Published in final edited form as:
Infant Behav Dev. 2016 August ; 44: 59–67. doi:10.1016/j.infbeh.2016.05.003.

Associations Between Gross Motor and Communicative Development in At-Risk Infants

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Abstract

Infants' advances in locomotion relate to advances in communicative development. However, little is known about these relations in infants at risk for delays in these domains and whether they may extend to earlier achievements in gross motor development in infancy. We examined whether advances in sitting and prone locomotion are related to communicative development in infants who have an older sibling with autism spectrum disorder (ASD) and are at risk for motor and communication delays (heightened-risk; HR). We conducted a longitudinal study with 37 HR infants who did not receive an ASD diagnosis at 36 months. Infants were observed monthly between the ages of 5 and 14 months. We assessed gross motor development using the Alberta Infant Motor Scales (AIMS) and recorded ages of onset of verbal and nonverbal communicative behaviors. Results indicated increased presence of early gross motor delay from 5 to 10 months. In addition, there were positive relations between sitting and gesture and babble onset and between prone development and gesture onset. Thus, links between gross motor development and communication extend to at-risk development and provide a starting point for future research on potential cascading consequences of motor advances on communication development.

Keywords

motor development; communication; at-risk development; ASD

1. Introduction

1.1 Relations between motor and communication skills

Although motor and communication skills were once considered unrelated in early development, a growing body of research has demonstrated links between the two domains (e.g., see Iverson, 2010, for a review). Campos and colleagues (1997) found a relationship

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between prone progression in 8.5 month-olds and responsiveness to gestural communication (Campos et al., 1997). And in a study with infants at 11 and 13 months, Karasik, Tamis-LeMonda, & Adolph (2011) observed that developments in locomotion related to subsequent developments in communication, such that walking status predicted quantity and quality of social communication bids. There is also evidence that these relations extend beyond the first two years of life; for example, communication skills related to fine and gross motor skills on the Ages and Stages Questionnaire in children at 3 years of age (Wang, Lekhal, Aarø, Schjølberg, 2013). Such findings are consistent with dynamic systems approaches to development that emphasize that emerging skills occur in the context of both the external environment and other developing skills in the child and that this influence may extend beyond moment to moment interactions (e.g., Thelen & Smith, 1996). Communication occurs with the body, and thus this approach is consistent with the prediction that development in bodily capabilities may impact communication.

Why might motor and communication development be related? One possibility is that developing motor skills afford experiences that support emerging communication skills (Iverson, 2010). For instance, development in prone locomotion brings with it new opportunities to access and interact with a broad range of entities in the environment, which may consequently increase attention to and talk about distal objects (Campos et al., 2000). Walking affords similar opportunities. Relative to crawling infants, infants in the standing posture with hands free and a broader view of their environment have new opportunities to carry objects and share interest in them with others (Karasik et al., 2011; Kretch, Franchak, & Adolph, 2013).

While much of the current literature has focused on locomotor skills and their potential relationship to communicative development, the emergence and consolidation of new postures earlier in infancy may also have an impact on communicative development. Thus, for example, sitting has the anatomical consequence of opening the rib cage and allowing the head to be held in an upright position. Both of these changes support the production of consonant-vowel units like those produced in reduplicative babbling (e.g., [babababa]). Indeed, development in unsupported sitting has been found to relate to advances in consonant-vowel vocalizations (Yingling, 1981).

While previous research with typically-developing (TD) infants provides valuable insight into the degree to which these behaviors typically cohere, the nature of motor-communication links in the face of delays in either or both domains is unclear. To date, only a few studies have examined populations at risk for motor delays, but they generally indicate that these links are robust in the face of early delays. Thus, for example, in a study of a group of infants with Spina Bifida between the ages of 8.5 and 13.5 months, relations were observed between prone progression and communication similar to those identified in work with TD infants (Campos, Anderson, & Telzrow, 2009), and overall delays in language in children with Spina Bifida relative to TD infants have been reported from 6 – 36 months (Lomax-Bream et al., 2007). A study by Suttora & Salerni (2012) with preterm infants is the only other study examining such links. They found that the production of pointing gestures during caregiver – child play and motor skill on the Bayley Scales of Infant Development Physical Development Index were related at 12 months.

