5-2020

Self-Perception in Infancy: The Posture of the Arm

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Honors Thesis

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May 4, 2020

Abstract

During the last months of gestation, fetal movements are limited due to the physical constraints of the womb. After birth, newborns are not constrained by space, but experience new challenges like gravity. Thus, we hypothesize that newborns will display flexed arm positions close to their bodies, similar to those positions experienced in the womb. Additionally, there may be a developmental trend where the arms shift to more variable, unsupported postures. This study followed four infants weekly from 3 weeks of age up until they gained head control (between 9 to 13-weeks-old) in the supine position for three, 5-minute conditions: baseline, toys-in-view, and caregiver speaking. The location of touches infants made on their bodies and the supporting surface was recorded in a preliminary analysis. The current analysis aimed to assess the posture of the arms at the onset of each touch according to three criteria: arm angle at elbow (acute or obtuse), forearm in contact with supporting surface or not, and arm oriented toward feet, head, left, right or vertical. The results showed that infants are just as capable of making contacts with the arms extended as they are with the arms flexed as early as three weeks after birth. Infants also oriented their arms more toward the source of the stimulus in the social condition. This study shows that infants are capable of a variety postures, despite being limited to a select few in the womb.

Keywords: infants, posture, angle, forearm, orientation

Self-Perception in Infancy: The Posture of the Arm

This research paper is concerned with the posture that neonates adopt outside of the womb. We know that activity in the womb serves as the foundation of infant behavior, however there is little known about the motor activity that infants engage in when they are born. The posture that their arms adopt is something that has never been studied before. In the present study, we plan to address this aspect of development during spontaneous motor activity in the first two months of life. The goal of this study is to observe infants in the supine position during awake periods to see whether the infants' touches to themselves or the supporting surface correspond with their arms making more acute or obtuse angles, whether more of the touches have the arm resting on the infant himself or the floor as a supporting surface or are the touches unsupported, and whether the arm is oriented toward the head, feet, left, right or vertical during the infant's contacts.

These observations were made under three conditions: baseline, where no stimulus is presented, toys-in-view, where brightly colored toys rest on the infant's preferred head turn side, and mother-speaking, where the caregiver is positioned overhead the infant while speaking to him. Within each of those conditions we recorded the angle the arm is in when the infant makes contacts with himself or the supporting surface, whether the forearm rests on a supporting surface or are the touches more mature such that they do not require a supporting surface , as well as the direction the infant orients his arm when making these contacts.

With this study, we hope to learn what posture neonates adopt outside of the womb. We want to assess if neonates retain the postures that were performed in the womb at later stages of a pregnancy or adopt a variety of postures such that the arms are extended. If the infant adopts a range of different postures, we want to understand at what point the transitions take place and possibly establish a developmental trend.

Literature Review

The development of spontaneous movements starts before birth. Full-term infants spend approximately 40 weeks inside of their mother's wombs before being born. During their time in the womb, fetuses are rapidly growing until the uterus no longer has the elasticity to allow further growth. At this point, the fetus becomes limited in its movements, particularly the arms. The amount of large-scale general movements the fetus performs during the later stages of gestation decrease significantly, while localized movements, or seemingly goal-oriented ones tend to increase (Piontelli, 2010). Studies have shown that fetuses begin to make more contacts to the face, particularly the mouth, than any other part of their body due to it being highly innervated by the quickly developing trigeminal nerve and also due to the finite number of bounded movements the infant is able to make (Kurjack & Azumedi, 2003). This phenomenon would also explain why so many fetuses and newborns are observed sucking their thumbs. This contact provides sensory feedback and could be done for soothing purposes.

While making contacts with the face, and contacts in general, not only is tactile sensation occurring but also proprioceptive sensation. Fetuses begin to become more aware of themselves and eventually are able to distinguish themselves from their environments (Yamada et al, 2013). With each touch, it is believed that they are becoming progressively capable of directing their movements to desired locations, however these touches may not be accurate. Some studies have even shown that fetuses may be anticipating the movements they are going to make. Two studies have shown fetuses opening their mouths before the hand even made contact with it (Butterworth, 1988; Myowa-Yamakoshi and Takeshita, 2006). This evidence has been used to support the idea that fetuses have developed a representation of where their mouth is and can direct their arm towards the mouth.

