Effects of Sticky Mittens Training on Infants' Exploration Behaviors in Various Postures

By

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CHAPTER 1

Pilot Study Introduction

What does early object exploration look like? Object exploration during infancy may bring to mind images of infants examining toys visually and manually or enthusiastically shoving toys into their mouths. On the contrary, object exploration begins very early during infancy and may not be obvious to the untrained eye. Infants' early object exploration allows them to learn about the affordances of objects. Detecting affordances involves learning about the relationship between oneself and the environment—That is, learning the actions made possible by the environment (Gibson, 1966; Gibson, 1988). Even as newborns, infants' actions on objects are guided by objects' affordances.

From birth, infants' manual and oral patterns of exploration show that they are able to discriminate between rigid versus pliable objects (Rochat, 1987). Newborns have also been shown to use different patterns of pressure in their grasping responses to smooth versus granular stimuli placed in their hands (Molina & Jouen, 1998). Although very young infants do not use the same methods of exploration as adults, young babies are able to discriminate texture, temperature, compliance, and weight (Striano & Bushnell, 2005). Object exploration undergoes changes across infancy. For example, while two month olds are likely to bring objects to their mouths first for exploration, older babies tend to first bring objects to their eyes for visual inspection (Rochat, 1989).

Bushnell and Boudreau (1998) discuss two factors that appear to limit infants' haptic perception of object properties. The first factor is that infants may be unable to

manually perform the Exploratory Procedures, the repetitive hand motions that adults use to best detect certain properties of objects, necessary to detect certain object properties. The second factor that may limit infants' haptic exploration is their attentional capacities. Due to their limited processing capacities, infants may only focus on the properties of objects that they find most salient. As processing speed increases across development, more haptic perception is possible.

Importantly, Bushnell and Boudreau (1998) acknowledge that these limitations in haptic perception can be overcome; "infants can show sensitivities at earlier ages—if they are somehow coaxed into making certain hand movements 'before their time'" (p. 151). Thus, interventions encouraging infants to become motivated to explore and provide opportunities for infants to practice their explorative skills earlier than they normally would have the potential to impact the amount of information infants are able to glean through object exploration.

Infants explore objects early on before they are able to reach out and grasp objects independently (Rochat, 1989). Exploration during infancy allows infants to learn about the properties and affordances of objects. With the onset of reaching, infants' learning opportunities are expanded because they can reach out to obtain objects to explore. Increasing infants' exploration skills helps to build a strong foundation for future cognitive growth. Infants' object exploration and reaching skills are related to their abilities to detect affordances (Baumgartner & Oakes, 2013); their sensitivity to causality (Rakison & Krogh, 2012); when they begin to crawl, cruise, and walk (Lobo & Galloway, 2012); their learning about relationships between objects (Lobo & Galloway, 2008); their problem solving skills (Caruso, 1993); their ability to sustain attention

(Libertus, Joh, & Needham, 2016); the sophistication of their symbolic play (Tamis-LeMonda & Bornstein, 1993); the frequency with which they encounter social interactions and episodes of joint attention (Adolph & Tamis-LeMonda, 2014; Karasik, Tamis-LeMonda, & Adolph, 2011); and their working memory and processing speed (Piek, Dawson, Smith & Gasson, 2008). All of these mechanisms likely have important consequences for learning. Longitudinal research has linked early motor development with children's attention spans, academic outcomes, and standardized test scores across 14 years (Bornstein, Hahn, & Suwalsky, 2013).

Early motor interventions that encourage infants to begin reaching for and grasping objects before they normally would have proven successful among typically developing populations. Practice engaging in object-oriented reaching and exploration over the course of three weeks led to earlier reaching and increased object exploration in two-month-olds in comparison to a group of infants in a social experience condition (Lobo & Galloway, 2008). The longer-term effects of this intervention included transferring objects from one hand to the other earlier, and earlier crawling, cruising, and walking (Lobo & Galloway, 2012).

In the sticky mittens paradigm, infants wear specially designed infant mittens with Velcro loop on the palms. This allows babies to pick up and move around small toys covered in strips of Velcro hook. Sticky mittens training takes place while babies are sitting upright with their arms resting on a tabletop (see Figure 1). Pre- and post-measures of object exploration also take place in this posture. Sitting upright, however, may not be a common experience for three-month-old infants. Research findings show that two weeks of active sticky mittens training leads to earlier reaching and more sophisticated

object exploration (Needham, Barrett, & Peterman, 2002; Libertus & Needham, 2010). Libertus and Needham (2014) manipulated the experience of obtaining objects and the role of encouragement in increasing infants' interest in objects. Their findings suggest that both practice and encouragement are critical components of successful early motor interventions. When parents are incorporated into early interventions, this may lead to changes in caregiver-infant interactions. Parents may provide their infants with more learning opportunities, and they may become more sensitive to changes in their infants' motor abilities (Lobo & Galloway, 2012). Early experiences help to mold children's brains. Enriched early experiences and the cultivation of children's repertoires help to set children on a positive developmental trajectory (Potter, Mashburn, & Grissmer, 2013).

A sitting position encourages young infants to engage in more frequent and sophisticated reaching (Carvalho, Tudella, & Savelsbergh, 2007) and object exploration (Soska & Adolph, 2013). Lobo and Galloway (2008) illustrate the importance of the transition into reaching during infancy. Before the onset of reaching, infants spend the majority of their time on their backs engaging in social interactions. After the onset of reaching, infants begin sitting up and engaging in purposeful play. When seated upright, infants have to fight against gravity less when moving their arms and have better visual access to their hands and to objects compared to when supine (Soska, Galleon, & Adolph, 2011). The forces of gravity experienced when reaching in the supine compared to the sitting position are equivalent, but the timing of when the peak gravitational force is experienced within the trajectory of the reach differs (Out, van Soest, Savelsbergh, & Hopkins, 1998). Gravitational force is greatest when our arms are parallel to the earth. In the supine position, this means the maximum gravitational force is experienced when the

arms are alongside one's body, before a reach is initiated. For this reason, initiating the reach in a supine posture may be especially challenging. In contrast, in the sitting posture, the maximum gravitational force is experienced at the end of the reach when the arms are extended straight ahead. Infants may be able to overcome this gravitational force by picking up momentum as and using inertia to continue their reaching movements (Out et al., 1998). Research has found evidence that infants are more likely to initiate reaches in the sitting position compared to the supine position, but interestingly, one longitudinal study with infants between 0 and 6 months of age found that in terms of sustaining object exploration in these two postures, infants' behaviors did not differ significantly (Lobo, Kokkoni, de Campos, & Galloway, 2014). The authors of this study note that exploring while supine may be a very common experience for young infants.

The purpose of the pilot study was to investigate the types of object exploration three-month-old infants engage in when placed in three different postures. The goal was to learn more about infants' baseline levels of exploration when supine, reclining in a bouncy seat, or seated upright. Although research has established that older infants show more advanced exploration behaviors when seated upright, I was unsure whether this would be the case for three-month-olds.

Figure 1. Infant participating in sticky mittens training.

CHAPTER 2

Pilot Study Method

Participants

Fourteen (females = 7) three-month-old infants (M_{age} = 3 months, 5 days, SD_{age} = 9 days) completed the current study. Infants were recruited using birth records from the Tennessee Department of Health, Division of Policy, Planning and Assessment, Office of Health Statistics. Parents' email addresses were obtained using the Vanderbilt People Finder system. Four additional infants participated in this study, but their data were excluded from analyses due to difficulty coding the videos based on poor camera angles (n = 2) or fussiness that prevented infants from completing the entirety of the study (n =2).

Materials

Infant gym. A commercially available infant gym (Wee Workout Baby Gym purchased from the Land of Nod website: http://www.landofnod.com/wee-workout-baby-gym-natural/f15009) was used to suspend the toys within infants' reach in each of the three postures (see Figure 2). This wooden structure measures 28 inches across, 21 inches in height at the tallest point, and 21.5 inches in depth.

Figure 2. Wee Workout Baby Gym.

Toys. Plastic infant links were used to suspend stimuli from the infant gym in the current study. Study stimuli consisted of three commercially available toys (see Figure 3): a ball (Oball 4-inch Infant Rattle in green), a key ring with three fruit shapes attached to it (First Years LC23025 Fruity Teether), and a rattle (Bright Starts Rattle and Shake Barbell Rattle).

Figure 3. Toys presented to infants during the pilot study.

Supine position. Four 6-inch tall plastic bed risers were used to increase the height of the infant gym in both the supine and reclining postures. This additional height helped improve the visibility of the infants and their interactions with the toys in our videos. When in the supine posture, infants were placed on a 36-inch square mat that was 2 inches thick and covered in red vinyl. If parents had brought a blanket with them to our lab, the experimenter permitted them to cover the mat with the blanket if they requested to do so before the infant was placed in this position.

Figure 4. Infant in supine posture.

Reclining position. As stated earlier, bed risers were used to increase the height of the infant gym when infants were placed in the reclining posture (see Figure 5). Infants were placed in a commercially available infant bouncer seat (Bright Starts Elephant March Bouncer). The bouncer seat was placed on top of the red mat that was also used in the supine posture.

Figure 5. Infant in reclining posture.

Sitting position. Infants sat on a parent's lap during the sitting posture. The office chair that parents sat on was adjustable in height, and parents were also offered a pillow to place on their lap underneath their infants if infants' arms were too low to rest comfortably on the tabletop. Parents were instructed to place their hands around their

infants' midsections to provide adequate trunk support for reaching. They were asked to scoot their chair in so that their infant's belly was touching the edge of the table.

