Divergent Development of Manual Skills in Children Who Are Blind or Sighted

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Abstract: This empirical study compared the average ages at which four children with congenital blindness acquired 32 fine motor skills with age norms for sighted children. The results indicated that the children experienced extreme developmental delays in the acquisition of manual skills and a high degree of variability in developmental delays within and across six categories of fine-motor skills.

A great number of childhood activities are based on manual skills. For example, most children's games like building and painting or throwing and catching call for fine-motor dexterity. Moreover, nearly all daily living skills, such as eating and drinking or dressing and undressing, require manual competencies. Thus, the term *manual skills* covers a heterogeneous group of activities that lack any generally accepted classification scheme. The simple distinction among holding, exploring, and manipulative skills does not suffice because the majority of manual skills are not just manipulative but are generally preceded by holding and exploring actions, making them multidimensional. However, such a multidimensional description makes it more difficult to compare manual skills with each other because it is often not clear which components make the strongest contribution to the acquisition of a specific skill.

Because of the dominance of vision in the acquisition of manual skills, one has to anticipate major developmental delays for this domain in children who are blind. Fraiberg and her colleagues were the first to document these delays in detail (Fraiberg, 1968, 1977; Fraiberg, Siegel, & Gibson, 1966). They found that infants who are blind—like sighted infants—open their hands from the third month of life onward, but, unlike sighted infants, they do not begin to engage in exploring and grasping behavior. Frequently, their hands remain in a neonatal position; that is, the hands are held open at the shoulder level. Infants who are blind hardly ever play with their hands in a midline position or transfer an object from one side of the body to the other. With the exception of exploring the faces of familiar persons, the 10 children who were blind in Fraiberg's (1977) longitudinal study were initially inactive manually. It was only at age 8–9 months that they began to reach toward and grasp a familiar noise-making object without the object being first presented at their fingertips.

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In contrast, in a study by Tröster and Brambring (1993), only 3 of 16 1-year-old children who were blind (18.8%) grasped a well-known musical clock without having first felt it with their fingers. This divergent result is probably due to differences in the presentation of tasks: a testlike situation in Tröster and Brambring's study compared with the repeated presentation of one object in a familiar home environment in Fraiberg's study (1977).

The findings of both studies confirmed that grasping behavior triggered by an auditory stimulus emerges later in development than grasping behavior that is triggered visually (Bigelow, 1983, 1986). There are several possible reasons for this difference: (1) Vision delivers stimulating information on the attributes of an object (its size, form, and color), which encourages a child to reach toward it (Gibson, 2002; Webster & Roe, 1998); (2) auditory stimuli are frequently discontinuous and thus less contingent for reaching behavior than are visual stimuli (Fraiberg, 1977); (3) not all noises, for example, a bird singing in a tree, represent an object that can be touched (Webster & Roe, 1998), making it far more difficult to forge a link between an auditory stimulus and an object than between a visual stimulus and an object; (4) the spatial position of objects can be localized more precisely with vision than with hearing—greatly facilitating reaching behavior; and (5) the intensive listening reactions to auditory signals that are frequently observed in children who are blind may lead to an inhibition of grasping (Ross & Tobin, 1997).

Sound-making objects tend to be the exception in the real world; the majority of objects are silent. It can be anticipated that the ability to engage in an active search for silent objects will emerge later in development than will reaching for sound-making objects, although up to now there have been no empirical data on the acquisition of this skill in children who are blind. In addition, the dual function of the hands—as both the most important sensory organ for recognizing objects when vision is lacking and the executive organ for manual actions—is more crucial for children who are blind than for sighted ones and may interfere with the performance of manual skills.

Up to now, only a few studies have assessed the acquisition of manual skills in infants and preschoolers who are blind (Bigelow, 1986; Fraiberg, 1977; Jan, Freeman, & Scott, 1977; Norris, Spaulding, & Brodie, 1957; Rogow, 1987; Sanne & Brambring, 2001; Tröster & Brambring, 1993). With the exception of Jan et al. (1977), they all concluded that the empirical findings indicated strong to extreme developmental delays in such skills for the studied group.

