers with visual impairments to develop and perfect tactile recognition and exploration skills. Several especially informative guidelines exist that place these kinds of experiences in the context of other early literacy learning opportunities for young children with visual impairments (e.g., American Foundation for the Blind & National Association for Parents of Children with Visual Impairments, 2009; Drezek, 1999; Lamb, 1998; Lewis & Tolla, 2003; McComiskey, 1996). Exploratory behavior therefore is best understood in the context of early childhood intervention when exploratory interventions are done in concert with other early literacy learning experiences.

The kinds of surfaces and objects that were related to tactile exploration in the studies included in this *CELLreview* are the same or very similar to those typically used to promote Braille readiness. Lewis and Tolla (2003), for example, noted that "Tactile experience books offer a host of benefits... because they describe personal experiences, children request that they be read, memorize their content with ease, and are eager to pretend to read them aloud to adults" (p. 26). Tactile books that include a combination of print and Braille where the printed words have been adapted to include Braille labels will likely provide the kinds of experiences that enhance both exploration and the ability to differentiate between surfaces that are, for example, smooth compared to raised (see e.g., www.nbp.org/ic/nbp/programs/bumpybasics). Exploratory opportunities as well as tactile experiences therefore should be part of early literacy learning interventions for young children with visual impairments.

AUTHORS

Carl J. Dunst, Ph.D., is Co-Investigator of the Center for Early Literacy Learning and Co-Director of the Orelena Hawks Puckett Institute in Asheville and Morganton, North Carolina. Ellen Gorman, M.Ed., is a Research Assistant at the Puckett Institute.

REFERENCES

American Foundation for the Blind, & National Association for Parents of Children with Visual Impairments. (2009). *Promoting your child's development of reading and writing skills*. New York: Author. Retrieved September 9, 2009, from http://www.familyconnect.org/parentsite.asp?SectionID=76&TopicID=360&DocumentID=3870.

Bradley-Johnson, S., Johnson, C. M., Swanson, J., & Jackson, A. (2004). Exploratory behavior: A comparison of infants who are congenitally blind and infants who are sighted. *Journal of Visual Impairment and Blindness, 98*, 496-502.

Catherwood, D., Drew, L., Hein, B., & Grainger, H. (1998). Haptic recognition in two infants with low vision assessed by a familiarization procedure [Electronic version]. *Journal of Visual Impairment and Blindness, 92*, 212-215.

Cziker, E. R. (2006, July). *The exploration of tactile images: Pre-Braille guide for young blind children*. Paper presented at the 12th World Conference of the International Council for Education of People with Visual Impairment, Kuala Lumpur, Malaysia.

Drezek, W. (1999). Emergent Braille literacy with Move, Touch, Read. *Journal of Visual Impairment and Blindness, 93*, 104-107.

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.

Dunst, C. J., & Trivette, C. M. (in press). Meta-analysis of implementation practice research. In B. Kelly & D. F. Perkins (Eds.), *Handbook of implementation science for psychology and education*. Cambridge, England: Cambridge University Press.

Erickson, K. A., & Hatton, D. (2007). Literacy and visual impairment. *Seminars in Speech and Language, 28*, 58-68.

Lamb, G. (1996). Beginning Braille: A whole language-based strategy. *Journal of Visual Impairment and Blindness, 90*, 184-189. Retrieved February 16, 2011, from http://www.braille.org/papers/jvjb0696/vb960306.htm.

Lamb, G. (1998). Dots for tots: Emergent literacy and Braille reading. *British Journal of Visual Impairment, 16*, 111-115.

Landau, B. (1991). Spatial representation of objects in the young blind child. *Cognition, 38*, 145-178.

Lewis, S., & Tolla, J. (2003). Creating and using tactile experience books for young children with visual impairments. *Teaching Exceptional Children, 35*(3), 22-28.

McComiskey, A. V. (1996). The Braille Readiness Skills Grid: A guide to building a foundation for literacy. *Journal of Visual Impairment and Blindness, 90*, 190-193. Retrieved February 16, 2011, from http://www.braille.org/papers/jvib0696/vb960307.htm.

Millar, S. (1975). Effects of phonological and tactual similarity on serial object recall by blind and sighted children. *Cortex, 11*, 170-180.

Olson, M. R. (1981). Pre-school experiences important to Braille reading readiness. In M. R. Olson & S. S. Man-

gold (Eds.), *Guidelines and games for teaching efficient Braille reading* (pp. 19-34). New York: American Foundation for the Blind.

Patomäki, S., Raisamo, R., Salo, J., Pasto, V., & Hippula, A. (2004). *Experiences on haptic interfaces for visually impaired young children*. Paper presented at the International Conference on Multimodal Interfaces, State College, PA.

