THE DEVELOPMENT OF INFANT SELF-TOUCH IN THE FIRST HALF-YEAR AFTER BIRTH

AN ABSTRACT

SUBMITTED ON THE SIXTH DAY OF MAY, 2019

TO THE DEPARTMENT OF PSYCHOLOGY

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OF THE SCHOOL OF SCIENCE AND ENGINEERING OF

TULANE UNIVERSITY

FOR THE DEGREE OF

MASTERS OF SCIENCE

BY

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## Abstract

This study focuses on the development of infant self-touch in the first half-year after birth. Although it has not been studied extensively, self-touch allows infants to explore their bodies and may be influential in the development of body knowledge. Many aspects of body knowledge have been studied extensively. We know that infants have the ability to distinguish between intact and scrambled bodies as early as 3.5 months of age indicating an early understanding of body organization (Bhatt, Hock, White, Jubran, & Galati, 2016). Additionally, infant self-touch may be an important precursor in infant reaching to the body. Research on reaching suggests that infant grasping is a reflex that appears shortly after birth, whereas reaching to objects develops around five months of age (Corbetta & Snapp-Childs, 2009; Bhatt, Hock, White, Jubran, & Galati, 2016; Van Hof, van der Kamp, & Savelsbergh, 2002; Von Hofsten & Spelke, 1985). Understanding the development of self-touch may help explain how infants bridge the gap from grasping to reaching and how they are able to use this information to inform body knowledge. The results suggest that self-touch is frequent during the first half-year of life with the average duration of touches increasing with age. Additionally, self-touch also follows a similar progression to reaching in that most touches early in life are ipsilateral, followed by midline and contralateral.

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# TABLE OF CONTENTS

## List of Figures

## Introduction

The sensation of touch is a critical part of both daily life and development. Touch is one of the first senses to develop around seven to eight weeks gestation (Hooker, 1952; Humphrey & Hooker, 1959; Piontelli et al. 1997). Touch is critical for the physical exploration of our world. Additionally, touch is important in the early development of relationships allowing for an increase in successful attachment relationships and a decrease in infant stress (Barnard & Brazleton, 1990; Stack & Muir, 1992). Touch is also important in brain development, increasing the strength and number of synapses throughout the brain (Siegel, 1999). Despite the importance of touch, little is known about its development, specifically touch directed towards ones own body. Even before birth, infants learn about themselves by exploring their bodies through self-touch (Piontelli et al. 1997). Self-touch can be understood as infants' spontaneous or deliberate touches to their bodies. Self-touch may aid in the development of other types of body knowledge, such as body organization and the ability to deliberately reach to specific locations on the body.

Before birth, human fetuses have the ability to sense tactile and proprioceptive information. Piontelli and colleagues studied intrapair stimulation in monozygotic and dizygotic twins longitudinally over three time periods (eight to ten weeks, 11-13 weeks, and 15-22 weeks gestation) using ultrasound observation (Piontelli et al. 1997). Intrapair stimulation is defined in this study as the touch from one twin to the other, followed by a behavioral reaction in the stimulated twin (Piontelli et al. 1997). Behavioral reactions were recorded as a stretch, head rotation, startle response, or general movement. (Piontelli et al. 1997). They found that before 11 weeks, intrapair stimulation, although present, was rare, between 11-13 weeks intrapair stimulation was frequent in monozygotic twins, and between 12-13 weeks intrapair stimulation became prominent in dizygotic twins (Piontelli et al. 1997).

Although research on direct touch to a fetus is only possible in studies on twins, Kisilevsky, Muir, and Low (1992) observed the effects of vibroacustic stimulation to infants inutero from 23-36 weeks gestation. Through the use of ultrasound and fetal heart rate monitoring, Kisilevsky, et al. (1992) observed infant movement and heart rate while administering pulse like vibrations to the mother's abdomen over the location of a fetus' head. They found that human fetal response is present beginning around 26 weeks, increasing over-time and reaching full maturity around 32 weeks gestation (Kisilevsky, et al. 1992). These findings support the idea that touch is a constant stimulus present in the environment even before birth.

**Self-Touch and Emotion Regulation**

Shortly after birth, the continued importance of touch is evident in the development of infant emotional regulation. This idea has been studied using the Still- Faced (SF) Paradigm. Most research on infant SF paradigms investigates changes in infant affect as a result of the mother's still face (Ellsworth, Muir, & Hains, 1993; Stack, & Muir, 1990; Lamb, Morrison, & Malkin, 1987). The still-face procedure is usually described as a mother playfully interacting with her baby, the mother posing a "still-face" or maintaining a neutral expression during play, and then returning to normal play (Ellsworth, Muir, & Hains, 1993). Stack and Murir (1990) conducted a study in which they conducted the SF procedure with infants at three, six, and nine months of age divided into groups in which the mothers were or were not permitted to touch the infant throughout the procedure. They found that adult touch reduced the negative effect of a mother's still face by promoting attention directed towards the infant which increased infant positive affect. This was demonstrated in infants by increased smiling and less grimacing (Stack & Murir, 1990).

Additionally, although most research on the SF paradigm investigates affect-related changes, a few studies report deviations in infant tactile behaviors during the task (Toda & Fogel, 1993; Murray & Trevarthen, 1985; Trevarthen, 1986). Toda and Fogel (1993) observed infants during a SF paradigm at ages three and six months. They found that infants demonstrated an increase in grasping, touching the chair, and touching their clothes during the still-faced portion, but not during normal interaction (Toda & Fogel., 1993). These behaviors demonstrate clear tactile responses to emotional deprivation from a caregiver. These findings suggest that infants are attempting to self-regulate when mothers are emotionally unavailable. Both studies by Stack and Murir (1990) and Toda and Fogel (1993) indicate that infants have increased positive emotion in response to tactile stimulation and increased exploratory tactile response to maternal emotional deprivation.

**Self-Touch and Reaching**

Infant self-touch may also be important in the development of infant body knowledge. Rochat (2001) suggests that infants are able to develop early self-identities and differentiate the self from others through the exploration of touch. Additionally, Thomas, Karl, and Whishaw (2015) conducted a study on how spontaneous self-touch is an important precursor to the development of reaching and grasping. Infants were recorded from birth to 24 weeks of age lying on their back or sitting in an infant seat for approximately ten minutes of spontaneous activity (Thomas et al., 2015). They found that before 12 weeks, infants displayed mostly rostral/head touches, or touches within immediate proximity to the hands.

At 12 weeks, infants increased caudal touches to the hips and upper thighs, followed by touches to the knees and feet around 20 weeks (Thomas et al., 2015).

Thomas et al. (2015) found that, in the first six months of life, infant movement is characterized by frequent spontaneous self-touch that progressively develops into grasping and reaching. They proposed that this may indicate that self-touch represents a practice or precursor to reaching, allowing for the accumulation of increased body awareness related to reaching movements (Thomas et al., 2015). Moreover, when analyzing self-touch more specifically, Thomas et al. (2015) found that infants contacted the body in different ways. Contact using digit tips and palms may indicate early reaching motions whereas contact using manipulatory movements may indicate early grasping motions. The present study aims to investigate if a similar pattern of self-touch can be demonstrated in the first six months after birth.

The ability to reach across the body is another aspect of behavior that is relevant for understanding the development of self-touch. Contralateral reaching, or an infants' ability to move their arm across the midline of the body to targets in the external environment, develops in a predictable sequence with ipsilateral reaching occurring first between three and six months, followed by midline reaching, and ending with contralateral reaching between five and seven months (Van Hof, van der Kamp, & Savelsbergh, 2002). Ipsilateral reaching is characterized by the right hand reaching to the right side of the body whereas midline reaching occurs when the right or left hand reaches to the center, or midline of the body. Additionally, Van Hof and colleagues (2002) found that midline reaching to targets in the external environment develops within the context of bimanual, or two hand, reaching. Although the developmental sequence for contralateral reaching to external targets is clear, whether a similar pattern characterizes touches directed towards the body is not known. The present study aims to investigate if a similar pattern of contralateral self-touch is present in infants age one to six months.

**Self-Touch and Body Organization**

Although self-touch has not received much empirical attention, researchers have studied infants' visual knowledge about the arrangement of the body (Heron & Slaughter, 2010; Fox & McDaniel, 1982; Heron-Delaney, Wirth, & Pascalis, 2011). Although the research on awareness of body organization is extensive, there is much debate as to when body knowledge first develops. Heron and Slaughter (2010) noted that infant awareness of body arrangement develops around nine months by examining visual preference for intact and scrambled human bodies, mannequins, and dolls. On the other hand, Fox and McDaniel (1982) demonstrated this ability at four months by examining preference for biological motion in point light displays of upright and inverted human bodies. Finally, Bhatt and colleagues (2016) noted these age achievement discrepancies and tested 3.5-month-old infants' awareness of intact and scrambled female bodies in photographs. Their results concluded that 3.5-month-old infants could visually distinguish between intact and scrambled bodies (Bhatt, Hock, White, Jubran, & Galati, 2016). As a result, it is clear that before the second year of life, infants have a grasp on the arrangement of the human body. The present research aims to understand when infants gain a more functional, active understanding of their own body by examining the sequence by which infants begin to explore their bodies though self-touch.