1.2 Investigating motor – language links in the context of atypical development

In the present study, we examine links between gross motor and communicative development in a group of infants at risk for delays in both motor and language development—infants who have an older sibling with ASD (Georgiades et al., 2013; Iverson & Wozniak, 2007; Mitchell et al., 2006; Leonard, Elsabbagh, & Hill, 2013; Nickel, Thatcher, Keller, Wozniak, & Iverson, 2013; Toth et al., 2007; Winder, Wozniak, Parlade, & Iverson, 2013). These infants (High Risk infants; HR) are known to be at heightened risk for ASD (e.g., Ozonoff et al., 2011). However, in addition to risk for ASD, delays in motor development in the first and second years have been observed in many HR infants, even those who do not receive an ASD diagnosis (Leonard et al., 2013; Nickel et al., 2013).

Delays in communicative development have also been reported (Georgiades et al., 2013; Iverson & Wozniak, 2007; Mitchell et al., 2006; Toth et al., 2007). For instance, Winder and colleagues (2013) found that HR infants who did not receive an ASD diagnosis were more likely to exhibit delays in gestural communication than infants with no family history of ASD (Low Risk infants). In addition, there is some recent evidence that gross motor and communicative delays co-occur in HR infants. Bhat, Galloway, and Landa (2012) found that HR infants with gross motor delays on the Alberta Infant Motor Scales (total score) at 3 and 6 months were also more likely to exhibit language delays on the Mullen Scales for Early Learning (Expressive or Receptive Language) at 18 months than those who did not.

What remains unclear is whether developments in specific gross motor skills relate to specific achievements in communicative development in HR infants without ASD. The present study was designed to examine development in independent sitting and prone locomotion (gross motor skills) longitudinally in HR infants and relate it to onset of reduplicative babble, showing gestures, and pointing gestures (communication skills). This information is needed to test whether the motor-communication links observed in TD infants are apparent in the context of risk for motor and communication delays; and it can provide a starting point for identifying potential developmental pathways through which motor development and communication skills may relate.

Using the Alberta Infant Motor Scales (AIMS; Piper & Darrah, 1994), we observed infants at monthly intervals from 5 to 14 months. The AIMS is a standardized observational measure of motor development from birth through 18 months. The AIMS permits detailed characterization of skills in sitting and prone postures, including prone locomotion, via identification of the sitting and prone postures exhibited during the observation. The development of communication skills was examined at each monthly observation by recording whether the infant produced each of the 4 target communicative behaviors listed above. This permitted identification of the ages at which infants first produced each of the behaviors (i.e., ages of onset).

Based on the existing research with TD infants outlined above, we predicted that: (1) HR infants will exhibit gross motor delays as indexed by the AIMS; and (2) motor and communication measures will be related. Specifically, we expected that: a) the achievement of stable, unsupported sitting will relate to reduplicative babble onset, and b) advances in prone locomotion will relate to onset of communicative gestures. In light of prior research with HR infants, we expected that these links would be observed even when gross motor development is delayed.

2. Methods

2.1 Participants

Study participants included 37 HR infants (21 males) who have an older sibling with an Autism diagnosis. The older sibling's diagnosis was independently confirmed through a University Research Program where a trained clinician administered the Autism Diagnostic Observation Schedule (ADOS; Lord et al., 2000) and provided a clinical judgment using DSM-IV criteria. For an infant to qualify for the study, the older sibling had to score above the threshold for Autism on the ADOS with confirmation by clinical judgment using DSM-IV criteria. HR infants participated in this study as part of an ongoing longitudinal investigation of development between 5 and 36 months in infants who have an older sibling with ASD. Families were recruited through a University Research Program, parent support organizations, and local agencies and schools serving families of children with ASD. All participating infants were from full-term, uncomplicated pregnancies and came from monolingual, English-speaking households. Most infants were of Caucasian descent (34 Caucasian, 2 Hispanic, 1 Asian-American) and the majority of parents held college degrees or had completed some college (4 high-school, 6 some college, 27 college degree). At 36 months, all HR infants visited the Autism Research Program for a diagnostic assessment conducted by a clinician blind to all previous study data using the ADOS and DSM-IV-TR criteria. Infants in the longitudinal sample who met criteria for ASD were excluded from this study. Thus, all of the infants in the current study scored below the threshold for ASD.

2.2 Procedure

Infants and primary caregivers were videotaped monthly at home beginning at the age of 5 months through the age of 14 months. Each session included approximately 45 minutes of time-defined tasks that included naturalistic observation (infant and caregiver engaging in everyday household activities with no instructions provided), semi-structured dyadic play between infant and caregiver, and standardized assessments. Experimenters also recorded communication behaviors that they observed the infants produce over the course of the session. All study procedures received approval from the University's Institutional Review Board. Informed consent was obtained for each infant prior to the first observation.