Every contact a fetus makes at this point becomes integrated within its nervous system. These integrations build upon one another and eventually allow infants to make sense of these contacts and reproduce these motor activities, to some degree, in order to get similar effects (Yamada et al., 2010). Experience of the fetus in the womb matters and sets the stage for postnatal development, however, the environment outside the womb is very different. Here we review what we know about early motor development in the first months of life.

When discussing the transition from the prenatal environment to postnatal life, it must be taken into consideration that the environment outside of the womb is very different. The infant is no longer constrained, and the environment is no longer aquatic. All of the infant’s movements will now be affected by gravity. Therefore, arm movements may be more difficult than before due to the compounding forces of gravity with relatively weak muscle. According to Lange-Küttner (2018), neonates will neglect the left side of their spatial fields and display an asymmetric tonic neck reflex that is biased to the right side until around five months of age resulting in one arm being flexed in a rostral orientation while the other arm is extended to the left or right.

Furthermore, in Thomas et. al’s (2104) study, researchers observed that infants from birth to 6 months of age actually showed a developmental trend of contacting rostral areas more often earlier in development with an increase in caudal contacts later. The caudal contacts increased in frequency at around 14 weeks of age and consisted of contacts with the hips, legs and feet. The major difference between the Thomas et al.’s study and the present one is that Thomas and colleagues focused on the contacts the infant made, while this paper is more concerned with the posture of the arm at those moments of contact. Also, infants in this study were only followed from three weeks of age to 13 weeks; however, the period of observations were more intense. Infants were studied every week besides weeks the caregiver may have been unable to bring them. This study represents infants of an age group that have not been frequently observed.

Rönnqvist and von Hofsten's (1994) study is one of the few that have studied motor activity in newborns. He and colleagues observed the finger and arm movements of neonates between the age of two and six-days-old in a social condition, object condition, and baseline condition. In the social condition the mother interacted with the infant, without touching him, from a 40 cm distance. While in the object condition a ball swung in front of the infant while a rattle sounded as well. In the baseline condition, no stimulus or interaction with the newborn occurred. The study found that in the social condition infants performed twice as many finger movements than in the object and baseline conditions. While the study tried to make both conditions as similar as possible, such as the ball being swing closer to the infant to mimic the distance the mother's head was from the infant to account for its smaller size, there was difference in sound amongst the stimuli. The mother was speaking, while the ball was connected to a rattle. This brings into question the importance of the stimulus and social aspect presented because not only could it affect the activity of the infant, but it may affect the orientation of these contacts as well.

The Present Study

Studies in the past have focused on the motor activity of fetuses in the womb such as making contacts to their mouth and the anticipation fetuses have for these contacts. Others have focused on the movement of the fingers or the development of the ability to reach and grasp. These studies have provided the foundation for understanding motor abilities and development early in infancy. This study, however, is one of the first to study the arm posture of neonates when they are making contacts on themselves or the floor as early as three weeks. This study also observes the infants on an intense, weekly basis while exposing the infants to three conditions: baseline, toys-in-view and mother-speaking.

Hypotheses

We hypothesize that if infants continue to make movements similar to those exhibited in the womb at later stages of a pregnancy, then their arms will likely be tightly coupled to their body and form acute angles. However, if infants quickly adjust to their new, less enclosed environment after delivery, then they may demonstrate more expanded, obtuse angle postures, along with different orientations. We also hypothesize that infants will make more supported contacts than unsupported contacts as a result of having to oppose gravity in unsupported touches while having little muscle mass and strength.

If the infants possess the tonic neck reflex and perform it frequently, then more orientations toward the head and extensions toward the left and right may be observed. However, if the infants do not perform the tonic neck reflex often or are unable to perform it, then vertical orientations and those pointed towards the feet may be observed more. It should also be noted that the tonic neck reflex declines around 2 months of age, and the infants here are not studied beyond that time period. Thus, there is a chance of observing a developmental trend from lateral arm orientations toward the head, indicative of the tonic neck reflex, to vertical orientations and orientations toward the feet. If the developmental progression observed in Thomas et. al's study is consistent in this study, we would expect more contacts oriented towards the feet compared to the head, toward the later weeks of the study. If the infants presented in this study are too young, a developmental trend from rostral to caudal orientations will likely not be observed, and infants can be expected to display contacts oriented towards the head instead.