**Self-Touch and Motor Development**

Motor development also plays an important role in infant self-touch. With age and experience, movements become more complex and more efficient. Infants learn to sit up, crawl, and stand within the first year of life. A study by Heineman and colleagues (2010) reports that motor development progresses throughout childhood, with more complex skills developing as children age (Heineman, Middelburg, & Hadders-Algra, 2010). Moreover, research has also indicated that aiming trajectory in banging motions become more efficient and precise with age (Kahrs, Jung, & Lockman, 2013). Kahrs et al. (2013) found that at around one year of age, infants' banging motions are more consistent and have a more direct aiming trajectory than do those of younger infants. The present study aims to understand if self-touch becomes more deliberate with age. This can be understood by evaluating if infants at our lower age range (one to three months) execute more touches with shorter durations, whereas infants at our higher age range (three to six months) execute fewer touches with longer durations. This may indicate that infants are deliberately spending more time exploring one location as opposed to spontaneously touching multiple locations with little time spent at each.

The sensation of touch is very complex. It involves not only a sensory, but also a perceptual event that the infant must interpret. This is an intermodal event often referred to as double touch in which one surface of the body touches another surface and the infant senses and perceives both events (Rochat & Hespos, 1997). Additionally, infants early in life respond to this self-proprioceptive information differently than other sensory stimuli. Rochat and Hespos (1997) found that newborn infants, aged less than 15 hours, demonstrated an increased head turn response following an external touch as opposed to self-stimulation. Additionally, Blakemore, Frith, and Wolpert (1999) found a similar phenomenon in a study with adult subjects in which participants consistently rated self-stimulation as less "tickly" than when it was produced externally.

One recent study has looked specifically at the development of spontaneous self-touch in the first two months after birth. DiMercurio, Connell, Clark, & Corbetta (2018) conducted a study looking at spontaneous self- touch when infants were lying flat on the ground. They found that infants touch themselves frequently during the first two months after birth at a rate of 13 touches per minute for touches to the body and seven touches per minute for floor touches. They also found that infants touch the body more frequently than the floor, but touch duration for floor touches is longer than the duration of touches to the body (DiMercurio, et al. 2018). This may indicate that infants are more interested in exploring the body than the external environment. The present study hopes to add to these findings by observing self-touch up to six months of age.

Although much research on infant development focuses on infant body knowledge, motor development, and reaching to external space, few studies look at the process of self-touch, which may be a critical element in the development of each previously-mentioned skill. We hope to better understand how infant self-touch patterns develop throughout the first half-year after birth.

## Current Hypotheses

**Hypothesis 1:** Infants will engage in self-touch multiple times per minute between one and six months after birth.

**Hypothesis 2:** Infants will touch the face most frequently between one and three months, but will progressively develop from rostral to caudal touches as infants approach six months of age. As infants develop increased motor skills and muscle mass they will be better able to reach locations (e.g. feet) farther from the immediate proximity of their hands.

**Hypothesis 3:** Infant self-touch directed towards the face will be especially frequent with touches becoming more localized to the mouth as infants approach six months of age.

**Hypothesis 4:** Infants will make fewer touches with the feet at the youngest age ranges of around one to three months and more touches with the feet as age increases to six months.

**Hypothesis 5:** Infant self-touch will progress from predominantly ipsilateral touches at the youngest age ranges of around one to three months, to midline touches, followed by contralateral touches as age increases to six months.

# Method

## Subjects

A total of 19 infants (10 male, 9 female, age = 1.8- 4.8 months at visit one, mean age = 3.0, SD = 1.0 month) participated in this study. Infants participated longitudinally anywhere from one to four times over the first six months after birth (mean number of visits = 2.9, SD = 1.37 visits; Figure 1). Number of visits varied depending on schedule of parents, infant illness, and so forth. Participants were infants recruited from daycare centers in the greater New Orleans area, flyers or contact sheets at child-oriented events, and the Psychology Department of Tulane University. The sample consisted of mostly Caucasian participants (13 Caucasian, 2 mixed race, 3 Asian, and 1 African American). All children were tested in a laboratory setting. The data analyzed in the current study were previously collected as part of a larger project looking at infant hand to mouth movement. The analyses provided here represent a unique contribution to the larger project.

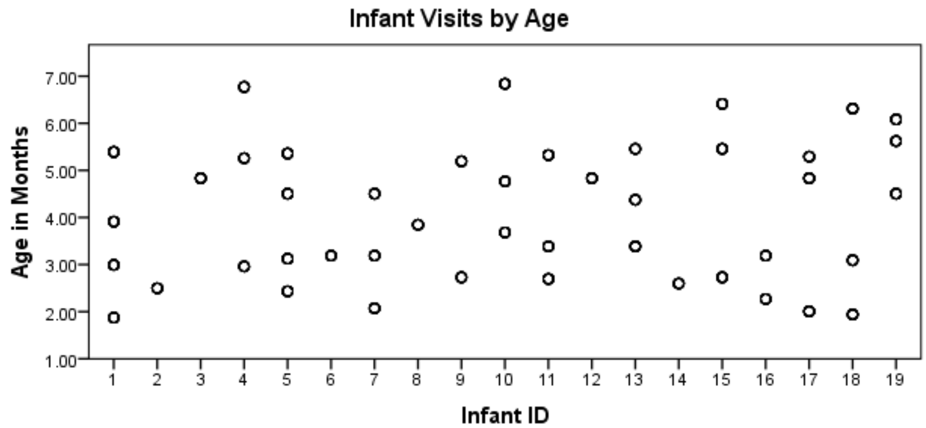



*Figure 1*. Frequency of infant visits by age in months. The x-axis indicates infant ID and the y-axis indicates age in months.

**Procedure and Design**

Before participating, written consent was obtained from a parent of each participant. This study utilized video data of infants collected as part of a previous longitudinal study on infant hand-to-mouth coordination during the first half-year. During each session, infants were seated in an infant seat at a 45-degree angle and observed in a non-crying, awake state for one to seven minutes, while their hands were free. As part of the previous study, infants were asked to hold a pacifier while wearing reflective markers on their arms. Reflective markers are present during segments of video analyzed for the present study. Pacifier placement was randomized between right and left hand. Timing varied based on how long each infant held the pacifier and was exhibiting fussy behavior. During video time used for the present study, infants were in a resting, awake state, while not participating in the previously mentioned study. Infants were observed without a shirt on and with their legs free. In reviewing the data for the current study, videos were used only when the infant was not holding the pacifier. Session length varied due to infant state, whether the hand held an object, and whether the parent was touching the infant (mean visit length = 4.32, SD = .89 minutes. Families were invited to participate once a month, although this was often not possible due to parents' schedules or illness.

**Data Coding**

Videos were coded using Datavyu software (Datavyu Team, 2014) to determine where and for how long infants touched themselves while reclining in an infant seat. Each video was coded for self-touches, chair touches, and location of each touch. Feet touch locations were coded for feet touching each other, foot touching opposite leg, foot touching hand or arm, and foot not touching anything. Hand touch locations were coded for face, mouth, foot, other hand, and torso touches, and hand not touching anything. Additionally, laterality of touches (ipsilateral, contralateral, midline) and duration of each touch were coded.

**Inter-Rater Reliability**

Inter-rater reliability (IRR) was computed on 20% of participants using intraclass correlations (ICC) for the proportion of time spent touching each location. An initial coder coded 100% of the data and a second coder coded an overlapping 20%. For the feet locations (no touch, feet touching each other, the hand or arm, or the opposite leg), high reliability was obtained for all variables (ICC = .91, $p < .001$). We also obtained high reliability for the left hand locations (Air, object, resting, face, mouth, arm, foot, leg, multiple body locations, other hand, and torso) (ICC = .79, $p < .001$). Similarly, high reliability was obtained for all variables analyzed for the right hand locations (Air, object, resting, face, mouth, arm, foot, leg, multiple body locations, other hand, and torso) (ICC = .83, $p < .001$).

**Data Analysis**

All analyses were conducted using generalized estimating equations (GEE) in SPSS. We used a tweedie distribution and log link function to accommodate our positively-skewed distribution and non-negative data (Kurz, 2017). GEE can also handle data clustered within subjects, irregularly spaced visits, missing repeated- measures data, and categorical and continuous independent and dependent variables. Across all analyses, video time in which the infant was holding the pacifier was excluded. In analyses looking at laterality, ipsilateral refers to a touch with the hand to the same side of the body as the touching hand, regardless of left versus right. Contralateral refers to a touch to the opposite side of the body regardless of left versus right. For all analyses that looked at effects on amount of time touching, total video time coded was included as a covariate to account for variability in video length for each infant, but not included as an independent variable. Finally, age is calculated and analyzed in months so as to be consistent with previous self-touch and reaching research.