2.3 Measures

2.3.1 Alberta Infant Motor Scales—At each session the Alberta Infant Motor Scales (AIMS, Piper & Darrah, 1994), a standardized observational measure of motor development designed for use with infants between the ages of birth and 18 months, was utilized and coded over the approximately 45 minutes of time-defined tasks. The AIMS assesses development in four postures (Prone, Supine, Sit, Stand), and scoring is based on both spontaneous and elicited behaviors. A subscale score is available for each posture; these can be summed to create a Total Score for which norms are available. The AIMS can be used to assess small changes in motor skill and has been used in previous studies to assess motor development longitudinally in both TD infants and preterm infants at risk for delays (Darrah, Redfern, Maguire, Beaulne, & Watt, 1998, Piper & Darrah, 1994; van Haastert, de Vries, Helders, & Jongmans, 2006). Postures assessed in each subscale represent a large range of development (e.g. Prone: early developing postures include prone lying with inability to lift head and later emerging postures include mature hands-and-knees crawling; Sit: early postures include supported sitting with minimal ability to lift and maintain head in midline and later postures include flexibly sitting without support and moving easily in and out of sitting positions). The AIMS was scored from video after the session. One rater (first author) had knowledge of study hypotheses but was blind to infants' outcome classification (i.e., was unaware of whether infants did or did not receive an ASD diagnosis). The other raters were blind to both study hypotheses and outcome classification.

A randomly selected 10% of the videos were double coded by raters blind to one another's scoring to assess interrater agreement. We calculated reliability for Total Score as well as for each subscale separately (Total score: intra-class correlation coefficient = .96, $p < .001$; Sit: intra-class correlation coefficient = .97, $p < .001$; Prone: intra-class correlation coefficient = .98, $p < .001$). Because we were interested in the transition to independent sitting and the transition to prone locomotion, we analyzed AIMS scores assessed between 5 and 10 months[1] with scores in the sitting domain from 5 – 7 months tapping skills in the transition to independent sitting and scores in the prone domain from 8 – 10 months tapping skills in the transition to prone locomotion.

2.3.2 Communication milestones—The experimenter observed the infant's communicative behaviors over the course of each session. We focused on the onset of 3 communicative behaviors: reduplicative babble and 2 nonverbal communicative gesture milestones (Show gestures and Point gestures). The onset of each communicative milestone was defined as the age at which the behavior was first observed by the experimenter during the session[2]. *Reduplicative babble* was defined as the repetition of consonant-vowel sequences (e.g. [bababa]) and was scored live at the session. Conventions for coding reduplicative babble have been developed in our laboratory (e.g., Iverson & Wozniak, 2007) and show good inter-coder agreement. The first age at which reduplicative babble was observed was coded as the age of onset. However, because infants may not produce all the sounds in their repertoires in the course of a session, we also provided caregivers with an audio recorder to tape a few minutes of the infant's vocalizations immediately before each visit. The experimenter reviewed the audiotapes immediately following the session. If reduplicative babble was heard on the audiotape but not observed at the home visit, the infant was still credited with the onset of that behavior at that age.

To ensure that *Show* and *Point* gestures were used communicatively, we required that they be accompanied by vocalization or eye gaze. Show gestures involved holding up an object to show to another person. Point gestures involved extending the hand in the direction of an

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[1] We examined development from 5 to 10 months because these are ages when the motor advancements of interest here typically emerge (Adolph & Berger, 2006; Bai & Bertenthal, 1992; Campos et al., 2000; Rochat & Goubet, 1995; Soska, Adolph, & Johnson, 2010; see details below).

[2] These communication skills typically emerge between 5 and 14 months. For instance, using a sample of infants at low risk for developmental delays, Iverson & Wozniak (2007) reported mean onset ages of: 7.06 months for reduplicative babble, 8.94 months for showing, and 10.71 months for pointing.

object, location, or person to indicate that entity (e.g. point to a dog; Iverson, Capirci, & Caselli, 1994). Conventions for coding these behaviors have been developed in our laboratory, used extensively to code infant gesture (e.g., Parlade & Iverson, 2015), and show good inter-coder agreement. The examiner scored live at the session whether each of the gestures had been observed. The first age at which the gesture was observed was coded as the age of onset. Because infants were seen between the ages of 5 and 14 months, the onset age for each communicative behavior could range from 5 – 14 months.