Figure 6. Infant in sitting posture.

Procedure

Behavioral. Posture was partially counterbalanced across infants. Initially, I was primarily concerned with comparing infants' exploration when infants were sitting versus supine. I was also concerned that infants may become too exhausted to complete the entirety of the study. Thus, all infants participated in the reclining posture third. The order of presentation of the three toys was counterbalanced across infants, but the order of toys was consistent across the three postures for each infant. Each toy was presented for 60 seconds. Toys were suspended within infants' reach via plastic links. The experimenter added or subtracted links so that the toy was judged to be within infants' reach. Parents were permitted to talk to their infants to encourage their exploration and comfort them, but parents were asked to refrain from touching the toys as well as infants' hands and arms.

Infants were video recorded with a four-way security camera system during the sitting posture. Cameras captured infants' exploration from the front, overhead, left, and

right. When infants were in the reclining and supine postures, a MacBook Air laptop video recorded infants using the Photobooth application.

Parent report. Parents completed three questionnaires: Postural Experience Questionnaire (created for the purpose of this study), Early Motor Questionnaire (Libertus & Landa, 2013), and Infant Behavior Questionnaire-Revised Very Short Form (Putnam, Helbig, Gartstein, Rothbart, & Leerkes, 2014). Parents completed consent forms before infants' participated in the study, but they were given the option of completing these three questionnaires while their infants completed the reclining and supine positions or after their infants participated in the study.

Measures

Behavioral. Datavyu coding software was used to code the frequency and duration of infants' touching behaviors (Datavyu Team, 2014). Coders specified which body part or parts (hand, belly, foot, head) infants used to contact the toys

Parent report. The Postural Experience Questionnaire was created for the purpose of this study to gain a better understanding of three-month-olds' postural experiences. This questionnaire asks parents to report the number of times their baby was placed in a specified posture during the last week as well as the duration the baby was in that posture during one bout. Questions are grouped into three categories: daytime postures, carrying postures, and nighttime postures. Parents also indicated whether or not infants typically had toys accessible to them in certain postures.

The Early Motor Questionnaire (EMQ; Libertus & Landa, 2013) asks parents to report how certain they are that they have ever seen their infant perform a certain behavior even once in the past. The scale ranges from -2 (sure that child does NOT show

behavior) to +2 (sure that child shows behavior and remember a particular instance). Questions are grouped into three domains: gross motor skills, fine motor skills, and visual reception skills.

Reliability

Intra-class correlation coefficients were used to test inter-rater reliability for infants' touching durations and touching frequencies. Decisions about the model and type of ICC to use were based on an article by Koo and Li (2016). A two-way mixed effects model was used because two raters coded the entirety of the dataset. Analyses were based on the average of the two raters' codes, and the ICC measured the absolute agreement to test how closely the two raters' codes aligned. The two research assistants' codes were highly correlated for touching duration (*ICC* = .984*,* 95% CI [.977-.989]) and touching frequency (*ICC* = .943*,* 95% CI [.906, .964]). Coders also specified which body parts infants used to touch the toys with (belly, hand, foot, head) and reached 100% agreement.

CHAPTER 3

Pilot Study Results

Behavioral

Upon analyzing our findings, it became clear that infants were not committed to exclusively using their hands to make contact with the toys they encountered in this study (see Figure 7). Infants took advantage of the affordances of each of the three postures. In the supine and reclining postures, infants sometimes belly bumped the toys, and occasionally they successfully contacted the toys with their feet. The sitting posture, in contrast, did not afford infants these opportunities because their bellies were resting against the edge of the table and their feet were underneath the table. Interestingly, in the sitting posture, infants sometimes dove headfirst for the toys and bonked them with their faces as they attempted to mouth the toys.

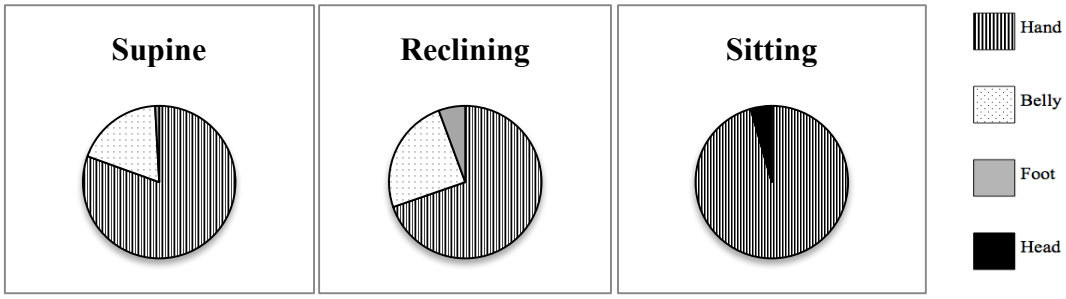

Figure 7. Infants took advantage of opportunities to make contact with the toys using their bellies, feet, and heads, in addition to using their hands.

Although the findings that infants employed their problem solving skills to contact the toys by various methods is fascinating, our primary interest in this pilot study was to learn how posture influences infants' touching using their hands. Thus, from this

point forward analyses will focus on the frequency and duration of touching behaviors only with infants' hands.

Touching Frequency. An ANOVA was used to test for differences in touching frequencies based on posture. This test revealed no significant differences in frequency of touching based on whether infants were placed in the supine (M = 2.55, SD = 2.75), reclining (M = 3.29, SD = 3.27), or sitting (M = 2.14, SD = 4.63) postures, $F(2,26) = .43$, $p = .654$, , $\eta_p^2 = .032$.

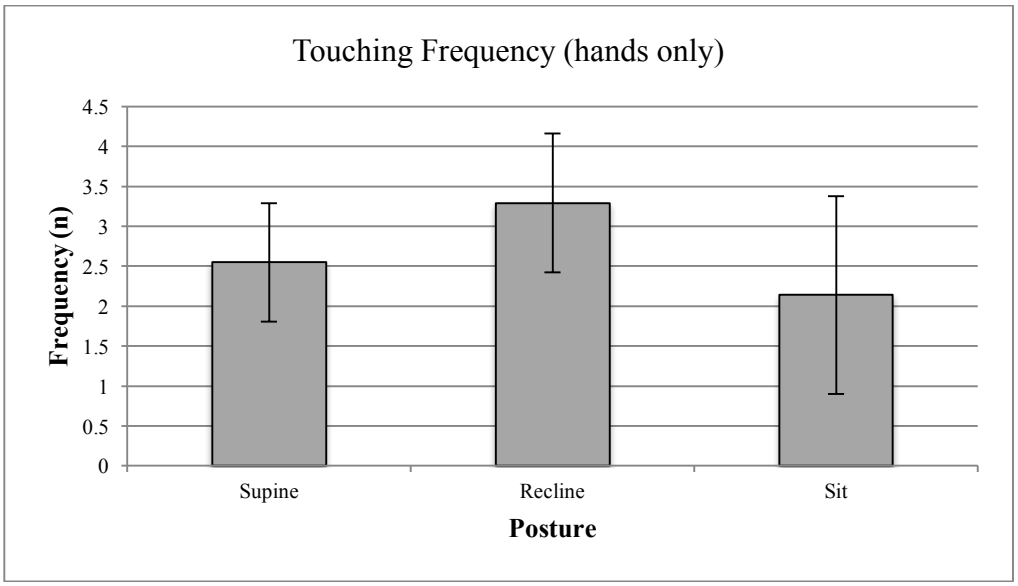

Figure 8. Touching frequencies (hands only).

Touching Duration. An ANOVA was used to test how posture affected infants' durations of touching the toys. Posture, the independent variable, was a within-participant factor with three levels (supine, reclining, and sitting). The dependent variable was duration of touching. Duration was averaged across the three toys for each participant. This ANOVA revealed a significant main effect of posture, $F(2, 26) = 4.63$, $p = .019$, $\eta_p^2 = .263$. Follow-up t tests were used to determine which postures had significantly different

effects on infants' touching durations. Difference scores were calculated by subtracting infants' average touching durations between pairs of postures. Comparing infants' touching behaviors in the reclining and supine ($M_{R\text{-}S}$ = 5.74, $SD_{R\text{-}S}$ = 10.55) postures revealed a marginally significant difference, $t(13) = 2.03$, $p = .063$, *95% CI* [-.36, 11.82]. Similarly, touches in the reclining compared to the sitting posture ($M_{R\text{-}T}$ = 5.87, $SD_{R\text{-}T}$ = 10.62) were marginally significantly different, $t(13) = 2.07$, $p = .059$, *95% CI* [-.26, 12.00]. In contrast, the difference in supine compared to sitting postures ($M_{S\text{-}T}$ = .14, $SD_{S\text{-}T}$ = 5.75) was non-significant, $t(13) = .09$, $p = .929$, *95% CI* [-3.18, 3.46].

