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Research Informing the Development of Infant Finger Drawing

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Research informing the emergence and development of infant finger drawing and haptic exploration was examined in 21 studies of human and nonhuman primates. Finger drawing involves the use of the hands and fingers to make marks or scribbles on some type of malleable substance (e.g., pudding). The 21 studies included a total of 192 participants. Finger drawing and haptic exploration were facilitated by visual and tactile prompts, naturally occurring visual and haptic reinforcements, and adult and mother modeling of behavior that was the focus of investigation. Improved performance was associated with multiple learning opportunities afforded within and across sessions. Implications for practice are described.

Around 8 to 10 months of age, most infants demonstrate the ability to engage in canonical pointing (Butterworth, 1998; Leavens & Hopkins, 1999) and use their forefingers to "draw" in food on their highchair trays, "scribble" on a steamed mirror or a frosted window, and make "marks" on surfaces that produce some type of image (e.g., touch sensitive computer screen; Iversen & Matsuzawa, 1996) or provide some type of reinforcement or feedback (e.g., touch sensitive reinforcement panels; Lipsitt, Pederson, & Delucia, 1966). The ability to engage in these types of behavior are described as infant finger drawing (Tanaka, Tomonaga, & Matsuzawa, 2003).

Studies of both human infants and nonhuman primates now provide an evidence base for understanding the emergence and development of infant finger drawing (Catherwood, 1993; Tanaka et al., 2003). As noted by Maestripieri and Roney (2006) and Weiss and Santos (2006) there are many similarities in the development of human infants and nonhuman primates, where studies of the latter inform the conditions under which human infant abilities emerge and develop.

This research synthesis examines the person and environmental characteristics that encourage and contribute to infants learning to use their fingers to draw. The main focus was the conditions that enabled study participants to use their hands and forefingers to draw, mark, and scribble. Infant finger drawing is considered a necessary but not sufficient condition for young children to learn conventional writing skills (Sheridan, 2005).

SEARCH STRATEGY

Studies were identified using *infant* and *finger* and *draw** or *scribbl** or *paint** as search terms. The main search was supplemented by using *infant* and *touch** or *reach** or *tactil** or *haptic* and *manipulat** or *explor** as search terms. We also searched for studies using *electronic* and *finger* and *drawing* or *painting* as search terms which are used widely to describe the study of infant finger drawing (e.g., Iversen & Matsuzawa, 1997; Matthews & Jessel, 1993).

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Psychological Abstracts (PsycInfo), Educational Resource Information Center (ERIC), MEDLINE, and Academic Search Premier were searched for studies. These were supplemented by a Google Scholar search and a search of an Endnote Library maintained by the Puckett Institute. We also conducted Social Science Citation Index article (e.g., Iversen & Matsuzawa, 2001a; Schwartz & Moran, 1999; Tanaka et al., 2003) and author (e.g., I.H. Iversen; H. Takeshita; M. Tanaka) searches to locate additional studies. Hand searches were conducted of the reference sections of all studies and other relevant sources to be sure no studies were missed.

Studies were included if they were investigations of the development of infant finger drawing or studies of the development of infant haptic (i.e., touch) exploration that mirrored the characteristics of infant finger drawing. The latter included studies of infants' haptic exploration of contrasting surfaces and studies that used experimental conditions similar to those that have been used to study infant finger drawing. Studies were excluded if infant finger drawing or haptic exploration were not the focus of analysis or insufficient information was provided to code the person and environmental characteristics that were associated with the target behavior.

SEARCH RESULTS

Twenty-one studies were located in 16 research reports. Table 1 includes selected characteristics on the study participants. Nine studies included human infants and 12 studies included nonhuman primates. The 21 studies included a total 192 participants. The infant study participants were between 7 and 21 months of age, with most between 7 and 18 months of age. There was almost an equal number of male and female participants.

Table 2 shows the characteristics of the studies that constituted the focus of investigation and the outcomes that were the main focus of analysis. There were three types of experimental conditions: Touch sensitive computer screens that recorded finger drawing movements, touch sensitive panels that produced some type of reinforcement, and contrasting surfaces that provided study participants different haptic exploratory opportunities. The participants' behavior that was the focus of analysis included finger movements and sweeps, and touching, fingering, rubbing, and other haptic responses.