2.3.3 Mullen Scales of Early Learning—As part of the larger longitudinal study, the Mullen Scales of Early Learning was administered at the 6- and 12-month observations (MSEL; Mullen, 1995) by a trained experimenter, and reliability in scoring between experimenters was monitored throughout testing. The MSEL is an experimenter-administered standardized assessment that is scored online and may be used from birth to 68 months of age. As part of the MSEL, an Early Learning Composite is available as a general measure of cognitive development ($M = 100$, $SD = 15$). Scores were not available for 11 infants at 6 months and 3 infants at 12 months because the visit was not completed or a valid score was unavailable on at least one of the subscales comprising the Early Learning Composite. Thus, we only present data from 12 months. Mean Early Learning Composite scores for the sample of infants included in this study at 12 months fell within the average range ($M = 95.65$, $SD = 13.61$, range = 70 – 125, n=34).

3. Results

3.1 Presence of Motor Delay in HR infants without ASD

We first asked whether, consistent with previous research, HR infants exhibited motor delays between 5 and 10 months. We thus calculated infants' AIMS percentile scores at each age (Piper & Darrah, 1994) and categorized infants as delayed if they scored at or below the 10th percentile (see e.g., Darrah et al., 1998). Table 1 contains descriptive statistics for total and percentile scores. In a sample of TD infants, we would expect 10% to fall below the 10th percentile and be categorized as delayed. However, in our sample of HR infants, the percentages of infants with delay were much higher: 61% at 5 months, 52% at 6 months, 24% at 7 months, 39% at 8 months, 42% at 9 months, and 29% at 10 months. Binomial tests indicated that the percentages of HR infants having a total score at or below the 10th percentile were indeed at above chance levels at all ages (all p's < .022). These delays were particularly pronounced at early ages, with a majority of the sample exhibiting delays at 5 and 6 months.

We next asked whether there was stability in gross motor development over the course of the 5-month observation period. We assessed intra-individual stability using Spearman correlations to determine whether infants' rank ordering for total score at each age (measured with AIMS percentile score) significantly related to their rank ordering for total score at adjacent ages (Darrah et al., 1998). At all ages, AIMS percentile score significantly related to scores at adjacent ages (e.g. 5-month AIMS percentile score significantly related to 6-month AIMS percentile score; Rho statistics .509 - .845; p-values < .007). Thus, infants with relatively low scores at one age were likely to have relatively low scores at a subsequent age.

Was likelihood for very low scores (i.e., delay) similarly stable? To determine whether children exhibited consistent delays, we divided sessions into developmental windows corresponding to age ranges in which the sitting and prone postures under consideration typically emerge and looked at their total score at these ages: (a) sitting: 5 – 7 months (transition to flexible, stable independent sitting; see e.g. Adolph & Berger, 2006; Rochat & Goubet, 1995; Soska et al., 2010); (b) prone: 8 – 10 months (transition to mature prone progression; see e.g. Bai & Bertenthal, 1992; Campos et al., 2000). Infants were categorized as having consistent delay during that period if they had a total score percentile at or below the 10th percentile at the majority of ages (i.e., 2 out of 3 ages) in that window. Roughly a third of infants exhibited consistent delay from 5 to 7 months (10 of 32 infants) and a similar proportion exhibited consistent delay between 8 and 10 months (13 of 40 infants). Infants with consistent delay in sitting were more likely to exhibit consistent delay in prone than those without consistent delay ($p = .001$, Fisher's exact test).

In summary, HR infants exhibited gross motor delays that were particularly pronounced early in development. Many infants recovered from these early delays, but they persisted for a subgroup of infants. Infants with delays at later ages also exhibited delays at preceding ages.

3.2 Relating motor development to communicative development

The presence of delayed gross motor development in our sample of HR infants provides a context for subsequent investigation of the relations between motor and communication development. Thus, our next set of analyses examined whether the transition to independent sitting and prone locomotion (assessed via scores on the Sit and Prone subscales of the AIMS respectively) related to onset of early communicative milestones. As noted above, we predicted that Sit subscale scores from 5 to 7 months (tapping emergence of independent sitting) would relate to babble onset, and that Prone subscale scores from 8 to 10 months (tapping emergence of prone locomotion) would relate to communicative gestures.