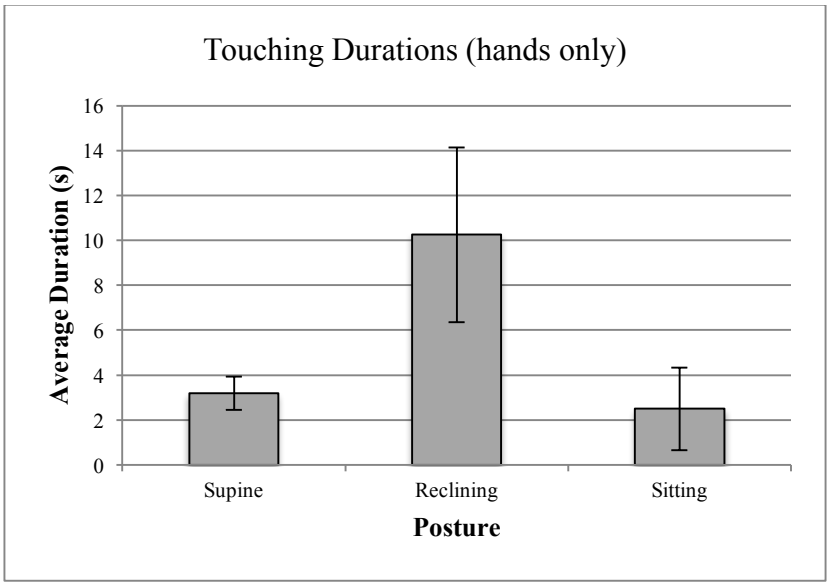

Figure 9. Touching durations (hands only).

Parent report

Postural experience questionnaire. I created this questionnaire to measure infants' postural experiences in the three postures they encountered during our pilot study: supine, reclining, and sitting. As I expected, the majority of parents reported that they had placed their three-month-olds in a supine posture under an infant gym (85.71%)

and reclining in a bouncy seat (78.57%) during the past week. In contrast, but also in line with our expectations, few parents reported sitting at a table with their infants in their laps during the past week (35.71%). The average durations reported for infants in each of these three postures also confirmed our hypotheses (see Figure 10). Parents reported their three-month-olds had spent little time sitting upright on their laps at a table (M = 6.46 minutes, SD = 13.02), but that they had spent quite a lot of time supine under an infant gym (M = 99.46 min, SD = 118.78) and reclining in a bouncy seat (M = 92.14, SD = 78.68) during the past week. Additionally, parents reported that infants had minimal (if any) experience sitting in high chairs and bumbo seats.

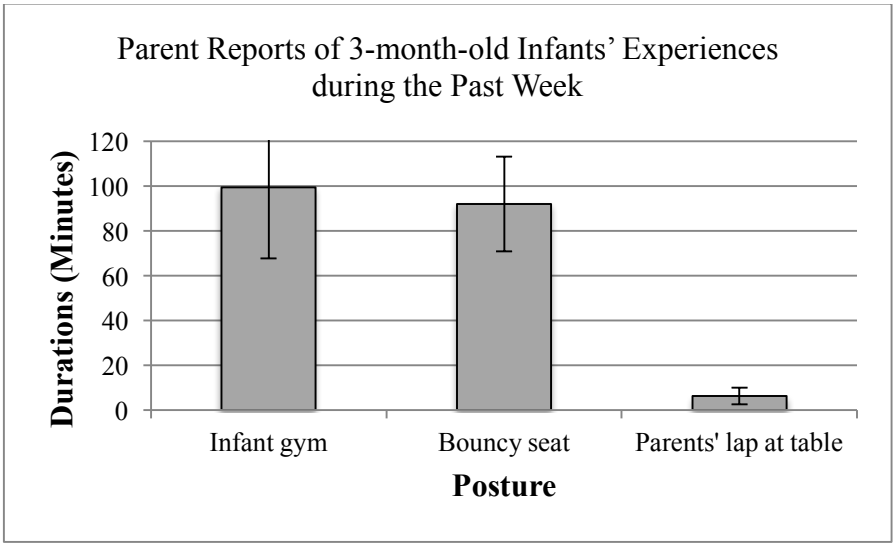

Figure 10. Postural experiences.

Early Motor Questionnaire. Two questions from the Early Motor Questionnaire were of interest to us (see Figures 11 and 12). These questions asked parents whether their infant had (1) swatted at a toy while supine on his/her back ("When lying on his/her back in a crib, baby gym, or on the floor, your child sometimes will swat at toys hanging from a baby gym or car seat"), and (2) reached for a toy when sitting upright ("When

sitting on your lap or in a highchair while playing with toys, you notice your child is able to reach for a toy with one hand by extending the arm and fingers"). Admittedly, parents' responses may have been impacted by the terms "swat" versus "reach." Swatting may have sounded less intentional to parents, whereas reaching is a goal-directed action. In any case, more parents reported they believed their infant had swatted at a toy when in the supine posture (85.71%) compared to reached for a toy in the sitting posture (57.14%). While this finding is in keeping with our hypotheses as well as parents' reports of their infants' recent experiences (i.e., infants are rarely in a sitting position), it is counterintuitive considering that the gravitational constraints on infants' limbs are greater when they are in the supine posture compared to a sitting posture.

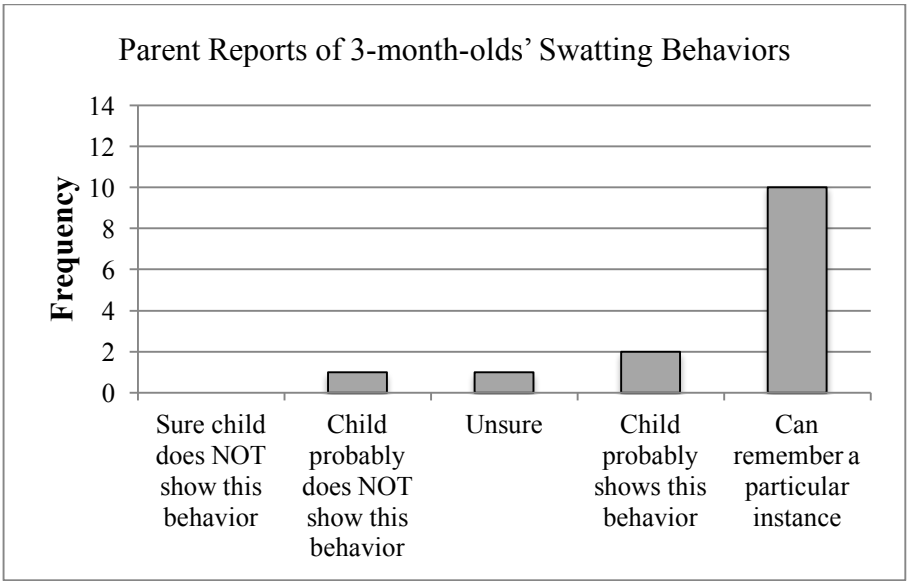

Figure 11. Reaching in supine posture.

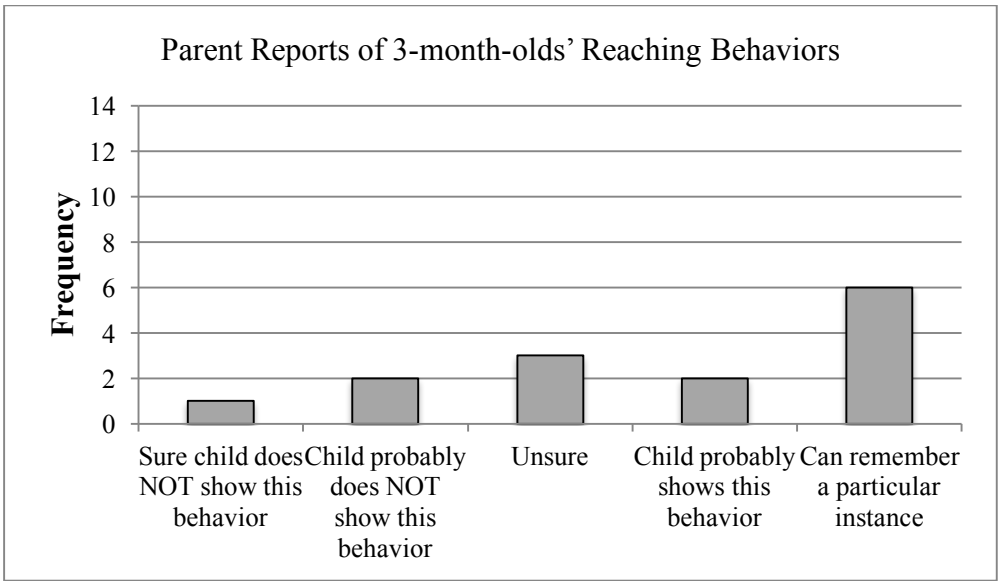

Figure 12. Reaching in sitting posture.

CHAPTER 4

Pilot Study Discussion

The findings from this pilot study confirmed our hypotheses that three-month-old infants may have limited experience sitting upright on parents' laps at tables, and infants may therefore find reaching in the sitting posture (as compared to the reclining or supine postures) more challenging than infants who have more sitting experience. Infants' postural experiences may influence their object exploration in various postures. Specifically, the challenge of stabilizing their heads and necks in the sitting position may discourage three-month-olds' exploration in the sitting posture. Whereas research has documented the advantages of the sitting posture for older infants in terms of their exploration behaviors (Carvalho, Tudella, & Savelsbergh, 2007; Soska & Adolph, 2013; Soska, Galleon, & Adolph, 2011), our findings indicate that the reclining posture, which offers better visual access to toys, and poses less of a motor challenge for infants than the supine position due to the lesser constraints of gravity, may be most advantageous for supporting three-month-olds' exploration behaviors (see Figure 13).

Posture	Measure	Level	Explanation
Supine	Parent-report	Lots of experience	- More motor challenges + More experience - Poor view
	Behavioral	Minimal touching	
Reclining	Parent-report	Lots of experience	+ Less motor challenges + More experience + Better view
	Behavioral	Lots of touching	
Sitting	Parent-report	Minimal experience	- More motor challenges - Less experience + Better view
	Behavioral	Minimal touching	

Figure 13. Possible explanations for our findings.