The present study uses a condition where toys are in the infants' view and a social condition where the caregiver speaks to the infant, in addition to the baseline condition. In the toys-in-view condition, the infants were presented with non-sounding toys to their preferred head turn side, while during the mother-speaking condition, the mother was positioned overhead the infant without making contact. If the infants in this study display the same pattern of behavior as the ones in Rönnqvist and von Hofsten's (1994) study where finger movements were found to be more frequent in the social condition, then maybe infants will be more active in the present study and orient more of their contacts to the source of the stimulus. We expect to observe more contacts oriented toward the head rather than the feet in the mother-speaking condition, considering she is positioned overhead the infant.

The infants in this study have not yet begun to reach, but the condition may have an effect on where their arms/contacts are localized. If this is the case, in the toys-in-view condition, we expect to see more contacts oriented to the side that is consistent with the infant's preferred head turn side. If the toys-in-view condition has no effect on the orientations of the contacts the infants make, then more variable orientations will be observed throughout the study.

Methods

Participants

Four infants (2 females) participated in this study. All of them were followed from 3 weeks of age up to 13 weeks of age, or until they gained head control. Infant DJ had missing data at week 5 and weeks 10-13. Infant CG had missing data at weeks 11-13. Infant MA had missing data at week 10, while infant KP had missing data at weeks 6-7 and weeks 10-13. All infants were recruited from the Greater Knoxville, Tennessee area (USA), via formal mailings, follow-up phone calls, or various forms of personal contact. Parents voluntarily enrolled their infants in the study and informed consent was collected for all infants. Infants were born full-term and were free of visual or motor impairment. All participating infants were White. Parents were given $25 and a photograph of their child at each visit and received a certificate of participation.

Materials

Testing sessions were completed in a well-lit room. A flat, padded surface was used for the infants to rest on. To minimize ambient distractions, infants were surrounded by all-white panels. Brightly colored toys were used for the toys-in-view condition. Two video cameras were used to record each trial.

Procedure

The touches to analyze the arm postures were from a prior analysis on self-touch performed on the same babies in DiMercurio et al's (2018) study. Infants were recorded in the supine position for five minutes during three conditions. The first condition was a baseline where no other stimuli were presented. The toys-in-view condition had brightly colored toys placed in the infant view field on the infant's preferred head turn side. The mother-speaking condition consisted of the infant's caregiver either speaking or reading to the infant while in the supine position. The caregiver was behind the infant's head, out of view. The infants were recorded using a video camera, and each touch they made on their bodies or the supporting surface was coded into the DataVyu software.

Coding Scheme

Each touch infants made to their body or the floor surface that was longer than 280 ms was coded according to a body map that sectioned the body into 10 zones bilaterally, resulting in

20 possible zones that the infants could have made a touch on themselves. Three possible zones were established on the surrounding supporting surface. The left and right arms were coded individually. Next, the position of the arm was coded at the onset of each touch. This code consisted of the angle of the arm (acute or obtuse), whether the forearm rested on a supporting surface (supported or unsupported), and the orientation of the arm (towards the head, feet, right, left, or vertical).

The posture coding was performed by two trained coders who worked independently. There was a randomly selected 20% overlap in their coding to assess reliability of coding between them. The interrater reliability for differentiating the left arm angles reached 94% agreement ($r = 0.87$) and 90% agreement for the right arm ($r = 0.86$). The agreement for whether the arm was resting on a supporting surface was 88% for the left arm ($r = 0.67$) and 83% for the right arm ($r = 0.58$). Lastly, the agreement for the orientation of the arm was 85% for the left arm ($r = 0.72$) and 84% for the right arm ($r = 0.68$).

Results

All infants in this data set successfully contributed data for all three conditions, up until week 9. Several infants progressed past week 9, however due to the infants missing sessions, only one infant contributed per week beyond week 9. Therefore, weeks 10 through 13 are excluded from the following analyses. Additionally, the data did not meet tests for normality, thus non-parametric tests were used.

Main Effects

The left and right arms were combined for statistical analyses. A Wilcoxon test showed no significant differences in the overall proportion of acute angles as compared to obtuse angles. Similarly, there was no significant difference in supported versus unsupported touches. for supported versus unsupported touches. However, there was a significant difference in the orientation of the arms as indicated by a Friedman Test, $\chi2(4) = 15.20$, $p = .004$. Overall, infants had a greater proportion of touches oriented towards the head and feet as compared to orientations toward the left, right and vertical. The average of these orientations is shown in Figure 1.