The environmental characteristics that were examined in the studies included adult and mother modeling of the targeted behavior, whether study participant behavior produced some kind of reinforcing consequence, and whether a prompt was used to elicit participant behavior. Two studies of nonhuman primates included mother modeling of the targeted infant behavior. All the studies included some type of naturally occurring reinforcement for the targeted behavior and seven studies included the use of extrinsic reinforcements. Nineteen studies included some type of visual or tactile prompt to elicit infant or nonhuman primate drawing or haptic behavior.

SYNTHESIS FINDINGS

The participants in all the studies demonstrated infant finger drawing or haptic exploration that involved behavior similar to infant finger drawing. The focus of analysis was the characteristics of the experimental conditions and experiences afforded the study participants that were associated with infant finger drawing.

Table 3 shows the major findings from the studies and the characteristics that affected the participants' behavior. The major findings column includes a description of the participants' finger drawing or haptic behavior. The characteristics affecting participant behavior lists the conditions under which participant behavior was elicited or evoked. The characteristics that were the focus of analysis were the type of prompt used to elicit or evoke participant behavior, the type of reinforcement that maintained participant responding, the influences of modeling on participant behavior, and the number of learning sessions afforded the participants and their effects on participant performance. In the studies including human infants less than one year of age, children as young as 7 months of age demonstrated haptic exploration where the behavior became more differentiated by 14 to 15 months of age.

Some type of visual or tactile stimuli was used in 19 of the 21 studies to prompt participant behavior. The prompts mostly involved a visual stimuli that elicited operant behavior or infant or nonhuman primate finger drawing. In all of the electronic finger drawing studies, some type of computer image or start and end dots prompted participant drawing (Iversen & Matsuzawa, 1996, 1997, 2001a, 2001b; Moran & Schwartz, 1999a, 1999b; Schwartz, 1992; Schwartz & Moran, 1999; Stack & Tsonis, 1999; Tanaka et al., 2003).

All of the studies included naturally occurring visual or haptic reinforcement for participant production of exploratory finger movements or finger drawing. The visual reinforcements included slides of familiar television characters, illuminated screens, and observation of the effects of drawing. The haptic reinforcements included the touch and feel of surfaces that varied in softness or texture. In the seven studies that included external reinforcements, shaping procedures were used to improve participant performance (Iversen & Matsuzawa, 1996, 1997, 2001a, 2001b; Mandell, 2006; Schwartz & Moran, 1999).

In the two studies that provided the participants opportunities to observe targeted behavior, modeling facilitated more rapid learning. The nonhuman primates' mothers demonstrated behavior which the participants imitated or attempted to imitate in both the Takeshita et al. (2005) and

Tanaka et al. (2003) studies. The investigators also modeled targeted behavior in the Takeshita et al. (2005) study.

The more opportunities the participants had within and across sessions, the more they engaged in haptic exploration or finger drawing. In the 13 studies that included multiple sessions over time, all the participants demonstrated discernable improvements in finger drawing the more opportunities they had to draw.

DISCUSSION

Findings showed that finger drawing and haptic exploration were facilitated by experiences that prompted and reinforced participant behavior, where modeling and multiple learning opportunities hastened the emergence and development of targeted behavior. The Tanaka et al. (2003) study of nonhuman primates is exemplary for understanding the conditions under which finger drawing develops. The study participants observed their mothers' finger drawing, were provided multiple opportunities to engage in finger drawing, and seemed to derive gratification in seeing their scribbles appear on a computer screen. All of the studies, taken together, showed that finger drawing and haptic exploration were easily facilitated and maintained by the opportunities to engage in canonical pointing that produced observable, reinforcing consequences.

The implications of this synthesis for practice are straightforward. Infants provided the opportunity to finger draw in pudding, yogurt, or other food that varies in texture will likely evoke exploratory behavior. This can be done on a high chair tray, a table top, or any other surface where a child is able to freely play in the "writing substance." The opportunity to finger draw will provide a child the kind of experience that help him or her learn the connection between haptic behavior and its consequences. This can be supplemented by naturally occurring opportunities like drawing on a steamed mirror or window to reinforce infant finger drawing. The likelihood of a child engaging in any type of finger drawing is maximized when the drawing act results in a discernable visual effect that functions as a reinforcement.

