



SHORT REPORT

Crawling and walking infants elicit different verbal responses from mothers

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Abstract

We examined mothers' verbal responses to their crawling or walking infants' object sharing (i.e. bids). Fifty mothers and their 13-month-olds were observed for 1 hour at home. Infants bid from a stationary position or they bid after carrying the object to their mothers. Mothers responded with affirmations (e.g. 'thank you'), descriptions ('red box'), or action directives ('open it'). Infants' locomotor status and the form of their bids predicted how mothers responded. Mothers of walkers responded with action directives more often than mothers of crawlers. Notably, differences in the responses of mothers of walkers versus those of crawlers were explained by differences in bid form between the two groups of infants. Walkers were more likely to engage in moving bids than crawlers, who typically shared objects from stationary positions. When crawlers displayed moving bids, their mothers offered action directives just as often as did mothers of walkers. Findings illustrate developmental cascades, wherein infants' locomotor status affects how infants share objects with mothers, which in turn shapes mothers' verbal responses.

Introduction

Emerging skills in one domain can have far-reaching, non-obvious consequences for development and experience in other domains. This idea is reflected in the theoretical construct of developmental cascades (Adolph & Robinson, 2013; Gottlieb, 1991; Masten & Cicchetti, 2010; Thelen & Smith, 1998). For example, the acquisition of sitting leads to more sophisticated visual-manual object exploration, which in turn, facilitates 3-D form perception (Soska, Adolph & Johnson, 2010). Here, we offer an additional illustration of a developmental cascade, in this case from motor skill acquisition to changes in linguistic input. We show how the transition from crawling to walking affects how infants share objects with their mothers, and how the form of infants' social bids, in turn, affects the verbal responses they receive.

Infant social bids and locomotion

Toward the end of the first year, infants' engagements with objects shift from being predominantly self-directed

to being a core means for sharing intentions with others (Masur, 1983). Infants increasingly use 'give' and 'show' gestures in active attempts to elicit adult engagement in triadic interactions that involve infant, adult, and object (Carpenter, Nagell & Tomasello, 1998; Trevarthen, 1993).

Although most researchers attribute developmental changes in infants' bids to cognitive factors, other non-cognitive factors affect the frequency and form of infant bids. Bids not only require the intention to share, but also the motor skills to execute those intentions (e.g. selecting, reaching, grasping, and extending objects to others). As a notable example, the transition from crawling to walking affects *how* infants share objects with their mothers – the form of their bids (Karasik, Tamis-LeMonda & Adolph, 2011). For example, at 11 months of age, infants primarily bid from a stationary position. By 13 months of age, those infants who could walk carried objects to their mothers to share (moving bids), but those infants who could only crawl continued to produce stationary bids.

The functional connection between locomotor status and bids illustrates the notion of developmental

cascades. Walking infants have their hands free, they move more efficiently, and they have a different vantage point on the world compared to crawlers (Adolph, 2008; Adolph, Cole, Komati, Garciaguirre, Badaly, Lingeman, Chan & Sotsky, 2012; Franchak, Kretch, Soska & Adolph, 2011). The changes that accompany the transition to walking in turn lead to new opportunities for sharing objects. Do infants' locomotor status and resulting changes to social bids also have implications for the types of verbal responses that infants receive from their mothers?

Mothers' responses to infant bids

Infant bids are salient social signals: Mothers respond to infant bids more frequently than to exploration or play (Bornstein, Tamis-LeMonda, Hahn & Haynes, 2008). Moreover, mothers are more likely to label the referents of bids than the referents of gestural requests (Masur, 1983). Perhaps bids elicit high responsiveness due to their unique communicative characteristics. Bids require infants to select, grasp, and extend objects to others, which contrasts with earlier emerging gestural points and open-handed reaching that do not involve direct object contact and can occur at various distances from the object and other people (Carpenter *et al.*, 1998). When infants bid with an object, mothers need not guess the target of their infants' attention, but need only notice the communicative attempt and respond accordingly.

Whether mothers differentially respond to crawlers versus walkers and whether mothers vary in the verbal information they offer in response to different bid forms remain untested. Mothers might be especially attuned to bids in which infants carry objects to them compared to bids in which infants are stationary. Moving bids require extra effort on the infants' part, but stationary bids require mothers to be in infants' vicinity and attend to their actions. Therefore, mothers might respond more often to moving bids than to stationary bids due to differences in the salience of the two bid forms.