## Results

We first look at overall self-touch frequency. The second section examines total time and average duration of hand self-touch behaviors. Here, we analyze the overall amount of time spent engaging in self-touch with the hands and whether this varied with age, as well as the average duration of touches that occurred and whether this changed with increasing age. The next analysis looks at the sex effect on total time touching versus not touching with the hands. The next section examines self-touch at individual body locations including total amount of time and duration for all hand self-touch locations (mouth, face, leg, torso, other hand) across age. Additionally, we analyze the total time and duration of feet behavior for touches versus no touches and for all feet touch locations. Finally, we look at the amount of time infants spend engaging in ipsilateral, contralateral, and midline hand and foot touches.

We also examined the developmental changes in infant self-touch during the first six months after birth. The results indicated frequent self-touch. Infants made an average of 86.08 hand touches per visit for an average visit length of 4.32 minutes. The average number of touches with the hands per minute was 19.92.

**Hand Self Touch vs. No Self-Touch**

**Time spent touching.** First, we examined how much time infants spent engaging in self-touch with the hands and the duration of these self-touches. To do so, we compared total time spent touching the body to time spent not touching the body (waving their hand in the air, floating their hand from location to location, touching an object such as the chair, or resting their hand with the palm facing upwards). Infants spent significantly more time not touching the body relative to time spent touching the body (Wald $x^2_{(1)} = 7.947$, $p < .05$). The predicted average time spent not touching was more than twice as long as the predicted average time spent touching with the hand (No touch = 176 seconds per visit, touch = 68 seconds per visit). The age effect on amount of time spent touching the body and the Age x Location interaction were not statistically significant.

**Duration of touches.** We next looked at touch duration to see whether—in addition to changes in total amount of time touching—length of individual hand touches changed across age. Similar to time spent touching, durations of no touches (M = 3.54, SD = .290) were significantly longer than durations of hand touches (M = 2.39, SD = .332) to the body (Wald $x^2_{(1)} = 12.746$, $p < .001$). The average duration of touches to the body was about 2.4 seconds whereas the average duration of time spent not touching was 3.5 seconds.

**Sex differences in self-touch.** Finally, we evaluated the effect of sex and location on the time infants spent engaging in self-touch. There was a significant main effect of location

(Wald $x^2_{(1)}$ = 35.600, $p < .001$) This effect was qualified by a significant Sex x Hand Behavior interaction on the amount of time infants spent engaging or not engaging in hand touches (Wald $x^2_{(1)}$ = 4.730, $p < .05$; Figure 2). There was no significant main effect of sex. Follow up tests indicated that males spent significantly more time engaging in no touch behaviors than females (Wald $x^2_{(1)}$ = 66.639, $p < .001$).

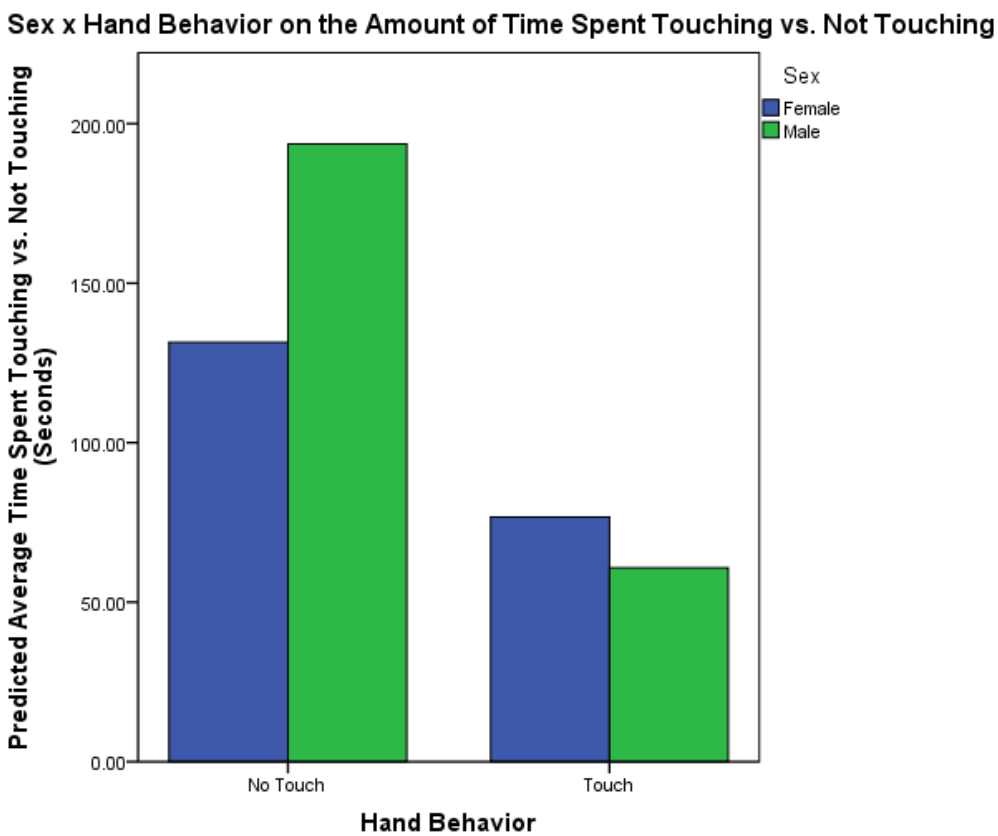



*Figure* 2. GEE predicted time spent engaging or not engaging in self-touch with the hands across sex. The x-axis indicates hand behavior (touch vs. no touch) and the y-axis indicates average predicted time spent touching in seconds.

**Hand Self Touch to Individual Body Locations**

**Time spent touching individual locations.** In order to examine which locations infants were touching while they were actively touching their bodies, we tested the effects of age, location (leg, face, mouth, other hand, torso), and the Age x Location interaction on the amount of time spent touching. There was a significant Age x Location interaction (Wald $x^2_{(4)} = 79.458$, $p < .01$), which showed that time spent touching increased across age for the mouth and other hand (Wald $x^2_{(1)} = 4.476$, $p < .05$, Wald $x^2_{(1)} = 20.716$, $p < .001$), decreased for the torso (Wald $x^2_{(1)} = 8.76$, $p < .05$) and did not change significantly across age for the face and leg (Wald $x^2_{(1)} = .272$, $p = .602$, Wald $x^2_{(1)} = 1.507$, $p = .220$; Figure 3). Raw data for this analysis are presented in the appendix (Figure 10a-Figure 10e).

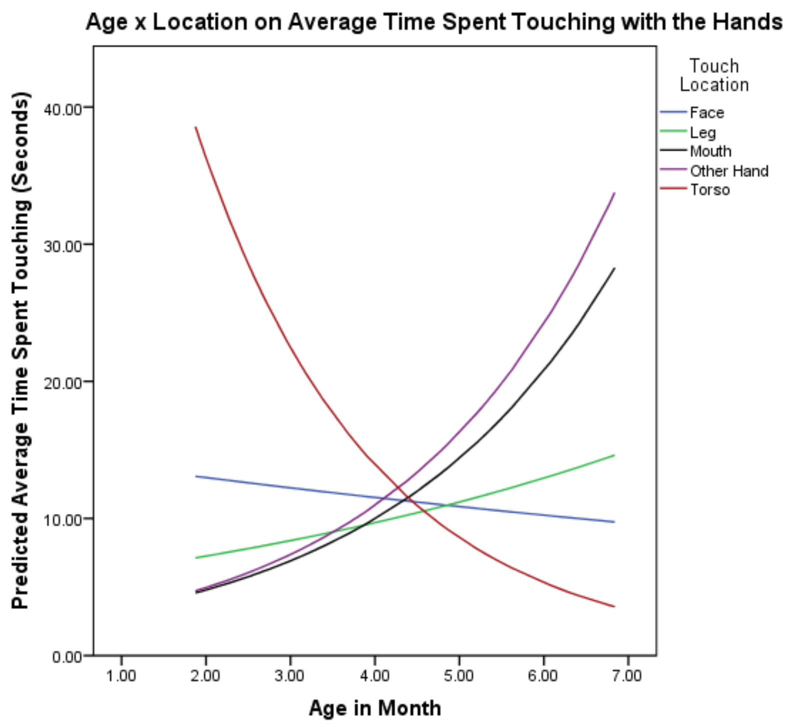



*Figure* 3. GEE predicted time spent touching for hand touch locations across age. All locations included in this analysis had a predicted average duration greater than five seconds. The x-axis indicates age in months and the y-axis indicates average predicted time spent touching in seconds.