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Table 1
Characteristics of the Study Participants

Study	Number	Age (Months)	Gender		Participants
			Male	Female	
Bailey et al. (1988) (Study 1)	13	12-18	6	7	Human Infants (Typical)
Bailey et al. (1988) (Study 2)	8	12-18	4	4	Human Infants (Typical)
Fontenelle et al. (2007)	48	8-10	24	24	Human Infants (Typical)
Iversen & Matsuzawa (1996)	2	—[a]	0	2	Chimpanzee
Iversen & Matsuzawa (1997) (Study 1)	2	—	0	2	Chimpanzee
Iversen & Matsuzawa (1997) (Study 2)	1	—	0	1	Chimpanzee
Iversen & Matsuzawa (1997) (Study 3)	2	—	0	2	Chimpanzee
Iversen & Matsuzawa (2001)	2	—	0	2	Chimpanzee
Lipsitt et al. (1966) (Study 1)	10	12	NR[b]	NR	Human Infants (Typical)
Lipsitt et al. (1966) (Study 2)	15	12	NR	NR	Human Infants (Typical)
Mandell (2005)	13	3-6	8	5	Pigtail Macaque monkey
Moran & Schwartz (1999a)	2	NR	NR	NR	Rhesus monkey
Moran & Schwartz (1999b)	4	NR	NR	NR	Rhesus monkey
Schellingerhout et al. (2005)	3	12-13	2	1	Human Infants (Visually impaired)
Schellingerhout et al. (1997)	8	8-21	2	6	Human Infants (Visually impaired)
Schwartz (1992)	3	NR	3	0	Rhesus monkey
Schwartz & Moran (1999)	2	NR	NR	NR	Rhesus monkey
Stack & Tsonis (1999) (Sample 1)	24	7	12	12	Human Infants (Typical)
Stack & Tsonis (1999) (Sample 2)	24	7	12	12	Human Infants (Typical)
Takeshita et al. (2005)	3	13-17	1	2	Chimpanzee
Tanaka et al. (2003)	3	13-23	1	2	Chimpanzee

[a] Older, nonhuman primates.
[b] Not reported.

Table 2

Characteristics and the Outcomes of the Infant Touch/Finger Drawing Activities

Study	Study Characteristics					Study Outcome
	Experimental Situation	Participants Behavior	Adult Modeling	Reinforcement	Prompt	
Bailey et al. (1988) (Study 1)	Touch Sensitive Video Screen	Touching	No	Yes	Yes	Operant Responding
Bailey et al. (1988) (Study 2)	Touch Sensitive Video Screen	Touching	No	Yes	Yes	Operant Responding
Fontenelle et al. (2007)	Contrasting Surface Textures	Pressing Picking Rubbing	No	Yes	Yes	Tactile Exploratory Behavior
Iversen & Matsuzawa (1996)	Touch Sensitive Monitor	Finger Press Finger Sweeps	No	Yes	Yes	Finger Drawing
Iversen & Matsuzawa (1997) (Study 1)	Touch Sensitive Monitor	Finger Sweeps	No	Yes	Yes	Finger Drawing
Iversen & Matsuzawa (1997) (Study 2)	Touch Sensitive Monitor	Finger Sweeps	No	Yes	Yes	Finger Drawing
Iversen & Matsuzawa (1997) (Study 3)	Touch Sensitive Monitor	Finger Sweeps	No	Yes	Yes	Finger Drawing
Iversen & Matsuzawa (2001)	Touch Sensitive Monitor	Finger Press Finger Sweeps	No	Yes	Yes	Finger Drawing
Lipsitt et al. (1966) (Study 1)	Touch Sensitive Panel	Pressure	No	Yes	Yes	Operant Responding
Lipsitt et al. (1966) (Study 2)	Touch Sensitive Panel	Pressure	No	Yes	Yes	Operant Responding
Mandell (2005)	Touch Screen Computer Monitor	Touching	No	Yes	Yes	Operant Responding
Moran & Schwartz (1999a)	Touch Screen Computer Monitor	Finger Movements	No	Yes	Yes	Finger Drawing
Moran & Schwartz (1999b)	Touch Screen Computer Monitor	Finger Movements	No	Yes	Yes	Finger Drawing
Schellingerhout et al. (2005)	Contrasting Textured Surfaces	Hand Movements	No	Yes	No	Tactile Exploratory Behavior
Schellingerhout et al. (1997)	Contrasting Textured Surfaces	Touching Hitting Rubbing Fingering	No	Yes	No	Tactile Exploratory Behavior
Schwartz (1992)	Touch Sensitive Computer Monitor	Finger Movements	No	Yes	Yes	Finger Drawing
Schwartz & Moran (1999)	Touch Sensitive Computer Monitor	Finger Movements	No	Yes	Yes	Finger Drawing
Stack & Tsonis (1999) (Sample 1)	Contrasting Textured Surfaces	Manual Contact Bimanual Contact Scrumbling Fingering	No	Yes	Yes	Tactile Exploratory Behavior
Stack & Tsonis (1999) (Sample 2)	Contrasting Textured Surfaces	Manual Contact Bimanual Contact Scrumbling Fingering	No	Yes	Yes	Tactile Exploratory Behavior
Takeshita et al. (2005)	Contrasting Textured Surfaces	Rubbing Hitting	Yes	Yes	Yes	Tactile Exploratory Behavior
Tanaka et al. (2003)	Touch Sensitive Computer Screen	Finger Movements	Yes	Yes	Yes	Finger Drawing