Limitations

Several limitations to the procedures described above became apparent during the process of collecting and coding this dataset. It was challenging to position the toys at a consistent distance from infants across postures, toys, and participants. Using a continuous string rather than the links that are each approximately 2.5 inches in diameter would allow us to more precisely position the toys. The string could be adjusted for each toy because the keys, for example, hang down lower than the other two toys. Another precaution to ensure that the toys are reachable to infants might be to stretch the infant's arm out and touch their hand to the toy at the beginning of each trial. This would provide confirmation that the toys are accessible to the infants. Although the infant gym must be placed on risers to make it a compatible height to use with the bouncy seat, the distance between infants and the toys will be consistent across the three postures.

Three additional adjustments are critical in moving forward with future studies using this paradigm. First, the order of the postures should be fully counterbalanced. The current findings could be influenced by infants always participating in the reclining posture last, after they'd been exposed to the toys and had practice reaching for and touching them in two prior postures. Fully counterbalancing the order of the postures that babies participate in would account for this possibility. Second, rearranging the room during the study takes time and is rather disruptive to the flow of the study. If the study were to take place in a room where all three postures could be set up and prepared for in advance, then the baby could simply be moved to a different area of the room and the study could continue smoothly. Lastly, it is imperative that two video recordings are obtained from diverse angles—preferably one angle from the side and one from straight ahead, so that touching behaviors are easier for coders to discern once the videos are later synced in Datavyu. Placing the cameras on boxes or tabletops is preferable to a research assistant holding the cameras because the former is more stable and easier to code from.

CHAPTER 5

Experiment 1 Introduction

Our pilot study sheds light on how posture affects three-month-olds' exploration behaviors. Prior research shows that early motor interventions have the potential to boost infants' reaching and exploration skills. The current study investigates how an early motor intervention, sticky mittens training, affects infants' exploration skills in various postures. During sticky mittens training, infants are seated upright on a parent's lap with their arms resting comfortably on a tabletop. Infants wear custom mittens with the palms covered in velcro loop. These mittens enable infants to move around small lightweight toys covered in velcro hook. Previous research has shown that the sticky mittens paradigm may jumpstart infants' interest in reaching for and exploring toys earlier (Needham, et al., 2002). Infants who are on the cusp of starting to reach and grasp for toys respond well to encouragement and motor practice (Libertus & Needham, 2014). Our pilot study findings indicate that many infants between 2 and 3 months of age do not have extensive experience sitting upright on their parents' laps with their arms resting on a tabletop. Nonetheless, all but one (Needham, et al., 2002) of the existing sticky mittens intervention studies place 3-month-olds in this posture during pre- and post-training measures of object exploration (ex. Libertus & Needham, 2010 & 2011; Sommerville, Woodward, & Needham, 2005; Gerson &Woodward, 2014; Rakison & Krogh, 2012). In Needham, Barrett, and Peterman (2002), pre- and post-training exploration measures took place while infants were seated in a bouncy seat, a reclined posture, and infants showed an increase in exploration from pre- to post-training, despite training taking place when

infants were seated in an upright position. If the reclined posture is less challenging for infants to explore in compared to the sitting posture, perhaps infants are able to transfer their new skills from the sitting posture, which they experience during training, to the reclined posture. It would be interesting to discover whether infants would also be able to generalize their new skills to the supine posture, which they likely have a lot of experience in, but which poses more of a challenge gravitationally than the sitting and reclining postures.

Two longitudinal studies that have tracked infants who participated in mittens training at 3-months over time have shown differences in these children's skills long after the conclusion of this training experience. One study found that infants who participated in sticky mittens training showed more sophisticated object exploration skills two months after training concluded in comparison to infants who received a passive training experience (Wiesen, Watkins, & Needham, 2016). The second study found that 15-month-old children who had the training when they were 3 months old showed greater manual and visual engagement with a toy, and their parents reported their toddlers to have longer attention spans compared to their peers without training (Libertus, Joh, & Needham, 2016). These findings indicate that the effects of mittens training influence infants' later skills and object engagement for quite some time after training ends. One could conclude that mittens training must be affecting infants' exploration during their daily activities after completing the training based on these findings. However, it is plausible that parents of infants who participate in sticky mittens training may seek out more opportunities to place their infants in upright, seated postures, after they witness their infant doing so during mittens training. Parents may also be encouraged to present

more toys to their infants or provide opportunities for their infants to practice their reaching and exploration skills.

While the majority of early motor intervention studies with three-month-olds do not directly study how posture influences exploration, there is one research article (Cunha, Woollacott, & Tudella, 2013) that examines at the effects of posture during training and how it affects pre- and post-training measures. This study found specificity in the relationship between training posture and increases in exploration from pre- to post-training. Infants who participated in a reaching intervention in the reclined position showed increases in exploration only in the reclined posture, and not in the supine posture. The opposite pattern was true of babies who trained in the supine posture—their reaching increased in the supine posture after training, but not in the reclined posture. This specificity between training posture and increases in exploration during post-training assessments may indicate that infants find it challenging to generalize their new skills to postures that differ from the posture they were in when they acquired the new skills. If this is the case, sticky mittens training, which takes place with infants in a seated posture, a postural experience that is mostly likely rare among three-month-olds, may not influence infants' exploration during much of their daily lives.

With sticky mittens training, parents are investing time and energy into supporting their infants' reaching and exploration skills. The purpose of the current study is to investigate whether infants will be able to transfer their new skills to contexts that differ from the context of their sticky mittens training. When discussing transferring learning from one context to another, it is important to specify what skills are being transferred and how these skills are measured (Barnett & Ceci, 2002). I am defining learning in the

context of sticky mittens training as infants increasing their exploration skills from pre- to post-training. In the current study, exploration skills are operationalized as the duration and frequency with which infants touch and grasp the Oballs.

Additionally, the distance of the transfer from training to test varies along several dimensions, which ought to be clearly defined (Barnett & Ceci, 2002). In the current study, there are many dimensions of transfer from sticky mittens training to the post-test context. Three of these dimensions have been present in the design of past sticky mittens research studies (ex. Libertus & Needham, 2010; Wiesen, Watkins, & Needham, 2016). The first of these three dimensions is the social context. The experimenter is present during pre- and post-training measures as well as the parent/guardian, whereas sticky mittens training takes place at home, presumably with familiar caretakers or family members present. Secondly, the physical location varies between training and test. The majority of sticky mittens training takes place in the infants' home, which is a highly familiar context compared to the laboratory environment. Thirdly, the objects that infants explore and whether or not they're wearing mittens differs between training and test. During sticky mittens training, infants wear sticky mittens and interact with Velcro covered Lego blocks and rubber bath toys. In contrast, during the post-training measure of exploration, infants were bare-handed and had the opportunity to explore an Oball. These three dimensions of transfer are not of primary interest in the current study because past research provides ample evidence that infants are able to transfer their increased exploration skills across these dimensions from training to test phase.

The current study includes four novel dimensions of transfer that have not been present in past sticky mittens training studies. The first of these is another component of

the stimuli that infants are exposed to during training compared to test. The infant gym, cord, and clip are present during the post-training measures in the current study. Secondly, we manipulated infants' postures to vary in degrees from the posture that infants were placed in during sticky mittens training. Two measures (near transfer and sitting) took place with infants in a posture identical to the posture they were in during training. Infants were seated upright on a parent's lap with their arms resting on a tabletop, and parents held infants' midsections to provide adequate support for reaching. Two additional measures took place in postures that varied from the posture infants experienced during training. In the reclining posture, infants were placed in a bouncy seat. In the supine posture, infants rested flat on their backs on a mat. Thirdly, the position of the ball varied across the four postures. The near transfer posture is considered the most similar to training, thus meriting the name, because the Oball rests on the tabletop similar to how toys were presented to infants during sticky mittens training. In the other three postures, the Oball was suspended mid-air. Making manual contact with the Oball necessitated infants elevating their arms, whereas in the near transfer posture infants could merely slide their arms across the tabletop surface to make contact with the Oball. Lastly, the motoric challenges inherent in each of the postures varied from the training context. The effect of gravity on infants' arm movements varies depending on whether infants' arms are parallel or perpendicular to the earth when initiating a reach. Another factor to consider is that when the Oball is suspended, as in the sitting posture, infants have to elevate their arms to contact the Oball, whereas this is not the case for the near transfer posture. The muscles recruited to engage in these actions thus differ.

The pre- and post-training design of this study will allow us to look at changes in infants' exploration behaviors across the four postures to see whether they gain exploration skills evenly or differentially across the postures. Infants' baseline exploration behaviors at visit 1 will serve as a control to help us determine the influence of sticky mittens training based on how their behaviors change from the first to the second visit. I anticipated three potential patterns of changes in exploration behaviors from pre- to post-training. Though these three patterns of findings are not exhaustive or mutually exclusive, I thought it seemed likely that some variation of these three patterns of changes in object exploration behaviors would characterize our findings. The first pattern I thought plausible is infants would only increase their exploration behaviors from pre- to post-training in the upright, seated posture because this is the posture experience during sticky mittens training. This pattern would mean there is specificity between training postures and postures where infants are able to utilize reaching skills gained during sticky mittens training. A second potential pattern of findings is one of generalized increases across the pre- and post-measures of exploration. This finding would indicate that infants were able to transfer improvements in fine motor skills gleaned from sticky mittens training taking place in the upright posture to other postures. A third potential pattern of results is a lack of change in exploration behaviors from pre- to post-training. A possible explanation for a lack of improvement in exploration behaviors might be that the study materials used in pre- and post-training measures of exploration were different enough from the mittens training materials that it was challenging for infants to transfer their new skills to this context.