**Duration of touches to individual locations.** Next we looked at duration of hand touches to individual body locations. GEE analysis testing the effect of age and location on the duration of touches to the body (face, leg, mouth, other hand, torso) indicated that hand touch duration increases with age as evidenced by a main effect of age (Wald $x^2_{(1)}$ = 15.277, $p < .001$; Figure 4). There was no main effect of location and no significant Age x Location interaction. Raw data for this analysis are presented in the appendix (Figure 11).

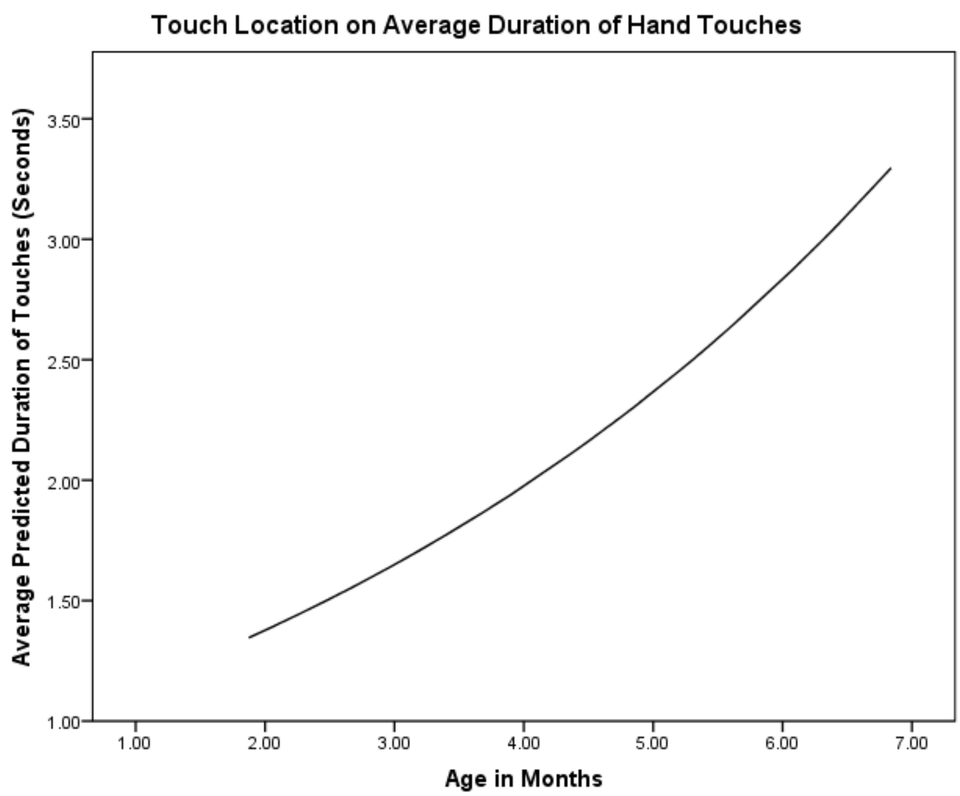



*Figure 4.* Average predicted duration of hand touches across age in months. The x-axis indicates age in months and the y-axis indicates the average predicted duration of touches.

**Head versus Body & Mouth versus Face Touches**

After comparing time spent engaging in hand touching and duration of each touch across location, we then collapsed across categories to compare only touches to the body versus touches to the face. We first compared the amount of time spent touching the face to the amount of time spent touching the rest of the body and found no significant difference. When looking at duration, a GEE analysis testing the effects of age, location, and the Age x Location interaction on the duration of touches to the face versus the body indicated that touch duration increased with age (Wald $x^2_{(4)} = 5.165$, $p < .05$). There was no significant main effect of location and no interaction effect on touch duration.

When looking at the effects of time spent touching the face versus the mouth, results indicated as infants became older, the difference between the amount of time spent touching the mouth versus the rest of the face with the hands increased, as indicated by a significant Age x Location interaction in GEE (Wald $x^2_{(1)} = 6.602$, $p < .05$; Figure 5. Although slopes for predicted time spent touching the face and mouth are significantly different from each other, neither is significantly different from a flat line. The main effects of age and location were not statistically significant. Raw data for this analysis are presented in the appendix (Figure 12a and Figure 12b). When looking at the effects of age, location, and the Age x Location interaction on the duration of hand touches to the mouth versus the face, duration of hand touches increased with age as indicated by a main effect of age (Wald $x^2_{(1)} = 7.533$, $p < .05$). There was no main effect of location and no interaction effect.

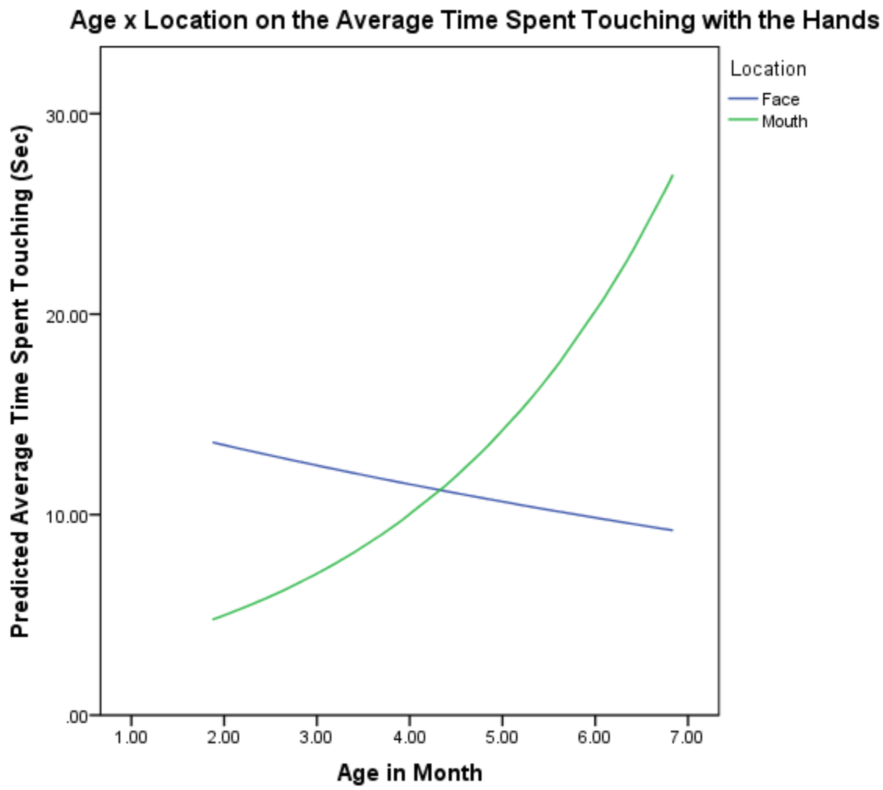



*Figure 5*. GEE predicted time spent touching for face and mouth touches across age. The x-axis indicates age in months and the y-axis indicates average predicted time spent touching in seconds.

**Feet Touches vs. No Touches**

Next we analyzed feet behavior. GEE analysis testing the effect of age, location, and Age x Location on the time spent engaging in feet touches indicated both a main effect of age (Wald $x^2_{(1)}$ = 5.321, $p < .001$) and a main effect of location (Wald $x^2_{(1)}$ = 28.565, $p < .05$). These effects were qualified by a significant Age x Location interaction (Wald $x^2_{(1)}$ = 19.515, $p < .001$, Figure 6). As infants age, they spend significantly more time engaging in feet touches (Wald $x^2_{(1)}$ = 12.836, $p < .001$) and significantly less time engaging in no feet behavior (Wald $x^2_{(1)}$ = 7.969, $p < .001$).