Two empirical studies have compared developmental differences between infants or preschoolers who are blind and their sighted peers in various developmental domains (Brambring, 2005; Hatton, Bailey, Burchinal, & Ferrell, 1997). Hatton et al. (1997) repeatedly tested 186 children who were blind or had low vision (the Prism Project) aged 12 months to 73 months with the Battelle Developmental Inventory (Newborg, Stock, Wnek, Guidubaldi, & Svinicki, 1984), a standardized developmental test with some modifications for children who are visually impaired. Of the total sample of 186 children, 27 were either totally blind or had, at most, light perception but exhibited no additional impairments according to physicians' and psychologists' reports. This group had a developmental age of 16.4 months for manual skills (a developmental delay of 13.6 months) at age 30 months.

The longitudinal study by Brambring (1996) observed 10 children who were legally blind (who were either totally blind or had light perception at most) in their family homes from age 10 months to 62 months. Observations were performed with the Bielefeld Observation Scales (BOS-BLIND; Brambring, 2006b), a blindness-specific instrument that provides a detailed assessment of development. As Brambring (2005) reported, at a chronological age of 30 months, the 4 children who had no further impairments had a developmental age of 15.5 months (a delay of 14.5 months) in manual skills compared with sighted peers.

One disadvantage of both Brambring's (2005) and Hatton et al.'s (1997) studies is that they reported only comparisons between means, which provided no information on the variability in the age at which single skills are acquired *within* each developmental domain. However, it is precisely this information that is needed to analyze at which developmental age which alternative-compensatory means of acquiring the skill become available to a child who is blind. A further disadvantage of earlier studies is that the assessments covered only a small number of items (four in Fraiberg, 1977; nine in Norris et al., 1957; and five in Tröster & Brambring, 1993); were carried out at three- or six-month intervals (Norris et al., 1957; Sanne & Brambring, 2001; and Tröster & Brambring, 1993); or were based on casual observations (Brambring, 1993; Pérez-Pereira & Castro, 1994, cited in Pérez-Pereira & Conti-Ramsden, 1999). Hence, there is a strong need for precise empirical reports on the acquisition of manual skills by children who are blind.

In contrast to earlier research, the study presented here assessed the ages at which 32 manual or daily living skills were acquired through regular observations (at two- to four-week intervals) over a period of more than four years. An analysis of this empirical data should permit conclusions on which alternative strategies children who are blind may use to reduce or compensate for their difficulties owing to the loss of vision.

Method

Participants

The participants were recruited from a group of 10 children with visual impairments who participated in Brambring's (1996) longitudinal study. Interventions were carried out during 2–3 hour home visits once every 2 weeks from ages 1–3 years and once every 4 weeks from ages 4–6 years. The comparisons of these children with sighted children used only children who had no further impairments. This "normal development," observed during the course of the longitudinal study, could be confirmed in 4 of the 10 project children (2 boys and 2 girls) in two ways: through intelligence quotients (IQs) measured at the end of the project with the verbal part of the HAWIK-R (Tewes, 1983) and through teachers' ratings before the children enrolled in school (Brambring, 2005). Three of the 4 children were completely blind (microphthalmos; anophthalmos; and retinopathy of prematurity, stage V) and one had minimal light perception (Leber's amaurosis).

Assessment instruments

Developmental data

Longitudinal developmental data were gathered during the early intervention home visits through participant observation based on the BOS-BLIND (Brambring, 2006b). The continuous observation of development over several years by the same graduate psychologists ensured that the data collection was highly reliable.

The age at which the children who are blind acquired manual skills was compared with age norms for sighted children (median, lower, and upper cutoffs) taken from four well-known, standardized developmental tests: Bayley Scales of Infant Development (Bayley, 1969); Denver Developmental Screening Test (German version; Flehmig, Schloon, Uhde, & von Bernuth, 1973); Griffiths Developmental Scales (German version; Brandt, 1954/1983); and Entwicklungskontrolle für Krippenkinder (Zwiener & Schmidt-Kolmer, 1982), a German-language developmental test.

Comparison items

A total of 157 tasks in the four developmental tests for sighted children corresponded with items for which age reports were available in BOS-BLIND. Some tasks were listed in several of the four developmental tests. In these cases, a mean value was computed for the medians, as well as for the lower and upper cutoffs, of the acquisition ages. This procedure left a final total of 107 different tasks in both the developmental tests for sighted children and the BOS-BLIND. Thirty-two of these items refer to manual or daily living skills.