Condition Effects

There was no significance in acute versus obtuse angles across conditions as indicated by the Friedman test. There was no significance in supported versus unsupported contacts across conditions. However, there was a significant difference between conditions in orientations toward the head, as indicated by a Friedman Test, $\chi2(2) = 6.50$, $p = .039$. In the mother-speaking condition, infants oriented their arm towards their head significantly more ($M = .51$, $SD = .20$) as compared to the baseline ($M = .45$, $SD = .15$) and toys-in-view condition ($M = .43$, $SD = .22$), see Figure 2. All other orientations were insignificant across conditions.

Effects by Weeks

A Friedman test revealed an N-shaped developmental trend for acute angles collapsed across conditions that peaked at week 6 ($M = .63$, $SD = .17$), $\chi2\ (6) =13.07$, $p = .014$. There was a U-shaped developmental trend for obtuse angles collapsed across conditions with a dip in obtuse angles at week 6 ($M = .37$, $SD = .17$), $\chi2\ (6) = 15.93$, $p = .014$, see Figure 3. No developmental trend was observed for supported or unsupported contacts across conditions. There was a significant, seesaw pattern observed in vertical orientations collapsed across conditions, $\chi2\ (6) =14.25$, $p = .027$, shown in Figure 5. All other orientations were insignificant.

Discussion

Infants in this study made contacts that resulted in the arm being held in obtuse angles just as much as them being held in acute angles. This observation does not support the hypothesis that infants would adopt postures that were tightly coupled to their bodies forming acute angles. From this finding, we conclude that infants are just as capable of making contacts with the arm extended as they are to making contacts with the arm flexed. Fetuses in the womb at later stages of a pregnancy may make more contacts with the arm held in acute angles not because they want to but due to the limited space for extending the limbs. Once outside of the enclosed environment, many different angles and orientations of the arms are observed.

We hypothesized that infants would make more contacts oriented towards the head and left and right as a result of performing the tonic reflex. However, this hypothesis was not supported considering infants made just as many contacts with the arms oriented towards the feet as they did with the arms oriented towards the head. This could mean that infants are not performing the tonic neck reflex as much as we expected, or the infants are capable of achieving other postures. Although we did not code specifically for the tonic neck reflex, contacts oriented towards the head, left or right were not due solely to the tonic neck reflex. The infants in this study fixed their arms in a variety of postures when making contacts; the characteristic fencing position of the tonic reflex is not the only posture that contributed to orientations toward the head, left and right.

Furthermore, there was a significant difference in the arm orientation across conditions. Infants oriented their arms toward the head more during the mother-speaking condition than in the baseline and toys-in-view conditions. A possible explanation for this could be that the infants are soothed by the voice of their caregivers, thus they take a more relaxed posture that results in both arms being oriented towards the head. This is an example of a posture that contributed to orientations toward the head rather than the tonic neck reflex. Another possible reason infants' arms were oriented towards the head more in the mother-speaking condition is that this represents their early attempt at reaching for the caregiver who was positioned overhead.

The results in effects by week showed an N-shaped trend for acute angles and a U-shaped trend for obtuse that peaked and dipped at week 6 respectively. The peaks and dips observed were likely driven by infant MA who made significantly more contacts resulting in acute angles than the other infants. The results were collapsed across conditions. These results do not support our hypothesis that we would see more obtuse angles at later weeks of the study due to developmental progression. On the contrary, the results show that infants are able to make acute and obtuse angles at nearly equal frequencies as early as three weeks after birth. A final significant finding of the study was a seesaw pattern observed in vertical orientations collapsed across conditions. However, vertical orientations had very low proportions throughout the study.

A limitation of this study is the small sample size, and future studies should aim for a bigger sample. Another recommendation would be to study infants as early as one week after birth and follow them beyond two months to see if any developmental trends occur in the posture of the arm.

In conclusion, infants are capable of diverse postures as early as three weeks after birth. The arm is just as likely to be obtuse and oriented toward the feet as it is to be acute and oriented towards the head during these touches. The findings of this study expel the assumption that newborn infants are bound to limited positions. The lack of developmental trend indicates that neonates already have the capability to move their arms in a variety of different postures.