The data in Table 1 indicate that there were large individual differences in raw scores on the AIMS Sit and Prone subscales in the targeted age ranges. As a reminder, a total score can be calculated for each of the AIMS subscales by summing the number of postures observed within the infant's window and the number of postures below the infant's window (Piper & Darrah, 1994). For instance, if an infant is observed to maintain sitting without arm support (item 8), the infant would have a score of at least 8 because s/he would also be credited for all 7 of the developmentally less advanced sitting postures below the window (e.g., sitting supported with examiner's hands around the trunk; sitting supported by own hands; sitting momentarily without arm support). As would be expected, Table 2 shows that infants' scores increased over time. Nonetheless, there was also evidence of very low scores in each age range. Thus, we had sufficient variability to examine potential relations between gross motor and communicative development.

Table 3 provides descriptive statistics for onset of communication milestones. As with AIMS subscale scores, there were large individual differences in the ages at which communication milestones were reached. Notably, some infants demonstrated significant delays in onset of communicative behaviors (e.g., babble onset later than 10 months; Oller, 1978).[3]

Finally, we examined whether Sit and Prone subscale scores related to age of onset of communicative behaviors. To address this question, we calculated Pearson product-moment correlations between AIMS subscale scores and ages of communication milestones achievement. We performed the correlations testing our hypotheses (grey boxes). However, to examine whether there was some specificity in which variables were related, we also performed Pearson product-moment correlations for relations that were not predicted. Negative correlations indicate that more advanced skills (i.e., a higher score) are related to earlier emergence of the associated communication skill (i.e., a younger onset age). The correlations provided in Table 4 support our hypotheses of relations between gross motor development and communication milestones.

With regard to sitting, because increasing stability in sitting supports production of more advanced consonant-vowel sequences, we predicted that Sit subscale scores between the ages of 5 and 7 months would relate to reduplicated babble onset. Sit subscale scores at 7 months were related to babble onset, and they also related to Show gesture onset.

With regard to prone locomotion, on the basis of previous research (Campos et al., 2000), we expected that Prone subscale scores between the ages of 8 and 10 months would relate to gesture development. Prone scores related to Show onset at 2 of the 3 ages (the earliest ages in the age range); and Prone scores related to Point onset at all ages. The relations between Prone score at 9 months and both gestures were statistically significant.

4. Discussion

Our data indicate increased likelihood of delays in gross motor development from 5 to 10 months in HR infants who did not receive an ASD diagnosis. Motor development was also related to the emergence of both verbal and nonverbal communicative milestones with some specificity: sitting development related to both verbal and nonverbal communication milestones, and prone development related to nonverbal communication milestones. These findings extend previous work examining relations between gross motor and communication development in general. They also contribute to the growing body of research on HR infants by demonstrating the existence of links between motor and communicative development in a sample of infants that was not later diagnosed with ASD.

4.1 Gross motor and communication development

Why might advances in prone and sitting control relate to the emergence of communicative milestones? Scores on the Sit subscale at 7 months significantly related to babble onset, and they also related to Show gesture onset. The mean score for the Sit subscale at 7 months was 7.55, a score that indicates the transition from sustained sitting to sitting without support (though not yet with the flexibility and stability required for higher scores; Piper & Darrah, 1994). This finding is consistent with the proposal that improvements in sitting relate to advances in consonant-vowel productions due to the anatomical consequences of the sitting

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[3] By 14 months (the final monthly session), 4 infants had not yet produced reduplicative babbling or had entered the study after the average age of babbling onset, 4 infants had not yet produced show gestures, and 8 had not produced point gestures. These infants were therefore excluded from these analyses. There were no significant differences in Sit or Prone subscale scores between infants who had attained these communication milestones by 14 months and those who did not (p's = .179 - .983).

posture (Yingling, 1981). Although not predicted, the relation with Show gesture onset is not surprising. Increasing stability in sitting demonstrates that the infant possesses the trunk control necessary to stabilize sitting while extending the arm. This ability potentially broadens the infant's opportunities to hold objects and extend them in the direction of the interlocutor to “show” the object to others in a manner that may support coordination with social behaviors (e.g., eye contact with the interlocutor).