CHAPTER 6

Experiment 1 Method

Participants

Twenty-four 2.5- to 3.5-month-old infants (M_{ageV1} = 85.13 days; SD_{ageV1} = 9.50 days; M_{ageV2} = 99.54 days; SD_{ageV2} = 9.31 days; female = 12) participated in the current research study. Parents reported infants' races as white (n = 18), Asian (n = 1); black (n = 1), Asian and white (n = 2), and black and white (n = 2). Birth data were provided by the Tennessee Department of Health, Division of Policy, Planning and Assessment, Office of Health Statistics. Parents' email addresses were acquired via the Vanderbilt People Finder system, contact information located online, and Facebook messages inviting parents to participate with their infants. Data from an additional twelve infants were excluded from analyses for the following reasons: infants did not return for the second visit (n = 2); infants disliked the mittens and parents opted to discontinue training (n = 2); infants were born preterm or had a known neurodevelopmental disability (n = 2); infants were too fussy to complete the first visit (n = 2); three weeks elapsed between visits (n = 2); parental interference during a laboratory study session (n = 1); and lastly, insufficient mittens training (n = 1).

Materials

Pre- and post-training. The materials used in the pilot study were used in the current study with the following exceptions. Two video cameras were used to record each participant from two different angles (front and side views). Rather than 3 measures of exploration, infants completed 4 measures in the current study. To more closely approximate the situation infants encountered during mittens training, we included a near

transfer posture where the toy was presented resting on a tabletop within infants' reach. The order of the postures was partially counterbalanced, with the near transfer posture always the last measure. This design decision was made because of concern that infants would be unable to complete all of the postures, and I wanted to prioritize data collection in the postures included in the Pilot Study. As in the Pilot Study, infants also completed exploration measures in the supine, reclining, and sitting postures with the ball suspended within infants' reaches. One of four multi-colored Oballs (see Figure 14) was presented to each infant during pre- and post-training measures to shorten the duration of the study. In contrast, in the Pilot Study infants were presented with 3 toys in each of the three postures. The order of the presentation of the four colors of Oballs across the four postures was counterbalanced between participants. Each participant received the same order of postures and balls across the two visits. The balls were hung using a cord so that the distance between the ball and the baby could be adjusted more precisely.

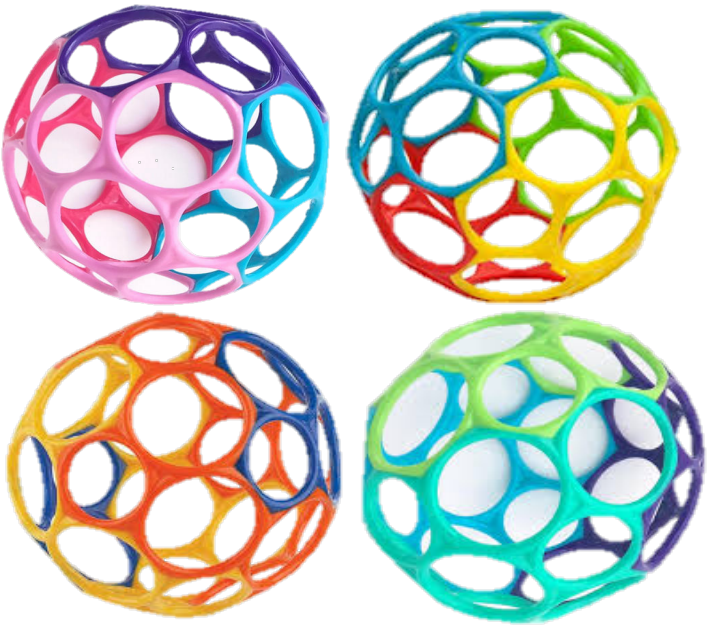

Figure 14. Oballs.

Training. Infants wore custom-made sticky mittens with the palms covered in velcro loop during the training procedure. They interacted with lightweight duplo blocks and bath toys covered in velcro hook. Infants sat on a parents' lap with their arms resting on a tabletop during training.

Figure 15. Stimuli used during mittens training

Procedure

Visit one. Visit one consisted of two parts: pre-training assessment of object exploration and a mittens training session led by the experimenter. During the pre-training assessment, infants were presented with one of four Oballs for 60 seconds each in four different contexts: supine, reclining in a bouncy seat, sitting upright with the ball suspended, and sitting upright with the ball resting on the tabletop. The distance between the infant's chest and the toy was measured and recorded as well as the length of the cord in each posture. Pilot data revealed that placing the Oball approximately 8 to 10 cm from the infant allowed three-month-old infants to occasionally make manual contact with the balls. Rochat, Goubet, & Senders (1999) presented objects to 6-month-old infants at the edge of their reaching range, and they estimated the distance between the toy and the infant to be approximately 30 cm. Since the infants in the current study were only three-months-old and not yet reaching, I found that placing the balls more than 10 cm away from infants made this paradigm too challenging. The average distance between the nearest edge of the Oball and the infant's chest was 8.63 cm (SD = .71 cm) across supine, reclining, sitting, and near transfer positions. The average distance from the bottom edge of the infant gym to the top of the carabiner clasp was 9.24 cm (*SD* = 3.28 cm) in the supine position, 9.58 cm (*SD* = 1.12 cm) in the reclining position, 19.16 cm (SD = 3.76 cm) in the sitting position, and 27.50 cm (*SD* = 3.54 cm) in the near transfer position.

After the pre-training assessment, infants participated in sticky mittens training until they became fussy or ten minutes elapsed. Training took place with infants seated on their parents' laps and their arms resting on a tabletop. The experimenter demonstrated how the toys stuck to the mittens during the first two trials so that infants could learn the

utility of the mittens. Toys were presented to infants one at a time for approximately one minute per toy. While the infant is participated in the mittens training, the experimenter explained to parents how to do this training at home with their infants.

Between visits. The second visit was scheduled for two weeks after the first. Infants were sent home from the first visit with a gallon-sized Ziploc bag containing a variety of velcro-hook covered toys, a pair of sticky mittens, instructions on how to do the training for parents, a training log to document the dates and duration of time that infants participated in training, and an observation sheet where parents could indicate if they noticed their infants making successful reaches in the postures of interest (supine, reclining, and sitting). The instructions specified that parents should complete a minimum of 10 sessions of mittens training, of 5 to 10 minutes duration each, during the course of the two weeks between visits to the laboratory. The experimenter contacted parnets via email one-week into the training period to ask if parents had any questions or concerns regarding the training procedure. Parents returned the toys, mittens, and forms to the laboratory at visit two.

Visit two. The second visit was identical to the first visit, with one major exception. Rather than the experimenter leading the sticky mittens training session, parents demonstrated how they led the sticky mittens training sessions with their infants at home.

Measures

Behavioral. As in the pilot study, the frequency and duration of touching in each posture were coded for each infant. Grasping was coded as a subset of touching, and it was defined as least one finger inserted into the ball and wrapped around it. Coders also

specified whether infants touched or grasped the ball with their left, right, or both hands. Occasionally infants used their heads, chests, bellies, arms, or legs to contact the balls, all of which was coded.

Parent report. As in the pilot study, parents completed the Postural Experience Questionnaire and the Early Motor Experience Questionnaire. Parents did not complete the Infant Behavior Questionnaire-Revised Very Short Form (Putnam et al., 2014).

Reliability

Inter-rater reliability for infants' touching onsets, touching offsets, and touching durations was tested using intra-class correlation coefficients (ICC). A two-way mixed effects model was used because two raters coded the entirety of the dataset. Analyses were based on a single rater's coding, and the ICC measured the absolute agreement to test how closely the two raters' codes aligned. These analyses revealed excellent reliability for touch onsets (ICC_{onset} = 1.00, 95% CI [1.00, 1.00]), touch offsets (ICC_{offset} = 1.00, 95% CI [1.00, 1.00]), and touch durations ($ICC_{duration}$ = .993, 95% CI [.992, .994]). The same analyses were used to evaluate coders' reliability for grasping behaviors. Reliability was extremely high for grasping onsets (ICC_{onset} = 1.00, 95% CI [1.00, 1.00]), grasping offsets (ICC_{offset} = 1.00, 95% CI [1.00, 1.00]), and grasping durations ($ICC_{duration}$ = 1.00, 95% CI [1.00, 1.00]).

CHAPTER 7

Experiment 1 Results

Behavioral

Touching. Two repeated measures multivariate analyses of variance (MANOVAs) were used to test for increases in the frequency and duration of touching behaviors from visit 1 to visit 2. Visit was entered as a repeated measure variable with 2 levels (Visit 1 and Visit 2). The four postures (supine, reclining, sitting, and near transfer) were entered as within-subject variables. Partial eta squared (η_p^2) is reported as a measure of effect size. Only marginally significant and significant findings are reported. All other results were nonsignificant.