Data analysis

Data on these 32 items were analyzed in the following three ways:

Categories of developmental divergence

The first step was to analyze the categories of developmental divergence. This analysis was based on the median scores for the age of acquisition in both the sighted (Mdn^{sig}) and blind (Mdn^{bli}) groups as well as the earliest (Min^{sig} and Min^{bli}) and latest acquisition ages (Max^{sig} and Max^{bli}). The earliest acquisition age in children who are blind was reported when the first child in the sample had acquired this skill, and the latest acquisition age was reported when the last child who was blind had acquired it. In the sighted children, the earliest acquisition age corresponded to the 5% criterion, that is, when 5% of the sighted children had acquired the corresponding skill, and the latest acquisition age corresponded to either the 90% or 95% criterion, depending on the specific test.

On the basis of the available data, only three categories could be formulated for the strength of developmental divergences between children who are blind and children who are sighted: (1) extreme developmental delay: when the acquisition age for the manual skill across all children who are blind was above the 90% or 95% criterion for sighted children; (2) strong developmental delay: when the acquisition age of at least one child who was blind was within the norm range of sighted children, but the median was above it; and (3) weak developmental delay: when the median for children who are blind was within the norm range for sighted children but higher than their median.

Absolute and relative developmental differences

The second step of the analysis was to calculate absolute and relative developmental differences. Absolute differences in development (Mdn^{bli} minus Mdn^{sig}) indicate the difference in mean acquisition ages for the various skills in children who are blind or sighted. However, equal-sized absolute differences in development need to be weighted more strongly at an early acquisition age than at a later acquisition age. To overcome this methodological difficulty, almost all developmental tests compute the developmental quotient (DQ = developmental age divided by chronological age x 100) as a relative measure. However, such a DQ is inappropriate here because acquisition ages are being compared in two different populations. A further problem is that DQs are often interpreted as if they were IQs; that is, a DQ of ≤ 70 is frequently evaluated as a sign of mental retardation. Such misinterpretations should be avoided because strong developmental delays in children who are blind do not necessarily indicate additional mental impairment. They may well reflect difficulties due to blindness and a continuing lack of opportunities to compensate for them.

Therefore, the median scores of the children who are blind were divided by the median scores of sighted children for each single developmental skill (Mdn^{bli} divided by Mdn^{sig}). This value reports the factor by which the acquisition age of sighted children needs to be multiplied to obtain the acquisition age of children who are blind for a particular developmental skill. For example, a value of 2.0 indicates that children who are blind do not acquire the skill until they are twice as old as sighted children. The third step in the analysis was to conduct a regression analysis of the relationship between the acquisition ages of children who are blind and the age norms of sighted children.

Results

Table 1 reports the distribution of developmental divergences in children who are blind in relation to norm data for sighted children. Table 2 reports the developmental data, the absolute differences (Mdn^{bli} minus Mdn^{sig}), and the relative differences (Mdn^{bli} divided by Mdn^{sig}) in development for the single skills. An attempt to form

Table 1.
Developmental differences in children who are blind compared with sighted norms.

Developmental domain: Manual skills	Items	Total (%)	Valid (%)
Extreme developmental delay	20	60.6	62.5
Strong developmental delay	11	33.3	34.4
Weak developmental delay	1	3.0	3.1
Nonclassifiable (missing value)	1	3.0	—

Note: Extreme delay: All acquisition ages for children who are blind are above the norm range for sighted children. Strong delay: The median for children who are blind is higher than the norm range, but one acquisition age lies within the norm range for sighted children. Weak delay: The median for children who are blind lies within the norm range but is later than the median for sighted children. Items = the number of skills per category; % = relative frequencies.

Table 2.
Acquisition of fine-motor skills in different content categories.