We also observed relations between development in prone and gesture onset. Prone subscale scores at 9 months in particular related to both Show and Point gestures. The mean score for Prone subscale at 9 months was 15.36, a score that indicates a transition into prone locomotion (Piper & Darrah, 1994). These findings are consistent with previous work examining the impact of locomotion on development (see Campos et al., 2000, for a review). In sum, the observed pattern of findings for sitting and prone skills suggests that the relations observed between gross motor and communicative development in TD children are robust in the face of delayed development.

4.2 Gross motor skill in infancy may have cascading consequences for communication development

The findings reported here also build on previous research examining relations between gross motor and communicative development that has utilized relatively global measures of ability in these two domains. In this study, we observed relatively precise relations between specific gross motor skills and communicative behaviors that have also been described for TD infants. Our results speak to potential learning processes—in particular, the potential for early sitting and prone development to have cascading effects on subsequent communication development[4]. In other words, advances in sitting and prone development may have far-reaching influence, impacting development both within and beyond the motor domain. This far-reaching influence may extend beyond the immediate context through these cascading consequences. In other words, relations may be indirect.

Thus, for example, motor development may shape the learning environment such that advances in motor skill bring with them novel experiences (e.g., Iverson, 2010). For instance, increasing stability and flexibility in sitting supports object manipulation and exploration activity by expanding the manual movement repertoire as well as supporting the coordination of looking while exploring (Perone, Modole, Ross-Sheehy, Carey, & Oakes, 2008; Soska et al., 2010; Spencer, Vereijken, Diedrich, & Thelen, 2000). For instance, Lobo and colleagues found that object manipulation did not differ in supported sitting in comparison to supine positions (Lobo, Kokkoni, de Campos, & Galloway, 2014). However, experience in sitting without support has been found to relate to visual coordinated object manipulation (Soska et al., 2010). More research is needed to unravel the relations between object exploration and degree of support needed in sitting postures. Research with TD infants suggests that manual exploration increases attention to object shape, which can support word learning (Ruff, 1984; Smith, Jones, Landau, Gershkoff-Stowe, & Samuelson, 2002). Findings such as these suggest that the consequences of improvements in sitting

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[4] This is one of many non-mutually exclusive ways in which motor and communication development may be related.

stability may even extend beyond vocal and gestural advancements achieved in infancy that were the focus of the current study.

In addition to supporting manual exploration development, gross motor development in infancy supports interactions with people (Karasik et al., 2011). For instance, changes in a infant's manual movement repertoire that occur as a result of stable sitting include the ability to lift and extend an object in the direction of the interlocutor—a necessary requirement for Show gestures. Critically, it is possible that the sitting position allows the infant to coordinate showing behavior with eye contact, a component of communicative gesture, to a greater range of potential interlocutors around a room. Experience in sitting may afford opportunities to practice skills such as socially directed gaze and joint attention that support the eventual emergence of social communication gestures. Impacting interactions with others may serve as an addition mechanism through which gross motor achievements can support language development. For instance, the production of gestures elicits input from others that may support word learning. Caregivers often ‘translate’ an infant's gestures (e.g., a caregiver may say, “that's a ball”, when the infant shows a ball to the caregiver); and such translations relate to the emergence of these words in the infant's spoken vocabulary (Goldin-Meadow, Goodrich, Sauer, & Iverson, 2007). Thus, developments in gesture production – supported by advances in gross motor skills -- may elicit these translations, which may in turn support word learning.

Although our findings are consistent with proposals that early developing motor skills have cascading consequences on development in other domains, additional work is needed to provide more direct evidence that motor skill impacts communicative development. If motor skill can impact communicative development, then manipulating movement experiences by easing performance demands such that infants are able to perform movements just outside their capabilities may facilitate advances in communication. Training studies focusing on fine and gross motor skills have shown advances in these skills as a result of manipulating movement experiences (e.g., Lobo & Galloway, 2008; Sommerville, Woodward, & Needham, 2005). This type of approach should be incorporated in future studies.

Finally, our findings shed light on our understanding of atypical development and provide a direction for future work aimed at supporting development in infants at risk for early delays. Of relevance to the current work, lags in object exploration behaviors have been observed in HR infants in the first year (Koterba, Leezenbaum, & Iverson, 2014; Mulligan & White, 2012). Examination of this and other potential developmental pathways has important implications for early intervention in HR infants and other populations at risk for communication and language delays. Our findings suggest the possibility that early-emerging gross motor skills such as independent sitting and prone locomotion can support advances in other domains. Consequently, targeting these skills in early intervention programs may have positive effects in multiple domains. When gross motor delays are present, it is standard practice to address them in early intervention programs. However, the results reported here suggest the utility of using treatment approaches that may support development in other domains as well (e.g., Lobo & Galloway, 2008). In addition, they highlight the importance of intervening early in development when delays first appear, particularly in at risk infants.