Frequency. The MANOVA testing for increases in the frequency of infants' touching behaviors from visit 1 to visit 2 revealed a significant main effect of visit, $F(1,20) = 4.52$, $p = .009$, $\eta_p^2 = .48$. Across the four postures, infants touched the balls more frequently at visit 2 ($M_{V2} = 13.46$, $SD_{V2} = 17.06$) than at visit 1 ($M_{V1} = 30.25$, $SD_{V1} = 27.66$). The difference in the number of times infants touched the balls in the reclining posture from visit 1 ($M_{V1} = 3.04$, $SD_{V1} = 7.24$) to visit 2 ($M_{V2} = 7.63$, $SD_{V2} = 10.96$) was significant, $F(1,23) = 8.53$, $p = .008$, $\eta_p^2 = .27$. Infants touched the ball more frequently at the second visit compared to the first when they were in the reclining position. Additionally, infants touched the balls much more frequently at visit 2 ($M_{V2} = 10.75$, $SD_{V2} = 8.64$) compared to visit 1 ($M_{V1} = 4.50$, $SD_{V1} = 5.70$) when they were placed in the near transfer position, $F(1,23) = 15.22$, $p = .001$, $\eta_p^2 = .40$

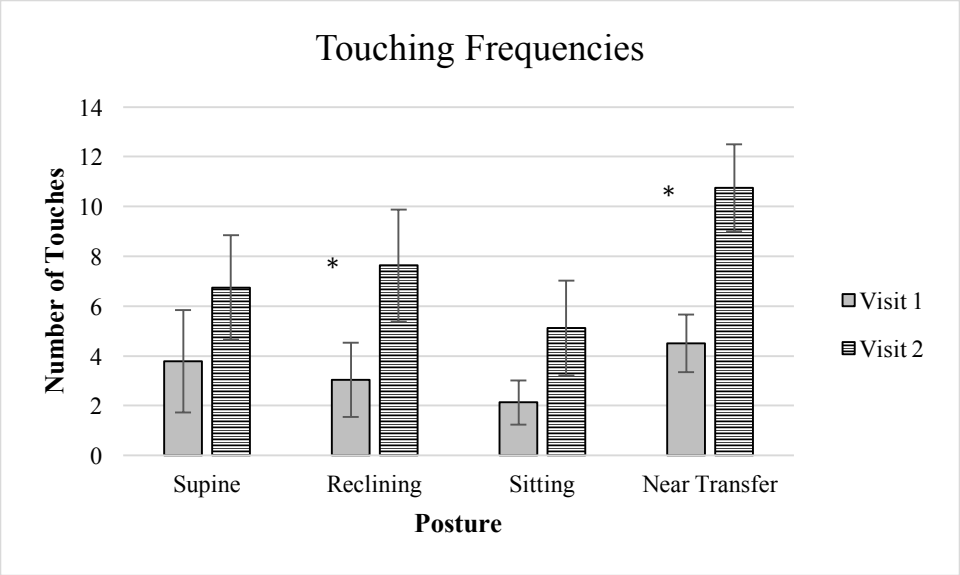

Figure 16. Touching frequencies.

***Duration*.** Across the four postures, infants touched the ball for significantly longer durations at visit 2 (M_{V2} = 49.49 s, SD_{V2} = 56.44 s) compared to visit 1(M_{V1} = 12.42 s, SD_{V1} = 22.77 s; $F(1,20) = 3.61$, $p = .023$, $\eta_p^2 = .42$). Infants touched the balls significantly longer durations when they were placed in the supine position at visit 2 (M_{V2} = 11.07 s, SD_{V2} = 20.87 s) compared to visit 1 (M_{V1} = 2.33 s, SD_{V1} = 6.31 s; $F(1,23) = 7.53$, $p = .012$, $\eta_p^2 = .25$). Infants also touched the balls for significantly longer durations when they were placed in the reclining position at visit 2 (M_{V2} = 10.55 s, SD_{V2} = 19.67 s) compared to visit 1 (M_{V1} = 3.36 s, SD_{V1} = 11.75 s; $F(1,23) = 6.99$, $p = .015$, $\eta_p^2 = .233$). Lastly, the increase in touching durations when infants were placed in the near transfer posture was significant from visit 1 (M_{V1} = 6.47 s, SD_{V1} = 9.21 s) to visit 2 (M_{V2} = 23.16 s, SD_{V2} = 20.76 s; $F(1,23) = 38.92$, $p < .001$, $\eta_p^2 = .63$).

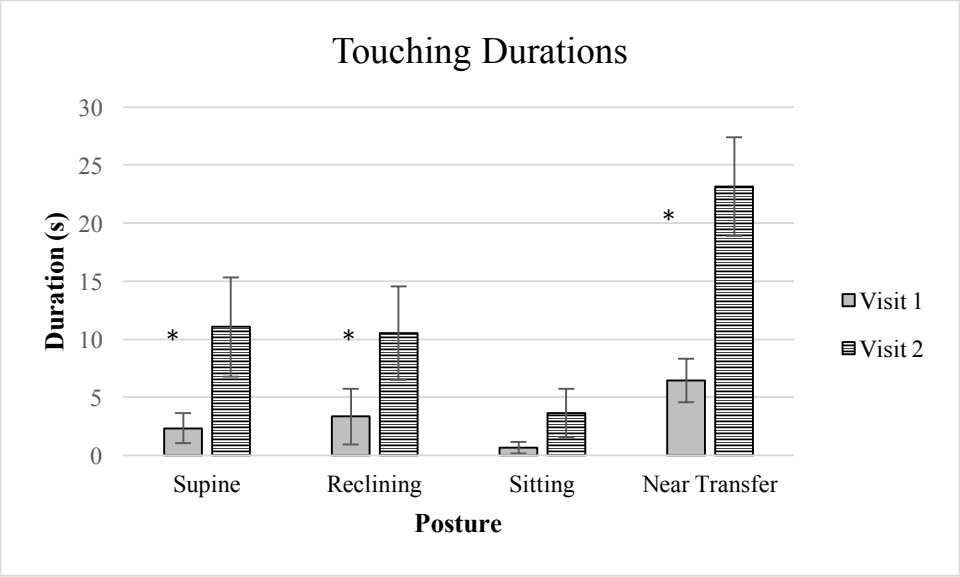

Figure 17. Touching durations.

Grasping. Not many infants grasped the balls during the first visit, but at the second visit many more infants engaged in grasping behaviors during the study (see Figure 18). Two repeated measures multivariate analyses of variance (MANOVAs) were used to test for increases in the frequency and duration of grasping behaviors from visit 1 to visit 2. Visit was entered as a repeated measure variable with 2 levels (Visit 1 and Visit 2). The four postures (supine, reclining, sitting, and near transfer) were entered as within-subject variables. Partial eta squared (η_p^2) is reported as a measure of effect size.

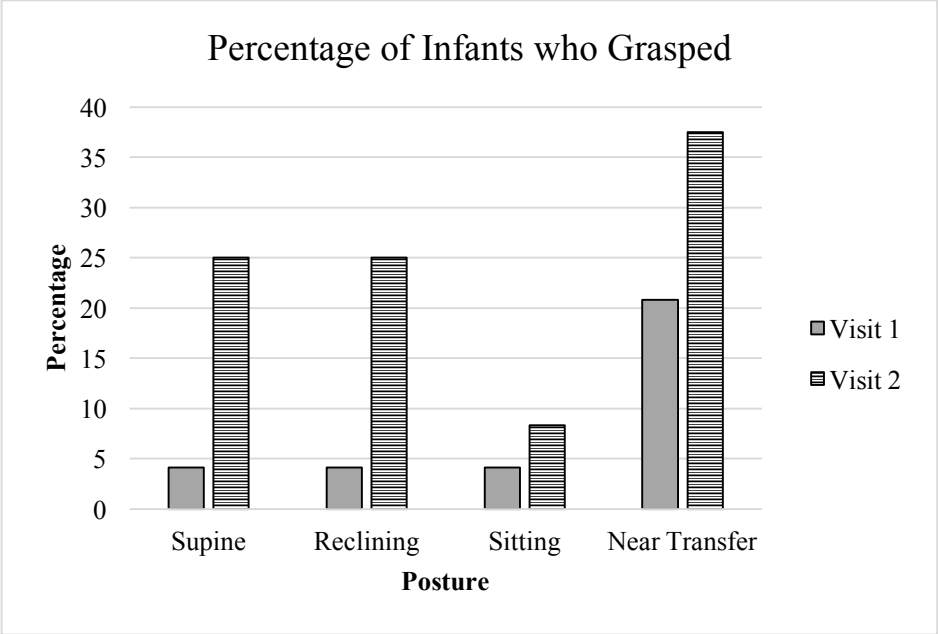

Figure 18. Infants who grasped.

Frequency. There was significant difference in the number of times infants grasped the balls in the supine posture from visit 1(M_{V1} = .04, SD_{V1} = .20) to visit 2 (M_{V2} = 2.46, SD_{V2} = 5.46; $F(1,23) = 4.66$, $p = .042$, $\eta_p^2 = .168$). The difference in the number of times infants grasped the balls in the reclining posture from visit 1 (M_{V1} = .13, SD_{V1} =.61) to visit 2 (M_{V2} = 1.54, SD_{V2} = 3.51) was marginally significant, $F(1, 23) = 4.08$, $p = .055$, $\eta_p^2 = .151$. Lastly, the difference in grasping frequencies from visit 1 (M_{V1} = .04, SD_{V1} = .33) to visit 2 (M_{V2} = 1.75, SD_{V2} = 3.66) was marginally significant when infants were placed in the near transfer position, $F(1, 23) = 3.62$, $p = .07$, $\eta_p^2 = .136$.