		Developmental data				Developmental difference	
		Sighted		Blind			
	Developmental skill	Median	(Minimum/ Maximum)	Median	(Minimum/ Maximum)	Absolute	Relative
Objects with tool function							
1	Beats drum rhythmically with two drumsticks	11.0	(xxxx/15.0)	37.0	(36.5/48.0)	26.0	3.36[E]
2	Drinks from normal cup when held by adult	7.0	(xxxx/12.0)	22.0	(15.5/26.5)	15.0	3.14[E]
3	Holds spoon horizontally for short time	5.1	(4.0/7.0)	15.0	(9.5/22.0)	9.9	2.94[E]
4	Eats independently with spoon, spilling hardly anything	15.9	(12.4/20.8)	38.0	(24.0/50.5)	22.1	2.39[E]
5	Can put filled spoon in mouth with minimal assistance	7.0	(5.0/11.0)	15.0	(12.0/22.0)	8.0	2.14[E]
6	Holds normal cup and drinks from it by herself	11.7	(9.7/16.4)	24.0	(19.0/27.0)	12.3	2.05[E]
			Total			***M***	**2.67**
						(SD)	**(0.55)**
High-precision demands							
	Item 1 (1st correction)						3.00
7	Places a round disk into correct hole in shape board	13.0	(10.0/17.5)	38.0	(31.5/43.0)	25.0	2.92[E]
8	Pours drink into cup by herself	18.0	(16.0/24.0)	50.0	(37.5/xxxx)	32.0	2.78[E]
9	Places a round disk and a square into correct holes in shape board	18.0	(15.0/21.0)	41.0	(35.0/47.5)	23.0	2.28[E]
10	Uses both hands to fold sheet of paper in two	26.1	(21.5/36.0)	54.0	(37.5/61.0)	27.9	2.07[E]
	Item 4 (1st correction)						2.03
11	Strings large beads	23.0	(xxxx/28.0)	45.0	(40.0/xxxx)	22.0	1.96[E]
12	Builds a tower with at least three jumbo DUPLO bricks	15.2	(12.7/20.0)	29.0	(24.0/35.5)	13.8	1.91[E]
13	Pincer grasp (thumb and index finger bent)	9.6	(8.2/12.2)	17.0	(16.0/25.5)	7.4	1.77[E]
14	Incomplete pincer grasp	8.0	(6.5/10.5)	13.0	(11.0/16.5)	5.0	1.63[E]
			Total			***M***	**2.24**
						(SD)	**(0.49)**
Combination of several objects							
	Item 1 (2nd correction)						2.95
	Item 7 (1st correction)						2.87
	Item 8 (1st correction)						2.72
	Item 9 (1st correction)						2.23

(Continued)

Table 2.
(Continued)

		Developmental data				Developmental difference	
		Sighted		Blind			
	Developmental skill	Median	(Minimum/ Maximum)	Median	(Minimum/ Maximum)	Absolute	Relative
15	Reaches toward third object when already holding two	12.0	(8.0/18.0)	25.0	(xxxx/38.0)	13.0	2.08[?]
	Item 11 (1st correction)						*1.91*
	Item 12 (1st correction)						*1.86*
16	Puts small objects into container	12.5	(9.5/16.0)	19.0	(15.5/39.0)	6.5	1.52[S]
17	Puts larger objects into large container	10.6	(7.5/15.5)	16.0	(12.5/20.0)	5.4	1.51[E]
			Total			***M***	**2.18**
						(SD)	**(0.55)**
External space reference							
	Item 1 (3rd correction)						*2.88*
	Item 7 (2nd correction)						*2.80*
	Item 8 (2nd correction)						*2.66*
18	Picks up, drinks, and puts down cup by herself	13.0	(xxxx/18.0)	29.0	(22.5/38.5)	16.0	2.23[E]
	Item 9 (2nd correction)						*2.16*
	Item 4 (2nd correction)						*1.91*
	Item 12 (2nd correction)						*1.79*
19	Reaches for and grasps “bell ball” before it touches her body	30.0	(xxxx/35.0)	50.0	(41.0/xxxx)	20.0	1.67[E]
20	Rolls “bell ball” away	14.8	(11.0/18.7)	23.0	(17.5/27.0)	8.2	1.55[S]
	Item 16 (1st correction)						*1.45*
	Item 17 (1st correction)						*1.44*
			Total			***M***	**2.04**
						(SD)	**(0.54)**
Body-related manipulations							
21	Takes off pullover by herself	14.6	(13.5/22.0)	46.5	(29.5/67.5)	31.9	3.18[E]
	Item 2 (2nd correction)						*2.66*
22	Sucks rusk or cookie while holding it herself	6.5	(5.2/10.8)	15.5	(10.0/21.5)	9.0	2.38[S]
23	Dries hands and face properly when asked	21.2	(18.9/24.0)	37.0	(24.0/67.5)	15.8	1.75[S]
	Item 4 (3rd correction)						*1.67*
	Item 5 (1st correction)						*1.52*
24	Takes off jacket or takes arms out of shirt sleeves	22.0	(xxxx/28.0)	33.0	(23.0/48.5)	11.0	1.50[S]