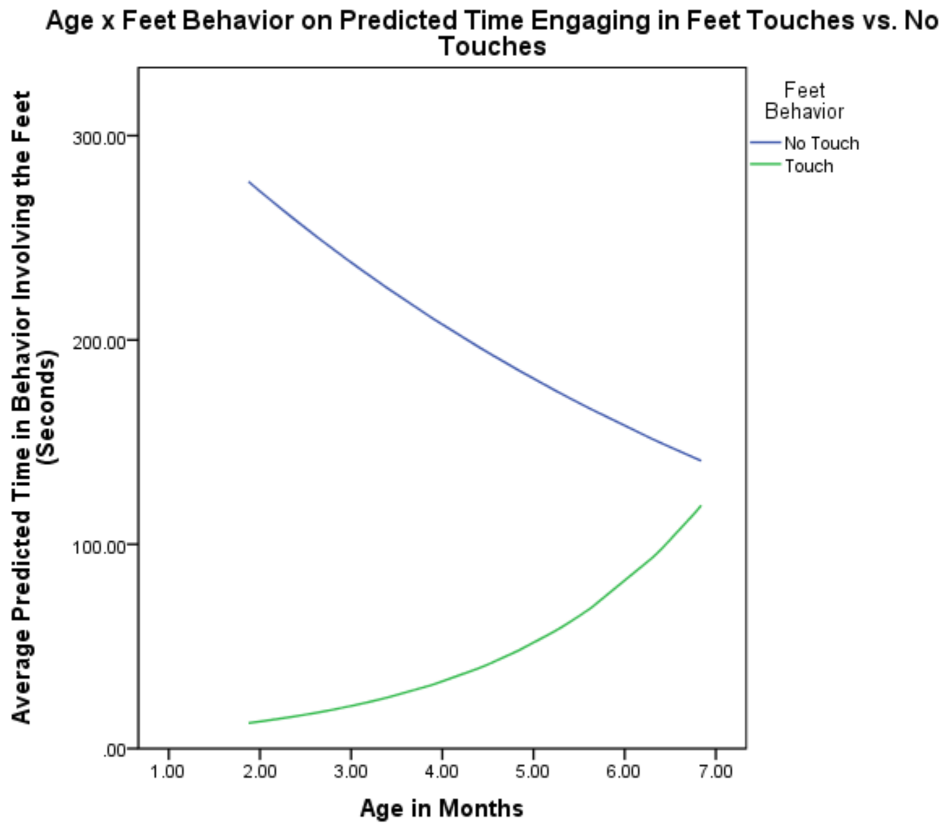



*Figure 6.* GEE predicted time spent engaging in feet touches versus no touches across age. The x-axis indicates age in months and the y-axis indicates average predicted time engaging in feet behavior in seconds.

**Feet Self-Touch**

In order to examine which locations infants were touching while they were actively engaging in feet touch, we tested the effects of age, location (feet together, foot/feet touching hand/arm, and foot touching opposite leg), and the Age x Location interaction on the amount of time spent touching with the feet. There was a main effect of feet touch location (Wald $x^2_{(2)} = 294.430$, $p < .001$) and a main effect of age (Wald $x^2_{(1)} = 57.992$, $p < .001$). These effects were qualified by a significant Age x Location interaction effect (Wald $x^2_{(2)} = 173.168$, $p < .001$; Figure 7). Touches to the hand/arm, opposite leg, and opposite foot all increased with age (Wald $x^2_{(1)}$ = 117.637, $p < .001$, Wald $x^2_{(1)}$ = 22.597, $p < .001$, Wald $x^2_{(1)}$ = 6.616, $p < .05$).

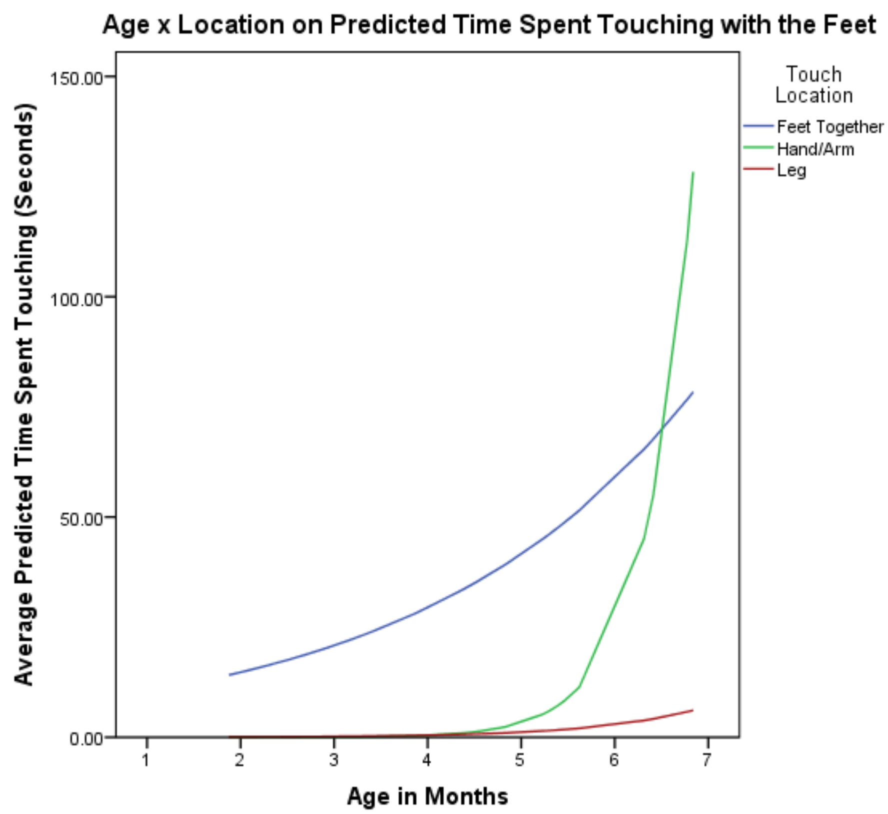



*Figure 7*. GEE predicted time spent touching for feet locations across age. The x-axis indicates age in months and the y-axis indicates average predicted time spent touching in seconds.

Similarly, in an analysis of feet touch duration, we tested the effects of age, location (feet together, hand/arm, and leg), and the Age x Location interaction on the duration of feet touches. There was a main effect of feet touch location (Wald $x^2_{(2)}$ = 94.903, $p < .001$) and a main effect of age (Wald $x^2_{(1)}$ = 64.171, $p < .001$). These effects were qualified by a significant Age x Location interaction effect (Wald $x^2_{(2)}$ = 141.452, $p < .001$; Figure 8).

Duration of touches to the hand/arm, opposite leg, and opposite foot all increased with age (Wald $x^2_{(1)} = 129.059$, $p < .001$, Wald $x^2_{(1)} = 9.570$, $p < .05$, Wald $x^2_{(1)} = 6.476$, $p < .05$).

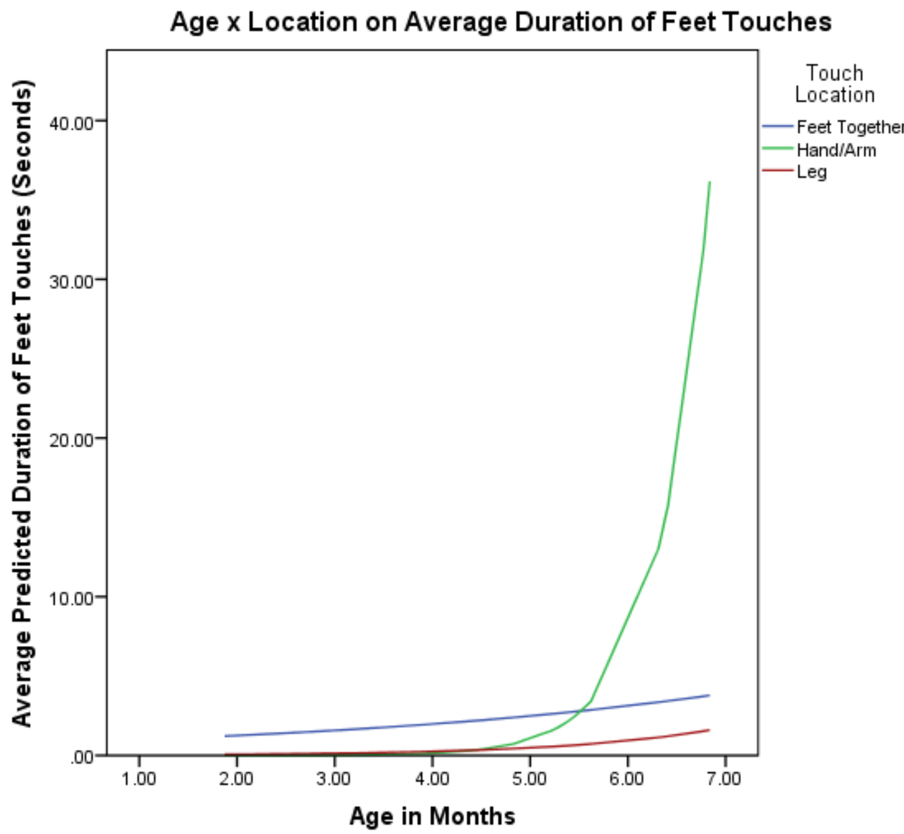



*Figure 8*. GEE predicted mean duration of feet touches across age. The x-axis indicates age in months and the y-axis indicates the predicted mean duration of touches in seconds.

**Ipsilateral, Contralateral, and Midline Hand and Feet Touches**

**Body.** In order to compare laterality patterns in self-touch to laterality patterns in reaching, we next looked at the time infants spent engaging in ipsilateral, midline, and contralateral hand touching. Infants spent significantly more time engaging in hand touches to the ipsilateral side of the body than the midline or contralateral side of the body (Wald $x^2_{(4)} = 40.641$, $p < .001$).