Acknowledgments

This research was supported by R01 HD054979 to Jana M. Iverson. We thank D. Williams, N. Minshew, and the NICHD-funded University of Pittsburgh-Carnegie Mellon Collaborative Program of Excellence in Autism Research (HD35469 and HD055748 to N. Minshew) for supporting assessments and assistance with participant recruitment; J. Hetherington for administrative assistance; and members of the Infant Communication Lab for assistance with data collection and coding. We offer special thanks to the families and infants who enthusiastically participated in the research.

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Highlights

- Little is known about motor–communication links in infants at risk for these delays.
- We examined motor – communication links in infants at risk for these delays.
- Gross motor and communication skill was longitudinally studied from 5 to 10 months.
- Independent sitting related to babble and gesture; prone skill related to gesture.
- Findings suggest the potential for cascading consequences between domains.

Table 1
AIMS Total and Percentile Scores at Each Age

Age	n	Total Score	Percentile Score
5 months	23	16.26 (3.32) 8 - 23	12.04 (11.66) <1 - 48
6 months	31	21.35 5.64 11 - 40	18.06 (21.96) <1 - 98
7 months	29	25.62 5.85 15 - 41	24.10 (21.96) <1 - 90
8 months	33	31.67 (7.87) 21 - 49	29.61 (30.17) <1 - 99
9 months	36	38.19 (9.41) 22 - 51	34.72 (31.79) <1 - 88
10 months	34	43.62 (8.15) 22 - 53	34.00 (27.30) <1 - 84

Note. Table provides sample mean, standard deviation (SD), and range for AIMS Total Score and Percentile score at each age. Sample sizes vary because some infants missed visits and some infants did not enter the study at 5 months. For instance, 13 infants entered the study after 5 months. In some cases, a visit occurred but it was not possible to obtain a valid score on one of the subscales. For instance, an infant may have cried immediately and persistently when placed in supine or prone. The minimum possible score is 0 and maximum is 58.

Table 2

AIMS Subscale Scores at Each Age

Age	n	Mean	Standard Deviation	Range
SIT Subscale Scores				
5	24	2.08	1.50	1 - 7
6	31	4.61	2.94	1 - 11
7	31	7.55	2.89	1 - 12
PRONE Subscale				
8	35	12.86	4.67	6 - 21
9	36	15.36	4.51	7 - 21
10	35	18.11	3.55	6 - 21

Note. Table presents AIMS Sit subscale scores from 5 – 7 months, when infants typically transition to independent sitting. AIMS Prone subscale scores are provided for ages 8 – 10 months since we are interested in the transition to prone locomotion at these ages. Sample sizes vary because some infants missed visits and some infants did not enter the study at 5 months. For instance, 13 infants entered the study after 5 months. Each subscale has a minimum score of 0, but maximum score varies by subscale. The score range for each subscale is: Sit (0 - 12); Prone (0 – 21).

Table 3

Onset Ages for Communicative Milestones

Milestone	**n**	**Mean**	**Standard Deviation**	**Range**
Babble	33	7.67	1.76	5-12
Show Gesture	33	11.21	1.54	8-14
Point Gesture	29	11.79	1.57	8-14

Note. Table presents descriptive statistics for age of onset of each communicative milestone. Because we observed infants between 5 and 14 months of age, the range of possible scores is 5 – 14. The range provided in the table is the range of scores that was observed in this sample. There were some infants who did not achieve the milestone by 14 months or began the study after the mean age of onset for the target skill and they are not included in this table (Babble: 4 infants; Show: 4 infants; Point: 8 infants).

Table 4

Correlations between Gross Motor Development and Communicative Milestones

Pearson r	**Babble**	**Show**	**Point**
AIMS Sit Subscale Score			
5m	-.012	-.290	-.196
6m	-.162	-.077	-.050
7m	**-.375**	**-.376**	-.270
AIMS Prone Subscale Score			
8m	.045	**-.306**	**-.318**
9m	-.060	**-.415**	**-.378**
10m	.063	-.288	**-.332**

Note. Table presents Pearson product-moment correlations for relations between each subscale and communicative milestones. Red bold = significant at .05, Black bold = significant at .10.