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Figure 1

Average Proportion (and standard deviation) of Arm Orientation as a Function of Direction

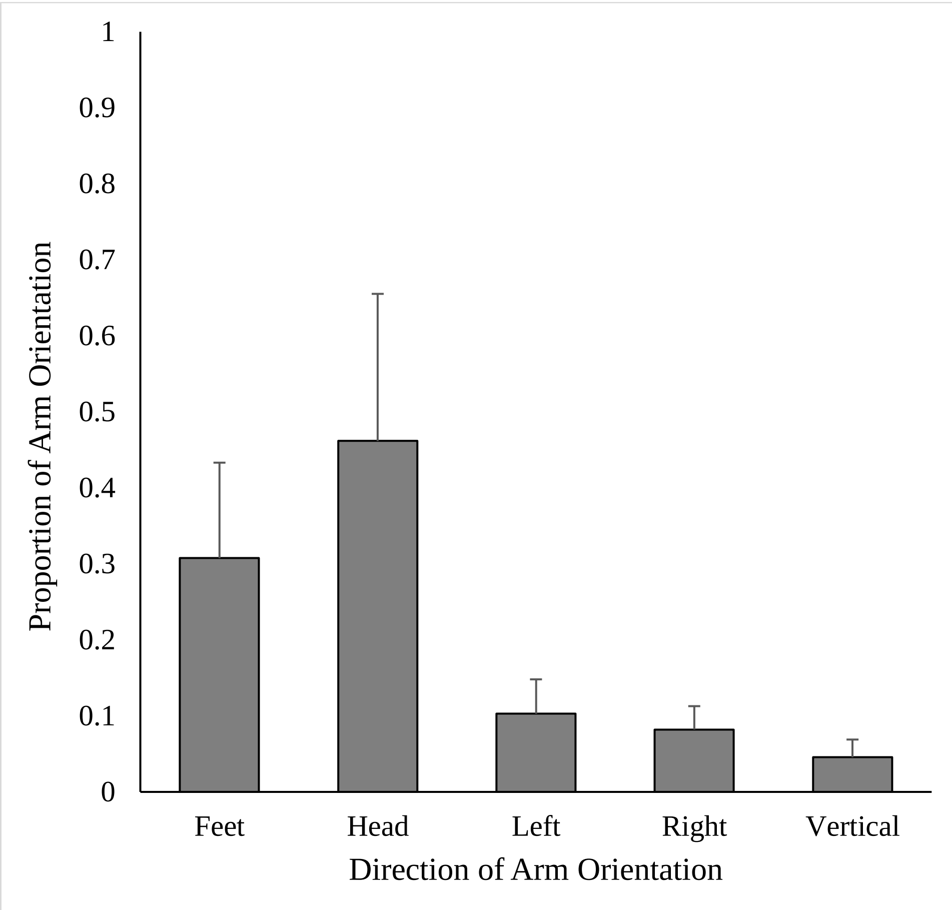

Figure 2

Rank of Arm Orientation Towards the Head Across Conditions