**Hand- foot touches.** When assessing ipsilateral, midline, and contralateral feet touches with the hand, we analyzed the main effect of laterality (ipsilateral and contralateral) on the amount of time spent touching. Midline touches were excluded because there were only two hand touches made to the feet. In this analysis, ipsilateral refers to a touch to the foot on the same side of the body as the touching arm/hand and contralateral touches refer to a touch to the foot on the opposite side of the body. For this analysis, we were unable to analyze an age effect because the first foot touch did not occur until 5.19 months of age. We found a significant effect of laterality (Wald $x^2_{(1)} = 16.179$, $p < .001$; Figure 9). The predicted average time spent conducting ipsilateral touches (15.492 seconds) was more than triple that of body contralateral touches (4.019 seconds). There were significantly less contralateral touches than ipsilateral touches (Wald $x^2_{(1)} = 16.179$, $p < .001$). A box plot of raw data is included in the appendix (Figure 13).

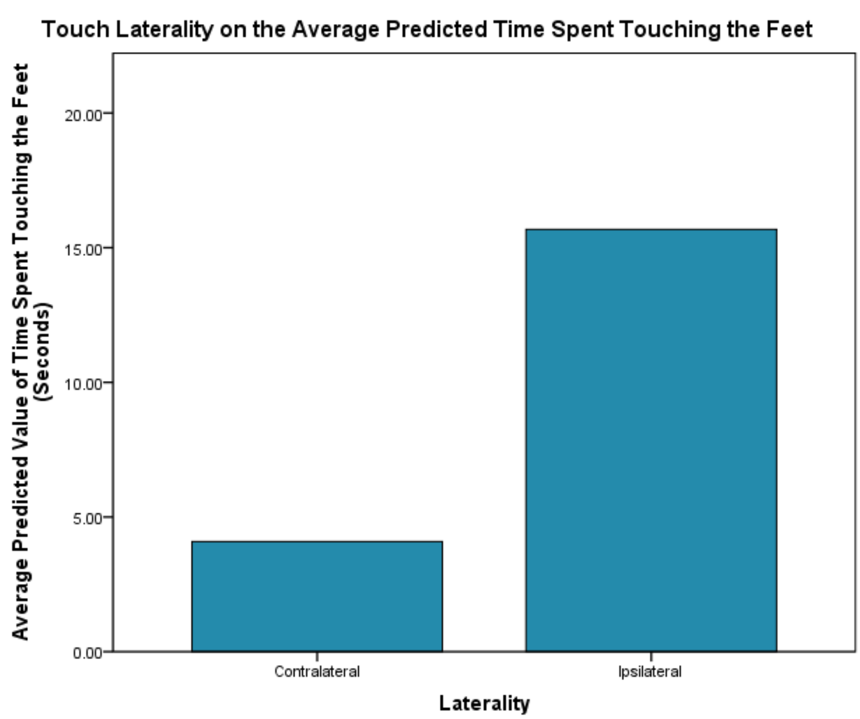


*Figure 9.* GEE looking at the predicted time spent conducting ipsilateral and contralateral touches. The x-axis indicates laterality (ipsilateral and contralateral) and the y-axis indicates the predicted average time spent touching in seconds. The adjusted mean time spent conducting ipsilateral touches was 15.492, SD = 3.74 seconds and the adjusted mean time spent conducting contralateral touches was 4.019, SD = 1.06 seconds.

We also assessed the duration of time infant spent conducting ipsilateral, midline, and contralateral touches. Similarity to total time spent touching, we found a significant effect of laterality (Wald $x^2_{(2)} = 16.572$, $p < .001$). The average duration of ipsilateral touches (6.529 seconds) was more than six times that of body midline and contralateral touches (1.043 seconds and 1.346 seconds, respectively).

## Discussion

Overall, our results confirmed self-touch occurs multiple times per minute during the first six months after birth. Infants made an average of 86.08 touches per visit for an average visit length of 4.32 minutes. The average number of touches with the hands per minute was 19.92. This finding is consistent with those of DiMercurio et al. (2018) who found that infants in the first two months after birth conduct about 13.35 touches per minute for a visit length of five minutes. Frequent self-touch may indicate that the first half-year after birth is a critical time when infants are beginning to explore their own bodies. The knowledge acquired through early self-touch may be an influential precursor to the understanding of body knowledge, body organization, and reaching.

When investigating how self-touch develops, it was important not only to understand the frequency of touches, but also where infants were touching and how these touching patterns changed across age. When looking at feet behavior only, we found that most of the time, infants were not engaging in feet touches, but rather resting their feet in a neutral position. As infants aged, the time they engaged in no feet behavior decreased, while time spend with the feet touching each other, the opposite leg, and the hand/ arm increased. This suggests that infants at older ages generally touch a greater variety of locations. The few studies evaluating infant self-touch look exclusively at hand touches to the body (DiMercurio, Connell, Clark, & Corbetta, 2018; Thomas, Karl, & Whishaw, 2015). As a result, this finding presents new evidence for the way infants explore their bodies. One specifically noteworthy finding is that infants spend significantly more time touching their feet to their hands with age. With the first instance of foot to hand touches occurring around five months of age and dramatically increasing, infants are beginning to learn about their bodies more entirely as they get older.

In addition to the amount of time infants spent engaging in feet behavior, we also looked at the duration of each individual foot touch. Similarly to time spent touching, duration of time was the greatest for no feet behavior. Moreover, as infants aged, duration of no feet behavior decreased while the duration of the feet touching each other, the opposite leg, and the hand/ arm increased. This shows that not only are infants engaging in more feet touches as they age, but also the duration of these touches increase with age. This may indicate that, with age, infant touch is less spontaneous and more deliberate to aid in body exploration.

After looking at differences in both time spent touching and duration of touch for the feet, we looked at the variability of time infants spent touching or not touching the body with the hands. When comparing time when the infant was touching the body to time when the infant was not touching the body, infants spent more than twice as much time not touching the body than engaging in self-touch. This finding is consistent with those of DiMercurio et al. (2018) who found that infants spent more time with their hands in the air than either touching their bodies or touching the floor. When infants were engaging in self-touch, the amount of time spent touching varied by location. As infants aged, they spent more time touching the mouth, less time touching the torso, and the same amount of time touching the face and leg. Although we hypothesized that infants would progress from rostral to caudal touches with age, the relative lack of touches to the feet and legs in general may have influenced our lack of evidence supporting rostral to caudal touches. Expanding the age range of infants in the study (currently one to six months) may allow for a greater understanding of if infant self-touch truly develops in a rostral to caudal progression.

As a result of the relative variation in amount of time spent touching each location, we then compared only touches to the mouth to touches to the rest of the face. As infants got older the amount of time infants spent touching the mouth increased while the amount of time spent touching the rest of the face decreased. This finding is consistent with research on infant banging trajectory that found that as infant's age, they have a more direct aiming trajectory than do younger infants (Kahrs et al., 2013).

We also looked at differences in males and females frequency of touching. Overall, we found that males spend significantly more time engaging in no hand behavior than females. Our findings may indicate that females touch their bodies more than males. No previous research on infant self- touch or examined sex differences. Previous research on gender differences in motor activity has found that males are overall more active than females (Eaton & Enns., 1986). Research looking at fine and gross motor movement in preschoolers has shown that females outperform males in fine motor movement and balance whereas males outperformed females in aiming and catching (Kokštejn, Musálek, & Tufano., 2017). Both gross and fine motor movements may be implicated in self-touch. Although females may have superior fine motor movements, males have superior gross motor movements. Additional research is required to determine the true nature of the relationship between total time spent touching the body and sex.

Finally, as infant self-touch may be an important precursor to reaching, we wanted to evaluate if the laterality of self –touch develops in a similar pattern to that of reaching. We found that infants spend more time touching the ipsilateral side of the body than the midline or contralateral side of the body. This finding is consistent with that of Van Hof and colleagues (2002) who found that ipsilateral reaching occurs predominantly between the first three to six months after birth. Van Hof et al. (2002) also reported that contralateral reaching does not begin to appear until five to seven months. As a result, this may be why the results of the present study did not indicate any change in self-touch laterality with age, as the oldest age included in this study was six months.

## Limitations

The present study utilized previously collected data looking at infant pacifier use. Pacifier to mouth trajectories were analyzed with motion tracking markers placed on the infants arms.  In order to improve this research it would be important to evaluate the role of self-touch without the placement of motion analysis markers on the infant's hands. Although it is possible that these markers influenced self-touch, touch to the hand markers was infrequent indicating that they were not drawing the attention of the infants. Additionally, previous research by Somogyi, et al. (2018) found that by six months of age, infants were only able to localize targets on the body about 20% of the time. This indicates that infants are most likely not deliberately reaching towards and touching the markers.