Mothers might also differ in the *types* of responses they display to different bid forms. Mothers display different responses to different target infant actions, indicating a high level of specificity in the moment-to-moment exchanges between infants and mothers (Bornstein *et al.*, 2008; Tamis-LeMonda, Song, Leavell, Kahana-Kalman & Yoshikawa, 2012). For example, across infant age, mothers increase their use of questions in response to infant vocalizations (Bornstein *et al.*, 2008). They are also more likely to label the referent of developmentally advanced gestures such as showing than earlier emerging gestures such as pointing or requesting (Olson & Masur, 2011).

Infant locomotor status might also have implications for maternal responsiveness. If moving bids are more salient to mothers than are stationary bids and walkers display more moving bids than do crawlers, locomotor status might relate to maternal responsiveness through a process of developmental cascades. Mothers of walkers would respond in different ways from mothers of crawlers, with differences explained by differences in the bid forms of walking and crawling infants.

Current study

We examined mothers' verbal responses to infant object bids during everyday home routines. We asked whether infants' locomotor status (crawler or walker) and/or the form of infants' object bids (stationary or moving) predict the frequencies and types of verbal responses mothers offer their infants. We focused on 13-month-olds because infants of this age display frequent and variable forms of object bids. Moreover, some infants have begun walking while others are still crawling, enabling a test of the influences of locomotor status and bid forms on mothers' verbal responsiveness with infant age held constant. Analyses controlled for infants' language and gestural skills to ensure that variations in infants' bids and mother responsiveness were not attributed to the different communicative skills of infants.

Method

Participants and procedure

Fifty 13-month-old (± 1 week), healthy, term infants participated. At the start of the home visit, the experimenter verified infants' locomotor status. Twenty-six infants (12 girls, 14 boys) were crawlers and 24 (12 girls, 12 boys) were walkers. At an earlier home visit when infants were 11 months of age (± 1 week), all were crawlers. Thus, at the time of the current study, all infants had > 2 months of crawling experience and < 2 months of walking experience.

Mothers of crawlers and walkers were similar in age ($M = 35$ and 36 years, $SD = 4.08$ and 4.47 , respectively) and education (65% of mothers of crawlers and 75% of mothers of walkers held graduate degrees). More than half of mothers (80% of mothers of crawlers and 67% of mothers of walkers) identified their ethnicity as White. The remaining mothers identified their ethnicity as Asian (8%), Latino (6%), African American (4%), or mixed heritage (4%).

Infants were videotaped for 1 hour in their homes at a time most convenient for families. During taping, the

experimenter remained in the background and offered minimal responses to infants and mothers. Mothers were told that the purpose of the study was to document infants' interactions with their environment and were instructed to go about their normal activities. Mothers were unaware that their verbal responses to their infants' actions with objects would be the focus of the study. Objects were those normally available in the home. Families were recruited from the greater New York City metropolitan area via purchased mailing lists, brochures, referrals, and parenting websites. English was the primary language at home. Families received photo albums of their infants as souvenirs for participation.

Data coding

Behavioral data were coded from video files using a computerized video coding system, Datavyu (www.Datavyu.org) that records the frequencies and durations of specific behaviors. A primary coder scored every variable. A second coder scored 50% of the data to ensure inter-rater reliability. Inter-rater reliability ranged from 91% to 98% and κ s ranged from .89 to .97 ($ps < .001$). Disagreements were resolved through discussion.

Infant bids

Infants' bids with objects were coded when infants extended an object toward their mothers to show or offer it; each bid was classified as either 'stationary' or 'moving' (Figure 1 a, b; see Karasik *et al.*, 2011, for complete description).

Mothers' response type

For each infant bid, coders noted whether the mother verbally responded within a 5-s window, and if so, coded the type of response. *Affirmations* acknowledged infants' behaviors ('Thank you', 'Good') without providing additional information about the object or action; *referential* utterances provided information about objects ('Orange ball') or elicited information about the object ('What's that?'). *Action directives* were statements that encouraged infants' actions with the object or on the object ('Stack the blocks', 'Bring it here'). *No response* was coded in instances when mothers did not provide a verbal message after infants' bid, as well as when mothers made statements that were not related to the infant bid (e.g. 'I'm getting some coffee').

We calculated proportions for each type of maternal response (affirmation, referential, action directive, no response) to each type of infant bid (moving, stationary). For example, one infant accumulated five object bids

(a) Stationary Bid



(b) Moving Bid



Figure 1 Line drawings from video files illustrating the ways infants bid to mothers with objects. (a) Infant bidding from a stationary position, typically sitting while holding the object in hand, extending the arm in the direction of the mother; (b) Infant performing a moving bid after approaching the mother with the object and then extending the object toward her.

over the hour: two stationary and three moving. The mother responded with one referential statement and one action directive to the two stationary bids and with three action directives to the three moving bids. Thus, when the infant bid to the mother from a stationary posture, the mother split her responses between referential statements (.50) and action directives (.50). When the infant displayed moving bids, the mother exclusively offered action directives (1.00). We used proportions in analyses of variance because infants' bid rates for the two bid forms varied immensely and, as a result, mothers' opportunities to respond to infants' bids varied. For the repeated measures analysis of variance, zeros replaced missing scores for individuals (e.g. Olson & Masur, 2011; Pan, Imbens-Bailey, Winner & Snow, 1996).