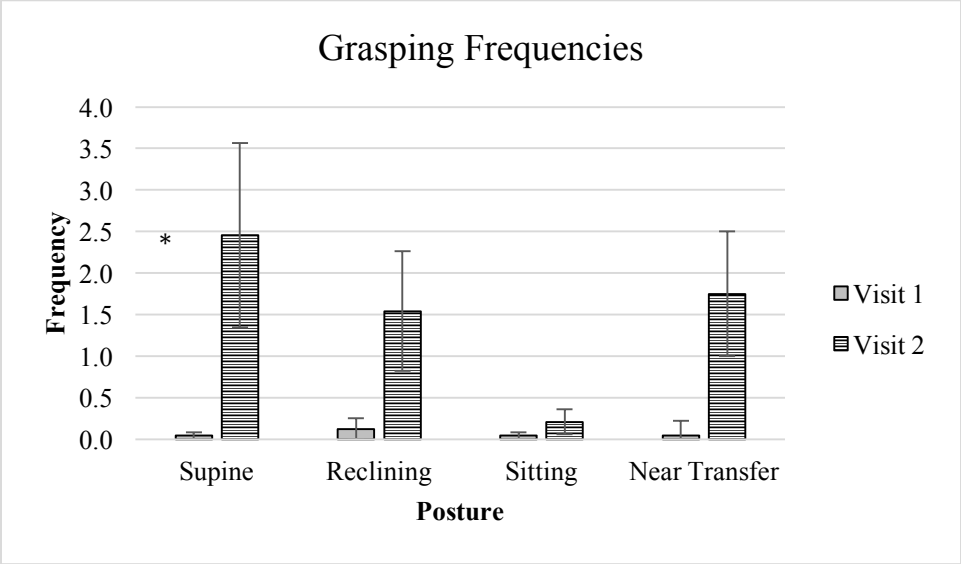

Figure 19. Grasping frequencies.

Duration. The difference in grasping durations from visit 1 (M_{V1} =.1.22 s, SD_{V1} = 6.26 s) to visit 2 (M_{V2} = 7.78 s, SD_{V2} = 16.48 s) across the four postures reached marginal significance, $F(4,20) = 2.25$, $p = .100$, $\eta_p^2 = .310$. When placed in the supine position, infants grasped the ball for significantly longer durations at the second visit (M_{V2} = 9.22 s, SD_{V2} = 18.78 s) compared to the first visit (M_{V1} =.61 s, SD_{V1} = 2.97 s; $F(1, 23) = 4.77$, $p = .039$, $\eta_p^2 = .172$). Infants also grasped the ball for significantly longer durations at visit 2 (M_{V2} = 11.56 s, SD_{V2} = 18.62 s) compared to visit 1 (M_{V1} = 2.04 s, SD_{V1} = 5.83 s) when they were in the near transfer position, $F(1, 23) = 6.95$, $p = .015$, $\eta_p^2 = .232$.

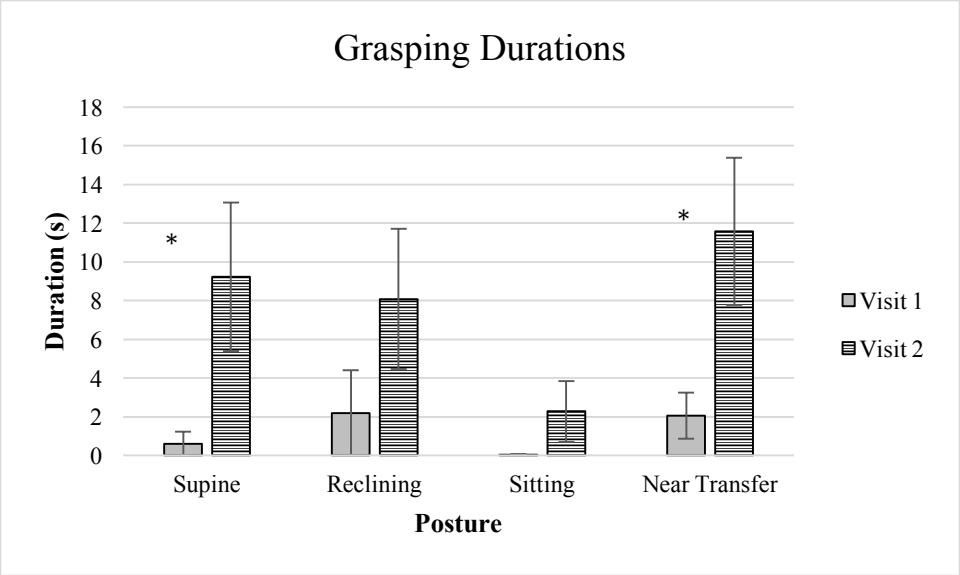

Figure 20. Grasping durations.

Parent Report

Training log. Parents reported that infants completed an average of 11.17 training sessions (*SD* = 4.22 training sessions) at home over the two week interim between visits. The average duration of training sessions was 8.26 minutes (*SD* = 1.71 minutes).

Observation form. On average, parents reported observing their infants make successful reaches, reaches that ended with contacting an object or toy, most frequently in the supine posture (*M* = 4.35, *SD* = 4.31), followed by the reclining posture (*M* = 3.7, *SD* = 3.23), and they noticed the least successful reaches in the sitting posture (*M* = 2.45, *SD* = 2.63; see Figure 18). This form clearly specified that parents should record their observations of successful reaches outside of the mittens training sessions.

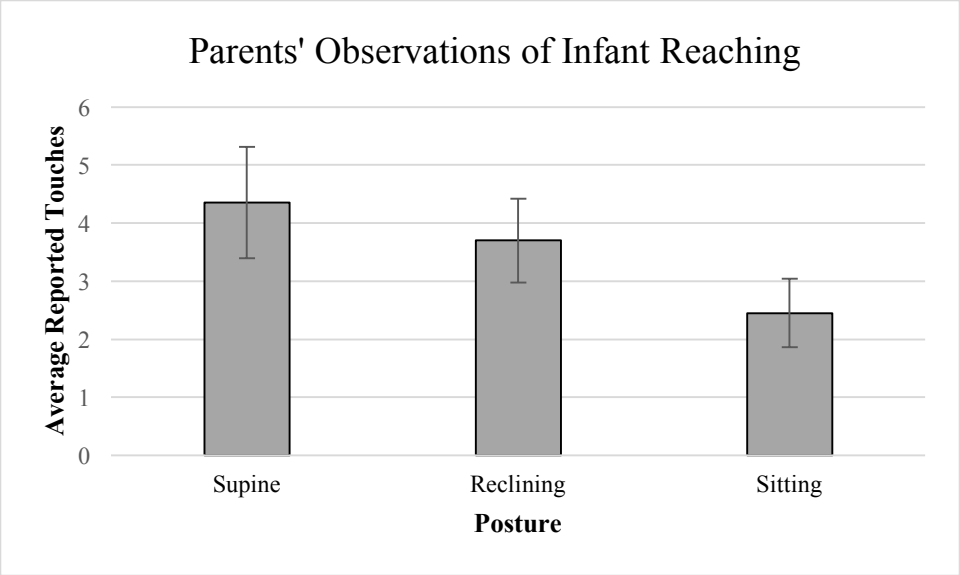

Figure 21. Parents' reports of infants' successful reaches.

Early Motor Questionnaire. Three t-tests were performed on the difference scores (Visit 2 minus Visit 1) of parents' ratings of their infants' gross motor, fine motor, and perceptual-action skills. Cohen's d (*d*) is reported as a measure of effect size. Parents rated their infants gross motor skills significantly higher at visit 2 (M_{V2} = -62.33, SD_{V2} = 5.23) compared to visit 1(M_{V1} = -64.38, SD_{V1} = 5.29; M_{diff} = 2.04, SD_{diff} = 4.59; $t(23)$ = 2.25, p = .034, *95% CI* [.16, 3.92], d = .94). Parents also rated their infants' fine motor skills significantly higher at visit 2 (M_{V2} = -57.92, SD_{V2} = 17.08) compared to visit 1(M_{V1} = -66.54, SD_{V1} = 9.69; M_{diff} = *8.63,* SD_{diff} = 4.59; $t(23)$ = 8.96, p < .001, *95% CI* [6.63, 10.62], d = 3.74). Lastly, parents rated infants' perceptual-action skills higher at visit 2 (M_{V2} = -21.74, SD_{V2} = 13.26) than visit 1(M_{V1} = -25.42, SD_{V1} = 4.76; M_{diff} = *3.96,* SD_{diff} = 3.76; , $t(22)$ = 5.13, p <.001, *95% CI* [2.36, 5.56][1], d = 2.19). For the purposes of the graph (see Figure 22), raw EMQ scores were adjusted by adding 75 to gross and fine

[1] Please note that the degrees of freedom in this t-test is 22 rather than 23 because of one missing data point. A page was missing from the early motor questionnaire that one participant's parent completed.

scores, and by adding 35 to perception-action scores. The raw scores were used in analyses. These adjustments of the raw scores for display purposes are standard (Libertus & Landa, 2014) because the raw scores are negative values, which makes the graph unnecessarily difficult to interpret. Also, the magnitude of the perception-action domain is not easily comparable to the gross and fine motor domains without these adjustments.