Another limitation of the present study is that there was variability in the both video length and number of infant visits. Although total video time was included as a covariate to account for this variability, it may be important to maintain consistently in the ages at which infants participated, the length of the visit, and the number of times infants participated.

**Future Directions**

Further examination of the role of vision could be important for understanding more clearly how infant self-touch develops. Future research could examine if infants are looking to the areas before they engage in self-touch. Moreover, studies using blindfolds or occurring in the dark could be implemented to determine how self-touch proceeds in the absence of visual information. Additionally, further research and analyses on this data could investigate the role of handedness in self-touch and possibly examine the relationship between more frequent self-touch with one hand to the development of a hand-preference.

Future studies on self-touch could also examine what hand positions and grips infants are using to contact their body. Understanding how infants contact their bodies may provide greater insight into the relationship between early self-touch and the development of grasping and reaching. Along these same lines, future studies could also vary infant posture to determine if infant self-touch varies depending on the body positioning of the infant. Lastly, it would be interesting to look at how the sensorimotor activity that occurs during self-touch relates to cortical activity. Understanding brain activation in relation to self-touch could provide insights into which brain areas or active or inactive during body exploration.

**Conclusion**

The present research intended to understand how infants develop and engage in self-touch. The results of this study provide new insights into how infants begin to explore their bodies through self-touch. Self-touch may play an important role in the understanding of body knowledge and body organization. Additionally information on self-touch could be influential in understanding the development of reaching and reaching patterns, specifically reaching to targets on the body. The present study has demonstrated that infant self-touch is frequent in the first six month after birth and amount of time spent touching different locations varies with age. This study is one of the first to evaluate the process of self-touch and adds to current studies by expanding the age range during which infants are observed. Continuing this research will help to inform future discoveries on body knowledge and our understanding of infant behavior.

## Appendix

*Figure 10a*. Age x Location on Average Time Spent Touching- Raw data**;** Time spent touching with the hands across age. The x-axis indicates age in months and the y-axis indicates the average predicted time spent touching in seconds. Each data point represents the amount of time infants spent touching the location indicated in the graph at each age. If an infant touched one location multiple times in one visit, you will see dots stacked vertically on top of one another to indicate separate touches to the same location in one visit.