Infants' language and gestures

Mothers reported their infants' gestural, receptive, and productive vocabularies using the MacArthur Communicative Development Inventory (Fenson, Dale, Reznick, Thal, Bates, Hartung, Pethick & Reilly, 2004). Infants' receptive vocabulary scores were the sum of words infants understood and the words they both understood and produced. Infants' productive vocabulary scores

were the words infants produced. Mothers also reported whether infants produced each of 12 gestures on the MCDI ‘sometimes’, ‘often’, or ‘not yet’. We gave infants a score of 1 if mothers reported that infants produced a particular gesture either sometimes or often and a score of 0 if mothers stated ‘not yet’ for a particular gesture. A composite gesture score was calculated by summing across these values (range = 0–12). On average, crawlers understood 39.54 words ($SD = 34.07$), spoke 6.71 words ($SD = 8.54$), and produced 7.33 gestures ($SD = 2.04$); walkers understood 45.36 words ($SD = 33.45$), spoke 4.59 words ($SD = 5.17$), and produced 6.86 gestures ($SD = 2.21$). There were no differences between crawlers and walkers on their receptive, productive, or gestural scores ($t_s = 0.68, 1.01, 0.75, p_s > .05$).

Results

We begin by reporting the frequencies and forms of infants’ bids to mothers. We then describe mothers’ responses to infants’ bids, compare the responses of mothers of crawlers versus walkers, and ask whether different bid forms result in different responses from mothers.

Frequency and forms of infants’ bids with objects

All infants bid to their mothers at least once, yielding a total of 783 bids at a rate of approximately one bid per 4 min. The objects that infants selected for sharing included toys (52% of bids), household items (32%), and books (16%). As reported previously (Karasik *et al.*, 2011), crawlers and walkers bid at similar rates. On average, crawlers bid 13.23 times ($SD = 11.13$) and walkers bid 18.29 times ($SD = 13.92$) per hour, $t(48) = 1.42, p > .05$.

The majority (75%) of bids were from stationary positions and 25% were moving bids. Moreover, the forms of infant bids varied with locomotor status (Karasik *et al.*, 2011). Crawlers exclusively bid to their mothers while stationary (97% of their bids), with all crawlers displaying stationary bids and only five crawlers displaying moving bids. In contrast, walkers were more balanced in the two forms of bids: 59% were stationary bids and 41% were moving bids. Virtually all walkers displayed both types of bids, with the exception of one walker who never bid while stationary and another who never displayed a moving bid. A 2 (locomotor status: crawlers vs. walkers) \times 2 (bid form: stationary and moving) ANOVA on the frequency of infants’ bids confirmed a significant main effect for bid form, $F(1, 48) = 35.54, p < .001$, and an interaction between locomotor status and bid form, $F(1, 48) = 12.31,$

$p < .01$. Post-hoc, Sidak-corrected pairwise comparisons showed that walkers exhibited more moving bids ($M = 7.54$ moving bids, $SD = 1.06$) than crawlers ($M = 0.42, SD = 1.02$), $p < .001$, but similar numbers of stationary bids ($M = 10.75$ and $12.81, SD = 1.98$ and 1.90 , for walkers and crawlers, respectively), $p > .05$.

Regressions controlling for infant gender and the three MacArthur variables (words produced, expressed, and number of gestures) confirmed the robustness of the association between locomotor status and infant bid form. Total object bids, stationary bids, and moving bids served as dependent variables. None of the variables predicted total bids and total stationary bids ($p_s > .05$); however, locomotor status (crawler vs. walkers) predicted ($R^2 = .36$) total moving bids above controls ($\Delta R^2 = .26, F = 17.19, p < .001$).

Mothers’ verbal response to infants’ bids

Figure 2 shows each mother’s verbal responses to their infant’s bids. Overall, mothers responded to 79.6% of infant bids, virtually all mothers (94%) responded to at least one infant bid, and 86% of mothers at times offered an informative message of reference or action – mothers described or labeled the object or told infants what to do with it.