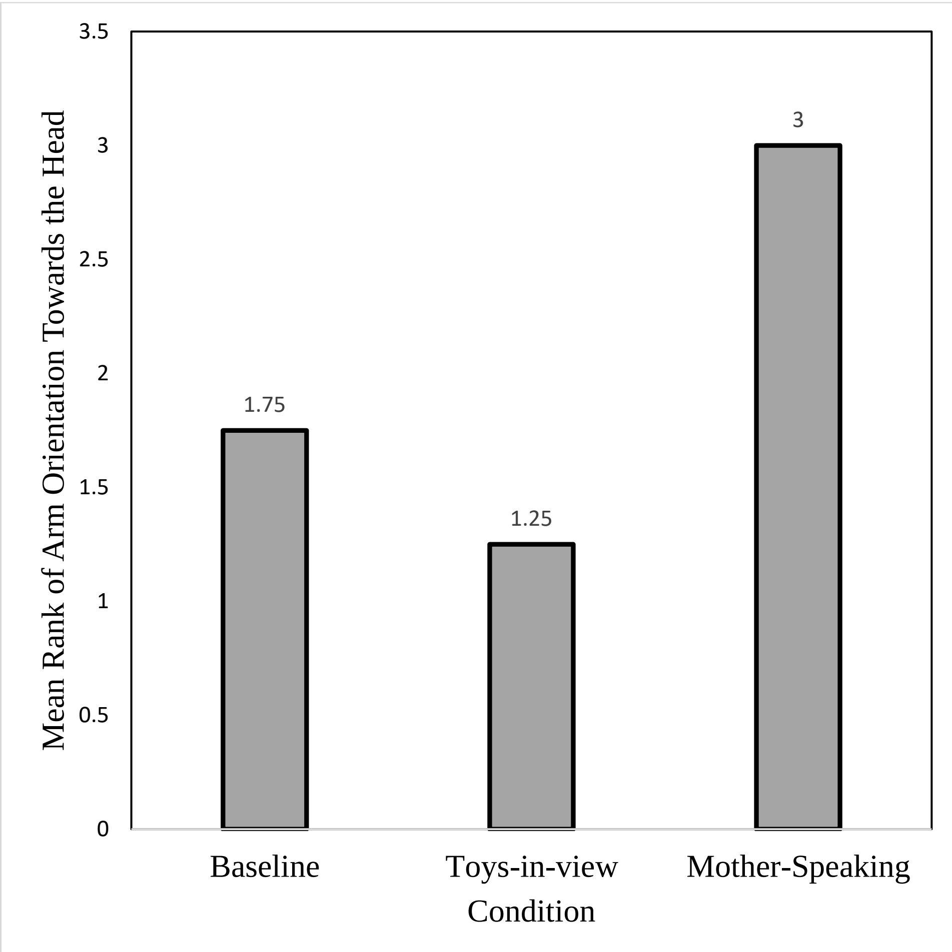

Figure 3

Average Proportion (and standard deviation) of Acute and Obtuse Angles Across Weeks

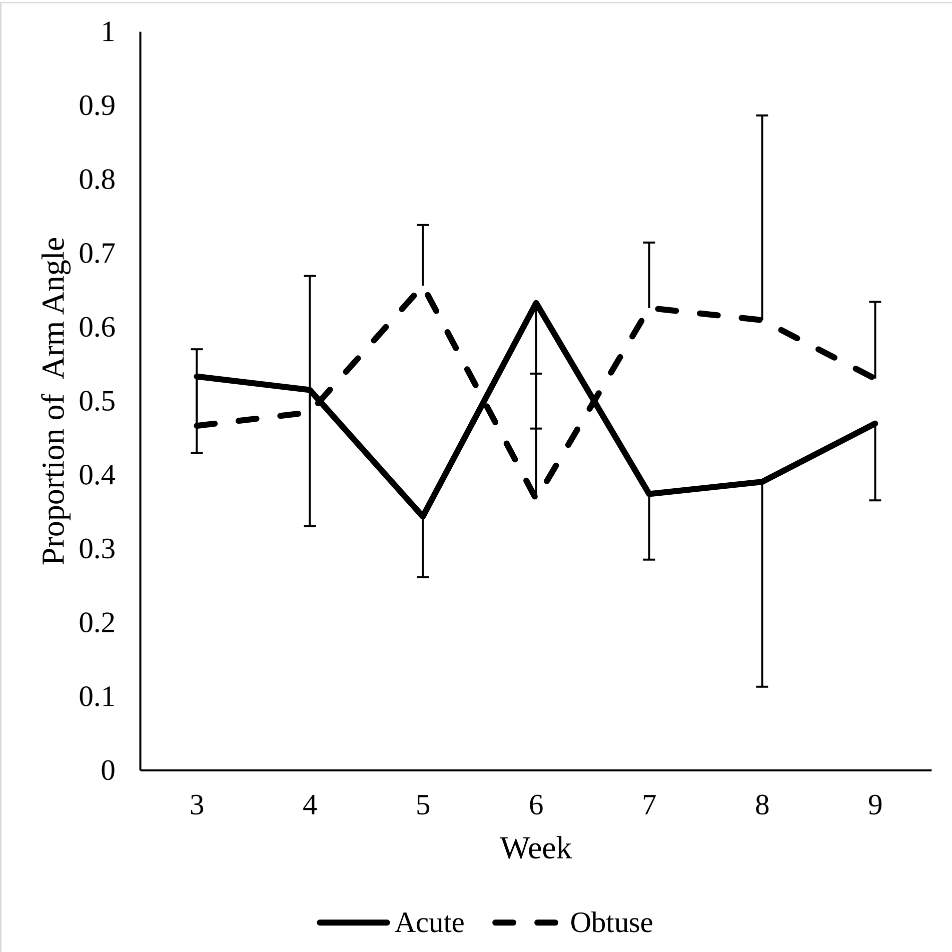

Figure 4

Average Proportion (and standard deviation) of Vertical Angles Across Weeks