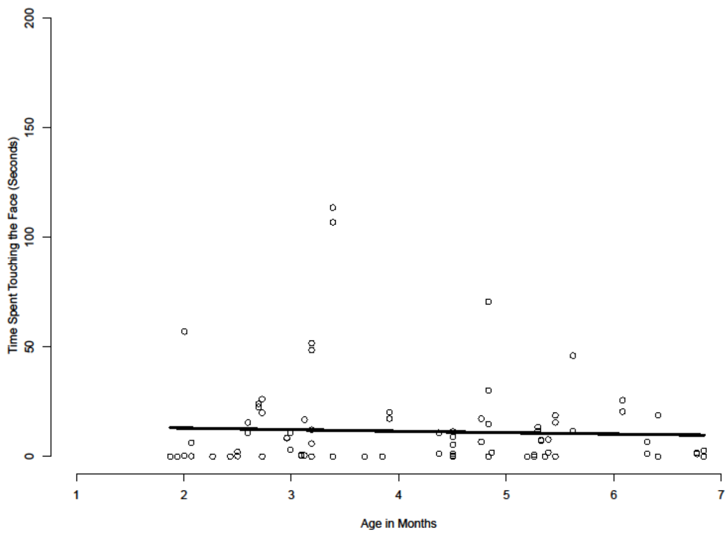



*Figure 10b*

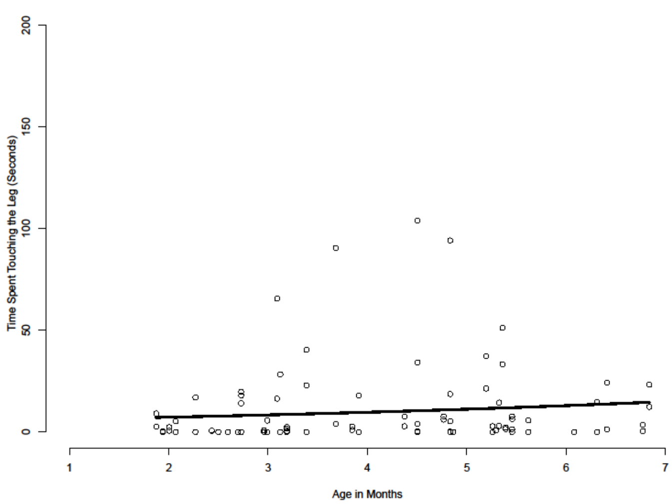


*Figure 10c*

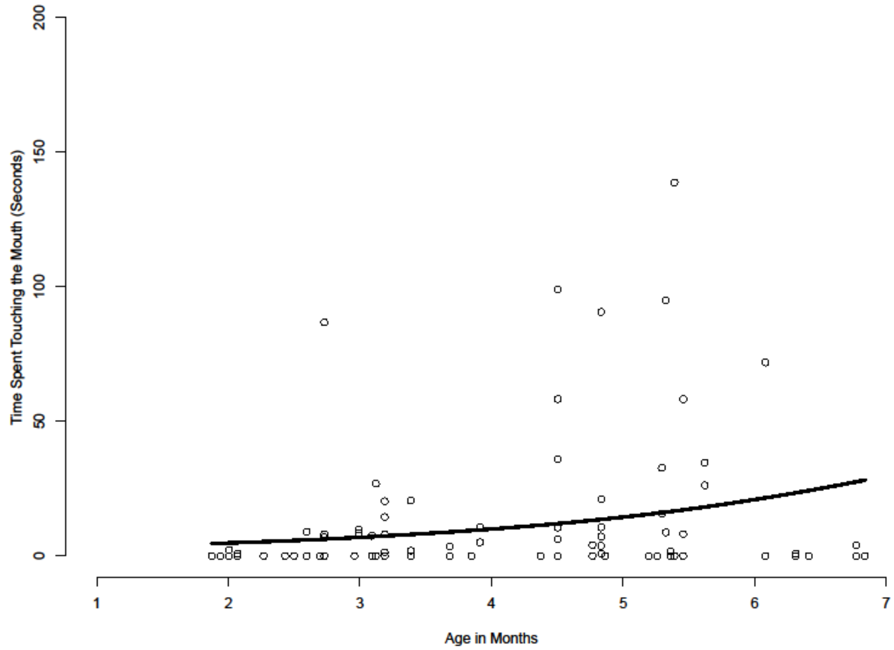



*Figure 10d*

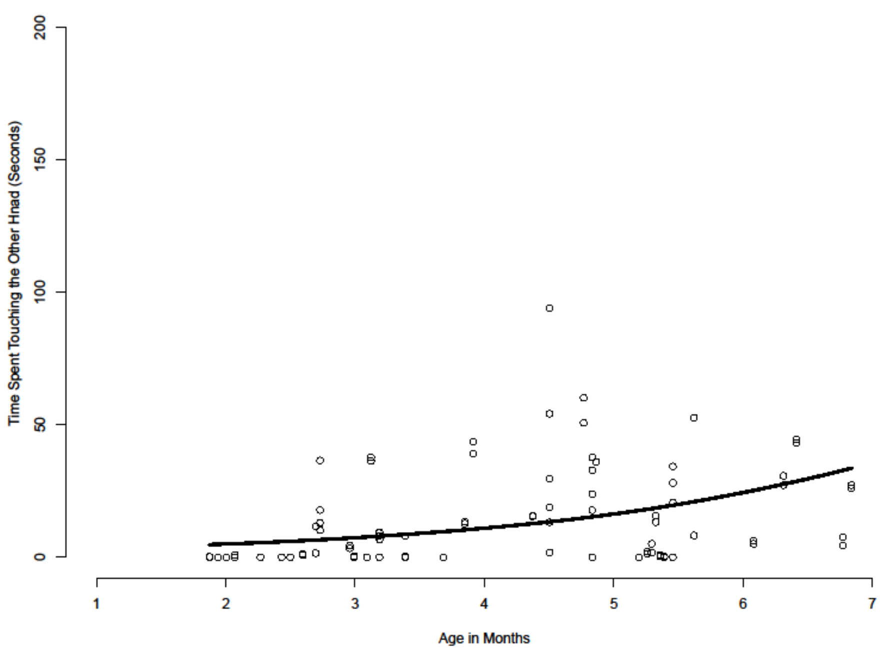


*Figure 10e*

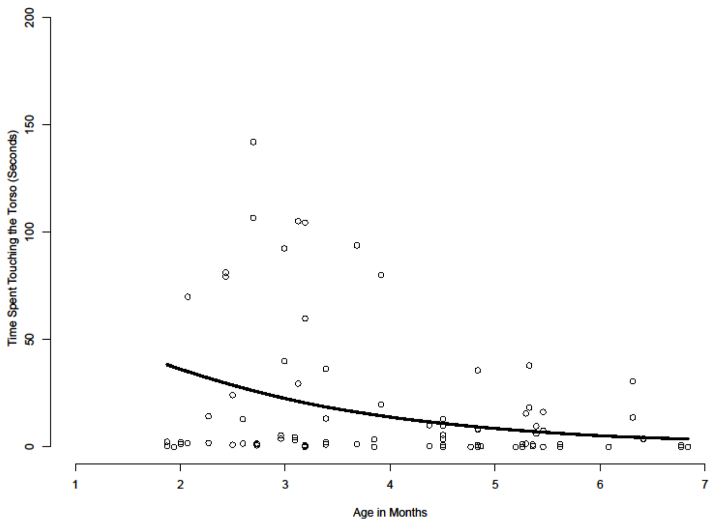



*Figure 11.* Age on duration of time spent touching with the hands- Raw data; The x-axis indicates age in months and the y-axis indicates the mean duration of touches in seconds. Each dot represents an infant touch at a specific visit. Infants made multiple touches per visit so you will see data points stacked vertically to represent each touch and the duration of each touch executed within one visit.

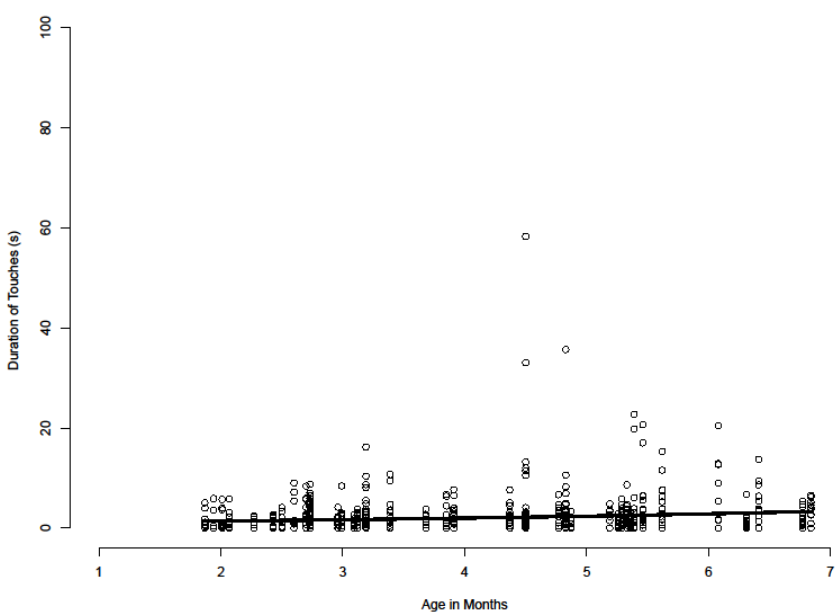


*Figure 12a*. Age x Location on Average Time Spent Touching (Face versus Mouth)- Raw data; Time spent touching the face and mouth across age. The x-axis indicates age in months and the y-axis indicates the average predicted time spent touching in seconds.

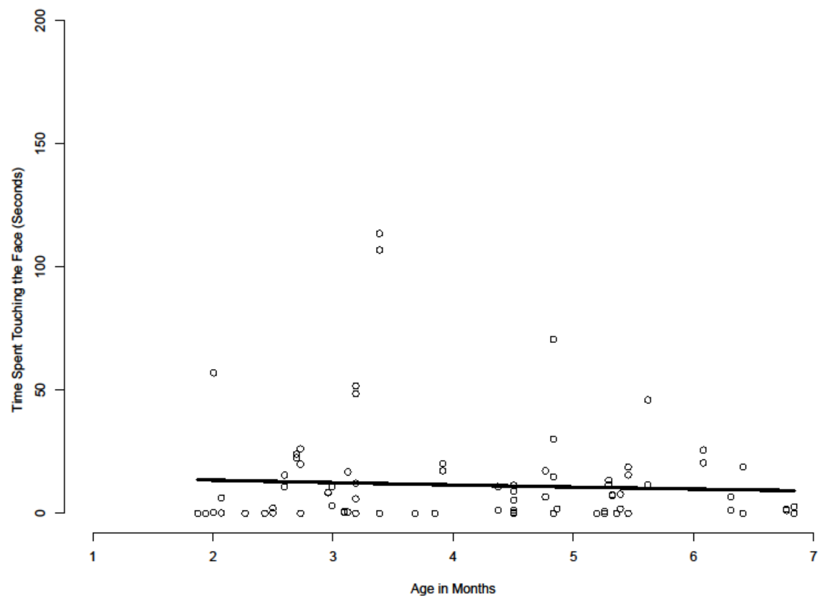



*Figure 12b*

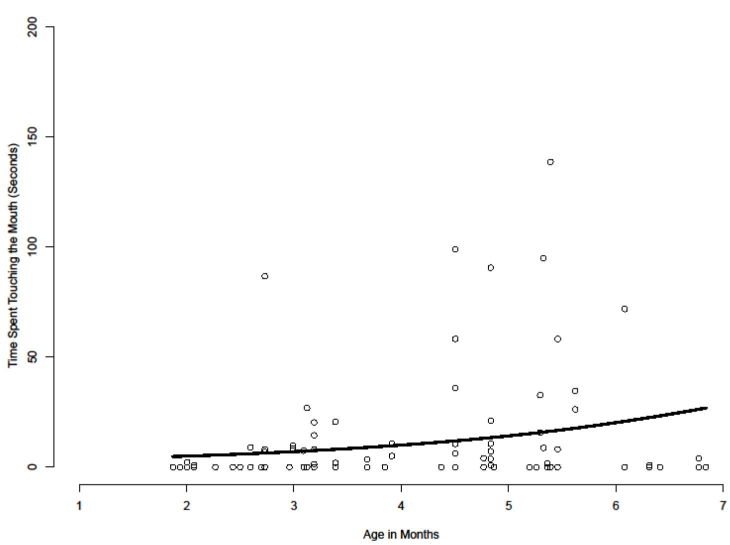
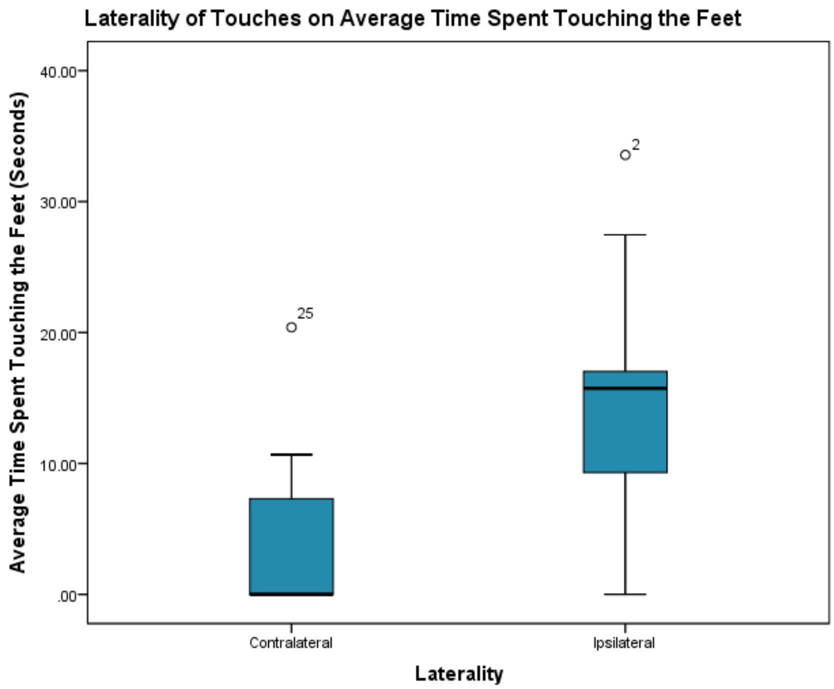


*Figure 13.* Laterality on the Average Time Spent Touching the Feet- Raw data**;** The x-axis indicates laterality (ipsilateral and contralateral) and the y-axis indicates the average predicted time spent touching in seconds.



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**Biography**

Lauren deBlanc was born in New Orleans, Louisiana. After completing her schoolwork at the Academy of the Sacred Heart in New Orleans in 2014, Lauren entered Rhodes Colleges in Memphis, Tennessee. During the fall of 2015, Lauren transferred to Tulane University. She received a bachelor's of science with a major in psychology and a minor in public health from Tulane University in May 2018. In August 2018, Lauren entered the Tulane University 4+1 Master's program with a concentration in behavioral health-assessment.