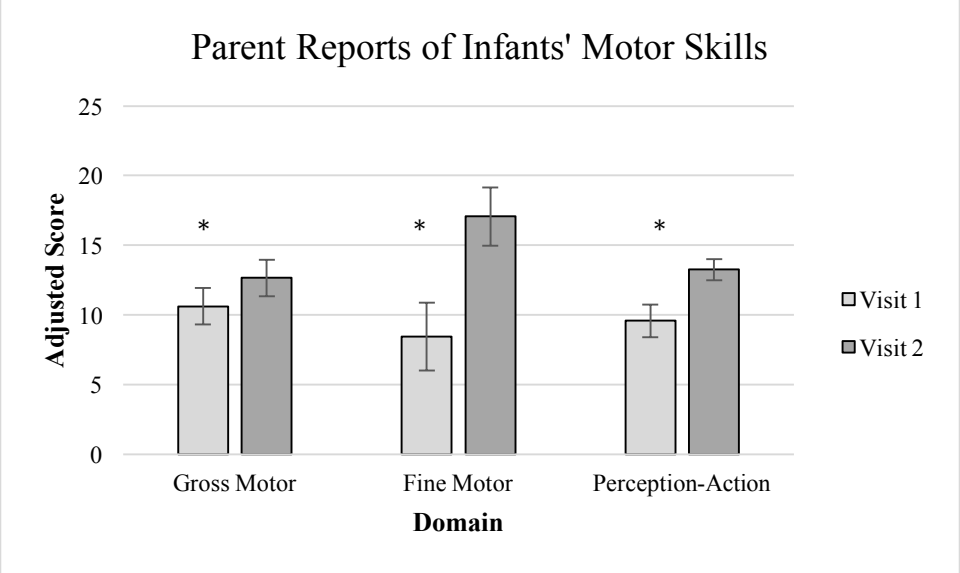

Figure 22. EMQ scores.

Postural experience questionnaire. Parents reported number of bouts in the past week as well as average duration spent in the position per bout. Difference scores were calculated (Visit 2 minus Visit 1), and three t tests were performed to test for changes in reported durations in the three postures of interest—supine, reclining, and sitting at a table. Cohen's d is reported as a measure of effect size.

From the first (M_{V1} = 118.00, SD_{V1} = 96.84) to the second visit (M_{V2} = 119.87, SD_{V2} = 75.58), parents reported nonsignificant differences (M_{diff} = 9.11, SD_{diff} = 58.50) in their estimates of the amount of time infants spent supine on their backs, $t(23) = .75$, p = .463, 95% CI [-16.19, 34.41], $d = .31$. Likewise, the reported change in durations infants

spent reclining in a bouncy seat was nonsignificant from visit one (M_{V1} = 85.25, SD_{V1} = 117.53) to visit two (M_{V2} = 146.83, SD_{V2} = 102.03; 34.21, SD_{diff} = 199.51; $t(21) = .79$, p = .441, 95% CI [-56.60, 125.03], d =.34. On the other hand, parents reported that their infants spent significantly longer durations of sitting at a table at visit 2 (M_{V2} = 54.73, SD_{V2} = 27.50) compared to visit 1 (M_{V1} = 5.03, SD_{V1} = 11.64; M_{diff} = 50.86, SD_{diff} = 30.65; $t(22) = 7.78$, p <.001, 95% CI [37.27, 64.45], d =3.32. Unfortunately, it is unclear whether parents were including mittens training time in their estimations of how much time their infants were seated at a tabletop with their arms resting on it.

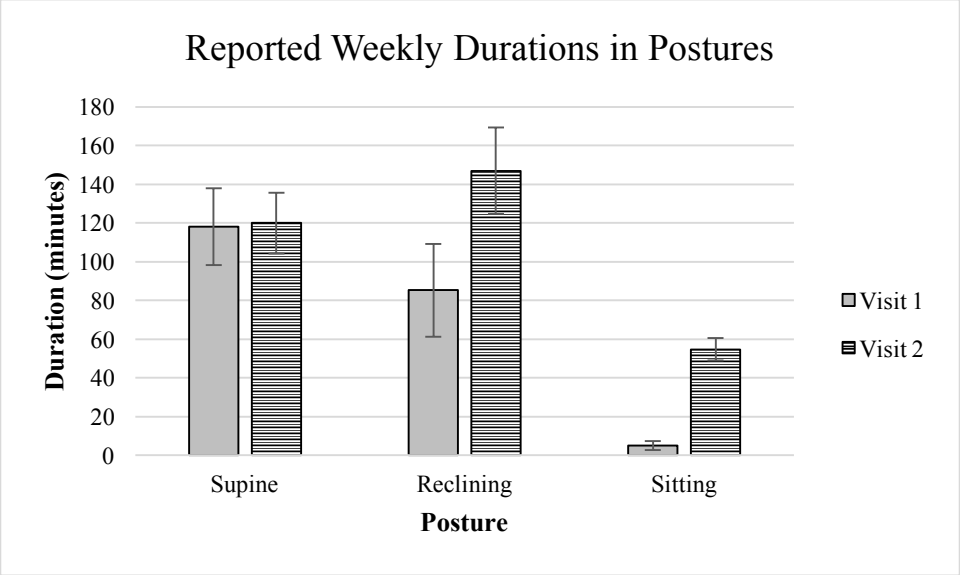

Figure 23. Parent reports of infants' experiences during the past week.

CHAPTER 8

Experiment 1 Discussion

I had anticipated three potential patterns of findings—specificity between training posture and increases in exploration, generalized increases in exploration across all postures, or a lack of change in pre and post measures. Our findings do not perfectly align with any of these expected patterns. Infants' patterns of exploration behaviors from visit one to visit two were not uniform across the four postures. There were some postures where infants showed significant increases in exploration, and other postures where changes in exploration were minimal. I interpret our findings to show some evidence of specificity between sticky mittens training posture as well as some evidence supporting the idea that infants are able to utilize new exploration skills in the supine and reclining postures.

Infants touched the Oballs more frequently and for longer durations from pre- to post-training in the near transfer posture, and they also spent more time grasping the Oballs in the near transfer posture at the second visit. Although I anticipated that infants would also show increases in exploration in the sitting posture, with the Oball suspended just a few centimeters above the surface of the table, this was not the case. Infants' exploration behaviors did not differ from the first to the second visit for the sitting position. Suspending the ball in the air versus resting the ball on the tabletop appears to be the main difference between these two postures. There is evidence in infant research that seemingly unimportant features of the test context, such as the presence of patterned crib bumpers, can serve as important retrieval cues for three-month-olds (Rovee-Collier,

Griesler, & Earley, 1985). Thus, the visual difference in study contexts between the sitting and near transfer positions may explain the discrepancy in increases in exploration behaviors between these two postures.

Another important consideration is the muscles involved in reaching for the Oball differ between the sitting and near transfer postures. During mittens training, infants did not have to elevate their arms from the tabletop to obtain the toy because they could slide their mittened hand across the surface of the table to make contact with the toy. Our findings indicate that infants found it challenging to transfer their skills to the sitting posture when the ball was suspended just a few centimeters from the table surface. A different type of training experience might better target the motor skills necessary to successfully contact toys presented above a tabletop surface.

Although I did find evidence that infants may have transferred their new skills to the reclining and supine postures, the effect sizes for increases in these postures were much smaller than the effect size for the near transfer posture. Thus, it seems that infants may have struggled to transfer their new skills, but they were able to do so at least to some extent. It is plausible that providing more varied and diverse sticky mittens training experiences may help infants to more easily generalize increases in exploration to other contexts. For example, three-month-old infants who were trained to kick their legs to produce movement in multiple mobiles with different appearances were more likely to generalize their learned behavior to a novel context than infants who were presented with only one mobile during the training phase (Greco, Hayne, & Rovee-Collier, 1990). Likewise, viewing multiple exemplars with distinct visual features facilitated object segregation among 4.5-month-old infants (Needham, Dueker, & Lockhead, 2005).

During sticky mittens training in the current study, infants were presented many different toys with unique visual features, and our results indicate that infants were able to generalize new skills gained from training to the Oball that was presented during pre- and post-measures of object exploration. Intentionally providing more variability within the training context might help infants to better generalize their exploration skills to new contexts. For example, if training were to take place in various postures rather than only in the upright, seated position, infants would gain diverse motor and visual experiences while practicing their object exploration skills. This might lessen the challenge associated with generalizing their new skills from sticky mittens training to everyday contexts.

Limitations

Our interpretations of our findings are limited because of the lack of a control group of infants either without mittens training experience or with a different type of training experience for comparison purposes. It is possible that over the course of the two weeks between visits, infants could be rapidly developing new touching and grasping skills. Comparing our current dataset to a control group of infants would allow us to disentangle the effects of mittens training from gains due to the natural course of development of exploration skills.

Another potential explanation for the increases in exploration behaviors seen after infants completed sticky mittens training might be that the experience of moving their arms to obtain the toys during training led to increases in infants' arm strength. Experience moving their arms under the weight of the mittens and toys during training cause infants' arms to become stronger, better enabling them to interact with the Oball during post-training measures compared to pre-training. Active training has been shown

to help infants maintain early stepping and placing behaviors during a period when these behaviors typically dissipate (Zelazo, Zelazo, & Kolb, 1972). Likewise, sticky mittens training could be seen as a form of exercise that encourages infants to exhibit increased reaching behaviors compared to their peers without experience. If this were the case, we might expect to see increases in exploration behaviors across the four postures. Thus, we think this interpretation is unlikely to fully explain our findings. Nonetheless, future research might manipulate the weight of the objects that infants interact with during training to better understand this aspect of sticky mittens training.

Implications

This study investigated the question of whether sticky mittens training might be beneficial to young infants in the naturalistic postures that infants tend to encounter on a daily basis. This is a worthwhile question because the results indicate the types of early experiences that facilitate early object exploration and support learning opportunities for infants. These findings may be meaningful in helping infants who are at risk for early motor delays to provide interventions that will help them to explore adaptively. For example, our results indicate that infants are able to transfer new exploration skills to supine and reclining positions. Based on these findings, providing early object exploration experiences in supported sitting postures might be especially helpful for infants whose sitting abilities are delayed. Skills learned in supported sitting postures could help these infants to better explore in their daily lives when they are in a wide variety of other postures.

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