(Continued)

Table 2.
(Continued)

Developmental skill		Developmental data				Developmental difference	
		Sighted		Blind			
		Median	(Minimum/ Maximum)	Median	(Minimum/ Maximum)	Absolute	Relative
25	Wipes mouth or nose with cloth (uncoordinated)	16.0	(xxxx/22.0)	23.0	(20.5/43.0)	7.0	1.44^{S}
	Item 6 (1st correction)						1.43
26	Pulls down underpants or unfastened pants	16.0	(xxxx/21.0)	21.5	(17.0/43.0)	5.5	1.34^{S}
27	Pulls up pants or underpants by herself	24.5	(21.1/33.5)	30.0	(20.5/43.0)	5.5	1.22^{W}
			Total			***M***	**1.83**
						(SD)	**(0.63)**
Simple object manipulations							
28	Uses string to pull object toward self	6.4	(4.5/10.0)	13.0	(11.5/21.0)	6.6	2.03^{E}
29	Turns several pages at once	12.0	(7.0/16.0)	22.0	(17.5/42.0)	10.0	1.83^{E}
30	Lets object dangle (e.g., toy on string)	12.4	(7.0/18.0)	20.0	(15.5/27.0)	7.6	1.61^{S}
31	Rolls/pushes object to and fro in front of body	11.3	(xxxx/15.0)	17.5	(14.0/xxxx)	6.2	1.55^{S}
32	Makes a shape with play dough (e.g., ball, "sausage")	33.0	(xxxx/37.0)	47.0	(43.5/48.5)	14.0	1.42^{E}
			Total			***M***	**1.69**
						(SD)	**(0.24)**

Note: Items are ranked within each category according to the declining strength of the relative developmental differences (last column). The items corrected for attenuation are set in italics, and the corrected values are underlined. According to the number of assignments to the categories, different corrections of attenuation were necessary (see the text). The item number refers to the number of the item with the original developmental data. The developmental data report the median age at which this skill was acquired in children who are blind or sighted as well as lower (Minimum) and upper cutoffs (Maximum). Some lower or upper cutoffs are missing in the developmental assessment data (xxxx). The developmental difference between children who are blind or sighted was computed in absolute and relative terms. The indices report the categorical assignment of the developmental item: ^{E} = extreme delay; ^{S} = strong delay; ^{W} = weak delay; and $^{?}$ = nonclassifiable (missing). (See the note to Table 1 for more information.) At the end of each category, the total average and the standard deviation of the relative developmental differences are computed for the items.

distinct classes for the 32 manual skills, such as daily living skills versus not daily living skills, failed to produce any satisfactory outcome because of the overlapping manual demands in both categories. Therefore, a system of six categories was devised that could be used for a content analysis. The categories differed in at least one central component of manual demands. These categories did not consist of distinct classes because the same manual skill could be assigned to several categories, depending on its components. Four independent raters then assigned the 32 skills to these six categories. Interrater agreement was only satisfactory (Kendall's $W = 0.65$, $p < .05$)

because the raters found the multidimensional classification difficult to perform.

The mean relative divergences for the six categories were determined as follows. First, the mean values for all six categories were computed on the basis of the original values of the items. Second, the six categories were ranked according to the size of the averaged developmental divergences. Finally, a correction for attenuation was performed for skills that were entered into several categories by subtracting the difference of the means of the assigned categories from the original value of the items. For example, the skill "beats drum rhythmically with two drumsticks" was assigned to Category 1: "Manual skills with tool function" and to Category 2: "Manual skills with high-precision demands." The means of the relative divergences based on the original values were $M = 2.67$ for Category 1 and $M = 2.31$ for Category 2; that is, a mean difference of $d = 0.36$. To partial out the proportion of the skill "beats drum rhythmically with two drumsticks" that could be traced back to the "tool function," the difference between the two means, $d = 0.36$, was deducted from the original value (rel. = 3.36) on this skill, resulting in an attenuation-corrected value of rel. = 3.00 (3.36 – 0.36) on this skill for Category 2. The same procedure was applied to all items with multiple assignments. The means for the categories were recomputed with these corrected values, as shown in Table 2. Attenuation-corrected items are presented in italics in the categories, the original acquisition ages are left out, and the attenuation-corrected values are presented in italics and underlined.