Schellingerhout, R., Smitsman, A. W., & Cox, R. F. (2005). Evolving patterns of haptic exploration in visually impaired infants. *Infant Behavior and Development, 28*, 360-388.

Schellingerhout, R., Smitsman, A. W., & van Galen, G. P. (1997). Exploration of surface-textures in congenitally blind infants. *Child: Care, Health and Development, 23*, 247-264.

Shadish, W. R., & Haddock, C. K. (2009). Combining estimates of effect size. In H. Cooper, L. V. Hedges, & J. C. Valentine (Eds.), *The handbook of research synthesis and meta-analysis* (2nd ed., pp. 257-277). New York, NY: Russell Sage Foundation.

Smitsman, A. W., & Schellingerhout, R. (2000). Exploratory behavior in blind infants: How to improve touch? *Infant Behavior and Development, 23*, 485-511.

Wright, S., & Stratton, J. M. (2007). *On the way to literacy: Early experiences for children with visual impairments* (2nd ed.). Louisville, KY: American Printing House for the Blind.

Zimmerman, G. A. (1986). An exploratory study of preferred textures of objects for visually handicapped infants and young children. *Dissertation Abstracts International, 47*(03), 871A.

Appendix A

Characteristics of the Study Participants

Study	Number	Age (Months)		Gender		Type of Visual Impairment[a]
		Mean	Range	Male	Female	
Bradley-Johnson et al. (2004)	12	17	12-23	4	8	Congenitally blind
Catherwood et al. (1998)	2	8	6-10	1	1	Severe low vision
Landau (1991) (Study 1)	3	19	18-21	1	2	Congenitally blind
Millar (1975)	20	72	47-82	12	8	Severely blind (light perception or less)
Patomäki et al. (2004) (Phase 1)	11	55	41-78	5	6	Severely visually impaired (some with residual vision)
Schellingerhout et al. (2005) (Child 1)	1	13	–	–	1	Visually impaired (no residual vision)
Schellingerhout et al. (2005) (Child 2)	1	12	–	1	–	Visually impaired (light perception)
Schellingerhout et al. (2005) (Child 3)	1	12	–	1	–	Visually impaired (no residual vision)
Schellingerhout et al. (1997)	6	17	13-21	5	1	Congenitally blind
Smitsman & Schellingerhout (2000)	3	51	–	3	0	Congenitally blind
Zimmerman (1985) (Sample 1)	7	16	12-19	3	4	Congenitally visually impaired (4) Congenitally visually impaired/ mild cerebral palsy (2) Congenitally visually impaired/ hearing impaired (1)
Zimmerman (1985) (Sample 2)	11	24	19-30	5	6	Congenitally visually impaired (9) Congenitally visually impaired/ mild cerebral palsy (2)
Zimmerman (1985) (Sample 3)	4	40	36-42	1	3	Congenitally visually impaired

[a] Type of child condition as described by the investigators.

Appendix B

Selected Characteristics of the Study Settings, Materials, and Types of Child Exploratory Behavior

Study	Setting	Child Position	Contrasting Conditions[a]	Type of Exploratory Behavior
Bradley-Johnson et al. (2004)	Home or Preschool	Seated on mother's lap	Fingering, banging, squeezing, shaking vs. *pushing, rotating, transferring, dropping* Plastic car, cotton ball, squeaky bear, musical box, dog ball vs. *rattle* Plastic car, cotton ball, squeaky bear, musical box, dog ball vs. *maraca*	Manipulative behavior
Catherwood et al. (1998)	Laboratory	Seated between mother's legs on the floor	Familiar shape and texture vs. *novel shape* Familiar shape and texture vs. *novel texture* Familiar shape and texture vs. *novel shape and texture*	Manipulative behavior
Landau (1991) (Study 1)	Laboratory	Seated at a small table or on the floor	Non-textured geometric forms vs. *textured geometric forms* Non-textured geometric forms vs. *novel shape*	Manipulative behavior
Millar (1975)	School	Not reported	Objects similar in size, contour & feel vs. *objects dissimilar in feel*	Tactile exploration
Patomäki et al. (2004) (Phase 1)	Laboratory	Not reported	Backside of mouse pad vs. *sandpaper*	Tactile exploration
Schellingerhout et al. (2005)	Home	Seated on mother's lap in front of a table	Single gradient textured surface vs. *random textured surface* Single gradient textured surface vs. *crossing gradient textured surface* Single gradient textured surface vs. *circular gradient textured surface*	Tactile exploration
Schellingerhout et al. (1997)	Home	Seated on mother's lap in front of a table	Smooth non-textured flat rectangular surface vs. *gradient and homogeneous textured rectangular surfaces*	Tactile exploration
Smitsman & Schellingerhout (2000)	Residential institution	Seated at a table	Minimally textured surface vs. *highly gradient textured surface*	Tactile exploration
Zimmerman (1985) (Sample 1)	Home or School	Seated with mother or teacher on the floor	Satin, metallic vs. *scrubber, plush*	Tactile exploration
Zimmerman (1985) (Sample 2)	Home or School	Seated with mother or teacher on the floor	Satin, metallic, vinyl vs. *scrubber, plush, terry cloth*	Tactile exploration
Zimmerman (1985) (Sample 3)	Home or School	Seated with mother or teacher on the floor	Satin, metallic, vinyl, chamois vs. *scrubber, plush, terry cloth, needlepoint canvas*	Tactile exploration