Table 3
Major Findings Related to Infant Finger Drawing

Study	Major Findings	Characteristics Affecting Haptic Behavior					
		Prompts		Reinforcement		Learning Opportunities	
		Tactile	Visual	Visual	Haptic	Modeling	Multiple Sessions
Bailey et al. (1988) (Study 1)	Infants touched the video screen more often when it produced contingent feedback (reinforcement)		✓	✓			
Bailey et al. (1988) (Study 2)	Infants touched the video screen more often when contingent feedback produced reinforcement on a 2 to 1 fixed ratio schedule		✓	✓			
Fontenelle et al. (2007)	Infants explored flexible (compared to rigid) surfaces more often with their hands		✓		✓		
Iversen & Matsuzawa (1996)	Participants learned to draw straight lines and circles on a touch screen monitor with their fingers		✓	✓			✓
Iversen & Matsuzawa (1997) (Study 1)	Participants were able to draw straight lines on a touch screen monitor copying different angled models with stopdot prompts using their fingers		✓	✓			✓
Iversen & Matsuzawa (1997) (Study 2)	Participants were able to draw straight lines on a touch screen monitor copying different angled models without stopdot prompts using their fingers		✓	✓			
Iversen & Matsuzawa (1997) (Study 3)	Participants were able to finger draw parallel lines on a touch screen monitor with both models and stopdot prompts		✓	✓			✓
Iversen & Matsuzawa (2001)	Participants were able to trace and copy different shapes by finger drawing on a touch screen monitor		✓	✓			✓
Lipsitt et al. (1966) (Study 1)	Infants touched a touch sensitive panel more often and with more intensity to elicit a visual reinforcement		✓	✓			
Lipsitt et al. (1966) (Study 2)	Infants touched a touch sensitive panel more often and with more intensity to elicit a visual reinforcement		✓	✓			
Mandell (2005)	Participants learned to touch a stimulus presented on a touch screen monitor to elicit a reinforcement		✓	✓			✓
Moran & Schwartz (1999a)	Participants learned to trace different spiral figures by finger drawing on a touch screen monitor		✓	✓			✓
Moran & Schwartz (1999b)	Participants learned to move their finger from a center position to peripherally arranged targets by finger drawing on a touch screen monitor		✓	✓			✓
Schellingerhout et al. (2005)	Infants (2 of 3) with visual impairments explored surfaces with their hands more often when the surfaces were soft and malleable				✓		✓
Schellingerhout et al. (1997)	Infants with visual impairments explored surfaces with their hands more often when the surfaces had dense gradients				✓		✓
Schwartz (1992)	Participants learned to trace curved figures by finger drawing on a touch screen monitor		✓	✓			✓
Schwartz & Moran (1999)	Participants learned to trace different curved figures by finger drawing on a touch screen monitor		✓	✓			✓
Stack & Tsonis (1999) (Sample 1)	Infants more often explored textured surfaces with their hands	✓	✓		✓		
Stack & Tsonis (1999) (Sample 2)	Infants more often explored textured surfaces with their hands	✓			✓		
Takeshita et al. (2005)	Participants explored surfaces with their hands more often when the surfaces moved in response to finger movements		✓	✓	✓	✓	✓
Tanaka et al. (2003)	Participants learned to scribble by finger drawing on a touch screen monitor		✓	✓		✓	✓