As Table 2 shows, the largest relative developmental divergences were found for manual skills requiring the use of a tool (a drumstick, cup, or spoon). On average, children who are blind acquired these skills 2.67 times later than did sighted children. Sighted children acquired the six skills in Category 1 at about 10 months, whereas children who are blind did not acquire them until about 25 months; that is, more than 15 months later than their sighted peers.

The lowest average relative developmental divergences were found in the simple object manipulations (Category 6)—pulling strings, turning pages, and dangling objects. Table 2 also shows divergences within categories, with marked differences in the relative developmental differences in the single items. This finding indicates that the classes have only limited homogeneity.

The multiple classification of several skills into different categories and the small sample prohibited a statistical comparison of means among the six categories. Nonetheless, some indications of significant differences could be gained by computing effect sizes for dependent measurements (Leonhart, 2004). Table 3

Table 3.
Effect sizes among the six manual skill categories.

Category	Prec	Comb	Spat	Body	Simple
Tool	0.84	0.89	1.16	1.39	2.23
Prec		0.12	0.39	0.72	1.28
Comb			0.26	0.59	1.04
Spat				0.36	0.74
Body					0.26

Categories: Tool = objects with tool function, Prec = high-precision demands, Comb = combination of several objects, Spat = external spatial reference, Body = body-related manipulations, and Simple = simple object manipulations. The effect sizes indicate that the mean relative development differences were higher in the line category than in the column category.

shows that a total of 10 out of 15 comparisons produced significant ($d > .50$) to very significant ($d > 1.0$) differences among categories, emphasizing variations in the difficulty of children who are blind acquiring manual or daily living skills as a function of the underlying demands that the acquisition of skills places on them.

The third step in the analysis was to compute a linear regression on the acquisition ages of children who are blind to children who are sighted. Children who are blind had an average developmental age of 15.5 months when sighted children exhibited a chronological or developmental age of 30 months. Despite the markedly slower development of children who are blind, there was a high correlation between the acquisition ages for single skills across both groups. In other words, the sequence in which developmental skills are acquired remains broadly the same (product-moment correlation: $r = .78$).

Discussion

The findings clearly confirm the importance of vision for the acquisition of fine-motor skills in early childhood. In line with the comparative-deficit approach (Fraiberg, 1977; Warren, 1984), they underline the advantage for sighted children of being able to use visual information to control and gain feedback on manual activities. Children who are congenitally blind experience major delays. The delays reported here were found in a group of children who are blind and had no additional impairment and who received intensive early intervention over five years. The developmental divergences between children who are blind and sighted children in these manual or daily living skills are even stronger than those found in gross-motor skills (Brambring, 2006a), perhaps because fine-motor movements impose higher coordinative demands than do gross-motor ones. The findings again underline Fraiberg's (1977, p. 154) warning against comparative diagnoses in the domain of manual or daily living skills: There is "no possibility of comparing the blind and sighted child in an item-by-item inventory of prehension and no possibility of fairly scoring these items using sighted-child criteria."

Nonetheless, in line with the adaptive-compensatory approach (Brambring, 2003, 2006a; Ferrell, 2000; Pérez-Pereira & Conti-Ramsden, 1999), the findings also confirm the central hypothesis of this study that even this strongly visually dominated domain of development reveals no consistent developmental delay compared with sighted children in the six categories of manual skills or in the items within the categories**.** Instead, there is a high degree of variability in relative developmental differences—from almost equal acquisition ages in both groups (a relative difference of 1.22 in "pulls up pants or underpants by herself") to ones that are more than three times as high in children who are blind (a relative difference of 3.36 in "beats drum rhythmically with two drumsticks"). This finding suggests that children who are blind apply different strategies to compensate for the loss of vision when they acquire single skills.