[a] The objects, material or surfaces in italics were expected to be associated with more exploratory behavior compared to those not in italics.

Appendix C

Cohen's d Effect Sizes for the Differences in the Child Exploratory Behavior

Study	Comparative Conditions	Type of Child Behavior	Measure	Effect Size
Bradley-Johnson et al. (2004)	Manipulation vs. haptic exploration	Hand movements	Frequency	0.45
	Non-noise producing vs. noise producing (rattle)	Shaking	Amount of time	1.71
	Non-noise producing vs. noise producing (maraca)	Shaking	Amount of time	2.41
Catherwood et al. (1998)	Familiar stimulus vs. novel stimulus	Manipulation	Amount of time	1.09
Landau (1991) (Study 1)	Standard objects vs. texture objects	Hand movements	Amount of time	2.79
	Standard objects vs. shape objects	Hand movements	Amount of time	4.39
	Standard objects vs. texture objects	Rotation	Proportion of time	2.15
	Standard objects vs. shape objects	Rotation	Proportion of time	2.15
	Standard objects vs. texture objects	Fingering	Proportion of time	1.47
	Standard objects vs. shape objects	Fingering	Proportion of time	0.13
	Standard objects vs. texture objects	Handling	Proportion of time	0.59
	Standard objects vs. shape objects	Handling	Proportion of time	1.05
	Standard objects vs. texture objects	Manipulation	Proportion of time	0.33
	Standard objects vs. shape objects	Manipulation	Proportion of time	0.50
Millar (1975)	Similar objects vs. dissimilar objects	Recognition	Proportion of correct responses	0.89
	Similar objects vs. dissimilar objects	Recognition	Proportion of correct responses	3.74
Patomäki et al. (2004) (Phase 1)	Smooth vs. rough	Surface recognition	Proportion of correct responses	1.03
Schellingerhout et al. (2005) (Child 1)	Single gradient vs. random texture	Hand movements	Percentage of exploratory difference	3.97
	Single gradient vs. crossing gradient	Hand movements	Percentage of exploratory difference	0.87
	Single gradient vs. circular gradient	Hand movements	Percentage of exploratory difference	0.71
Schellingerhout et al. (2005) (Child 2)	Single gradient vs. random texture	Hand movements	Percentage of exploratory difference	1.71
	Single gradient vs. crossing gradient	Hand movements	Percentage of exploratory difference	1.10
	Single gradient vs. circular gradient	Hand movements	Percentage of exploratory difference	1.28
Schellingerhout et al. (2005) (Child 3)	Single gradient vs. random texture	Hand movements	Percentage of exploratory difference	0.93
	Single gradient vs. crossing gradient	Hand movements	Percentage of exploratory difference	1.05
	Single gradient vs. circular gradient	Hand movements	Percentage of exploratory difference	0.85
Schellingerhout et al. (1997)	Smooth vs. gradient and homogeneous textures (13 months old)	Rubbing and fingering	Frequency	0.28
	Smooth vs. gradient and homogeneous textures (17 months)	Rubbing and fingering	Frequency	0.20
	Smooth vs. gradient and homogeneous textures (21 months)	Rubbing and fingering	Frequency	3.20
Smitsman & Schellingerhout (2000)	Homogeneous vs. gradient texture	Hand movements	Amount of time	0.32
Zimmerman (1985) (Sample 1)	Smooth vs. textured items	Handling	Frequency of time	-0.62

Appendix C, *continued*

Study	Comparative Conditions	Type of Child Behavior	Measure	Effect Size
Zimmerman (1985) (Sample 2)	Smooth vs. textured items	Handling	Frequency of time	0.03
Zimmerman (1985) (Sample 3)	Smooth vs. textured items	Handling	Frequency of time	0.49