The classification into six categories gives some indications of which demands make manual or daily living skills easier or more difficult for children who are blind to acquire. Children who are blind need at least twice as long as do sighted children to acquire manual activities with a "tool function." These are simple tools like a spoon, cup, or drumstick that the majority of sighted children already learn to use during their first year of life. Children who are blind do not acquire this skill until their second to fourth years of life. "Beats drum rhythmically with two drumsticks" has the strongest developmental divergence of rel. = 3.36. This is the highest score not only among all 32 manual skills, but among all 107 skills that were analyzed in total. This extreme developmental delay can be explained by the variety of demands that are linked to performing the skill. It calls for the coordinated, rhythmic use of two tools (drumsticks) to strike an external location (drum). Children who are blind can learn this skill only when they accept the principle of having their hands guided from behind and possess sufficient cognitive competencies to transform guiding and verbal instructions into a concrete action.

Body-related and simple object manipulations reveal the lowest average developmental divergences between children who are blind and those who are sighted. The body-related manual skills are exclusively the so-called daily living skills of eating and drinking, dressing and undressing, and personal hygiene. Supporters of the social-interactive approach (Warren, 1994; Webster & Roe, 1998) consider such skills to be particularly difficult to acquire and perform because parents often lack the necessary patience to let their children who are blind practice them sufficiently. Although children who are blind have strong to extreme developmental delays compared with their sighted peers on the majority of these skills, the average delays are lower than those in, for example, manual skills involving a combination of several objects, probably because their own bodies provide a reference point that makes these skills easier (in relative terms) for them to acquire and perform.

The simple object manipulations, which sighted children generally acquire during the first year of life, show the lowest developmental delays in children who are blind. These are skills that children can learn by trial and error, such as "uses string to pull object toward self" or "lets object dangle." Either vision is of only secondary importance for the performance of these skills or tactile feedback provides an alternative for children who are blind.

One tentative overall conclusion is that early compensation seems to be possible for skills that can be learned through trial and error or through tactile and kinesthetic feedback. Body-related manual activities prove to be easier to learn than do space-related ones. The acquisition of complex manipulative skills, such as combining several objects or activities that demand high precision, requires sufficient cognitive abilities to translate spoken or guided instructions into manual acts.

The averaged developmental delay of 14.5 months in the study is approximately equal to the delay of 13.6 months for children who are blind that was reported by Hatton et al. (1997) for the "adaptive domain." This finding indicates a high convergent validity between the two studies despite different assessment methods and different cultures.

Nonetheless, a few limitations need to be considered when interpreting the findings of this study. Comparisons are not always exact because of frequently imprecise and different evaluation criteria in the developmental assessments. Some developmental differences may be an artifact of performing different evaluations of what is actually the same skill. A further limitation is our classification of the 32 manual skills into six categories with its only satisfactory level of interrater agreement. Our grouping of difficulties in acquiring manual skills as a function of underlying demands is certainly only provisional. A further major limitation is the small sample, since a larger sample might well have revealed shifts in the findings on the categorical and quantitative comparison. Moreover, although it can be confidently assumed that the children who are blind in this study have no further impairments, this does not mean that these children are representative of the population of children who are blind. Finally, only some of the potential fine-motor skills could be compared–that is, those that were found in the diagnostic instruments during the observation period of 5 to 33 months in sighted children and 13 to 54 months in children who are blind. A larger range of manual tasks and a longer period of observation might have led to shifts in the developmental differences reported here.

Despite these limitations, this study is still the most comprehensive assessment of manual or daily living skills in children who are blind to date. The empirical findings confirm that when promoting the manual or daily living skills domain in children who are blind, an orientation toward the norms of sighted children would lead to false conclusions.

Our findings also indicate that teaching more complex manual activities requires a lot of patience by both professionals and parents of children who are blind. Before this stage, it seems important to allow children who are blind much time for tactile or auditory exploration of the environment because this exploration may encourage independent manual activities. With its differentiation of six central components of manual or daily living skills, the analysis permitted a more detailed way of looking at the alternative developmental paths of children who are blind—something that is urgently needed if professionals are to provide realistic and appropriate early intervention.

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