To investigate whether mothers’ response types differ with infants’ locomotor status and form of bid, we conducted a 2 (locomotor status) \times 2 (bid form) \times 4 (response type) ANOVA. Mothers’ response types were calculated as a proportion of infant bids. This analysis yielded significant two-way interactions between locomotor status and maternal response, $F(3, 144) = 7.39,$

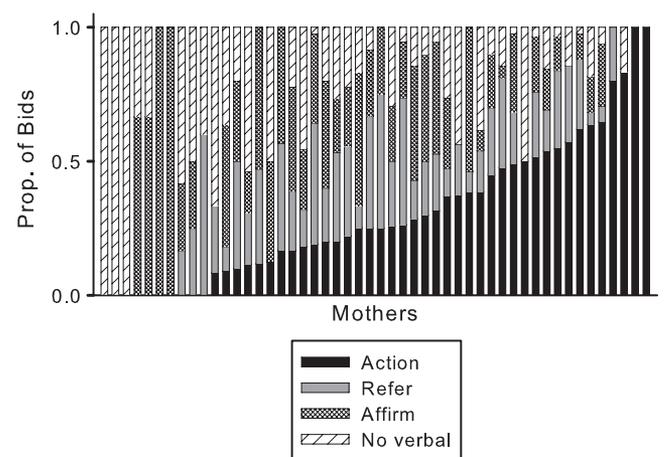


Figure 2 Distribution of maternal responses graphed as a proportion of infants’ bids for 50 mothers; each bar represents one mother. Data are sorted from mothers who provided no verbal response to mothers who mostly give action directives.

$p < .001$, and bid form and response type, $F(3, 144) = 20.37$, $p < .001$; and a significant three-way interaction between locomotor status, bid form, and response type, $F(3, 144) = 3.71$, $p < .05$.

Mothers' response types differed for crawlers and walkers. The interaction between locomotor status and maternal response type indicated that mothers of walkers were more likely to respond with an action directive ($M = .45$, $SD = .23$) than were mothers of crawlers ($M = .16$, $SD = .21$). In contrast, mothers of crawlers were more likely to provide no verbal response to their infants ($M = .36$, $SD = .32$) than were mothers of walkers ($M = .17$, $SD = .16$). Post-hoc, Sidak-corrected pairwise comparisons confirmed these differences, $ps < .05$ (see Figure 3).

Mothers responded differently to the two forms of infant bids. The interaction between bid form and maternal response type shows that when infants engaged in moving bids, mothers were more likely to respond with action directives ($M = .40$, $SD = .41$) than affirmations

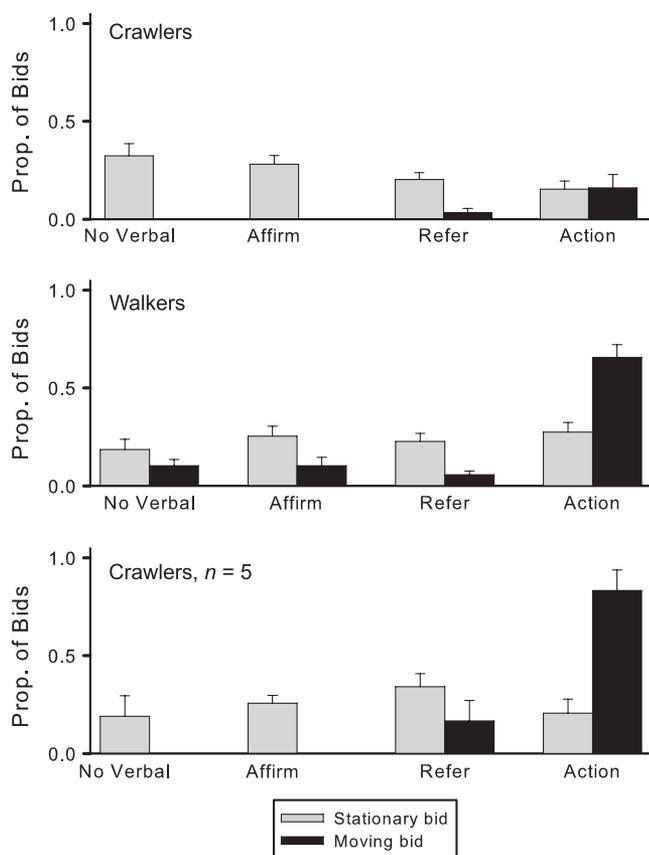


Figure 3 Distribution of maternal responses graphed as a proportion of infants' bids: data for mothers of all crawlers; data for mothers of all walkers; and data for mothers of five crawlers who displayed a moving bid at least once. Error bars represent the standard error of the mean.

($M = .05$, $SD = .16$), referential statements ($M = .04$, $SD = .11$), or to provide no verbal response ($M = .07$, $SD = .15$). Post-hoc, Sidak-corrected pairwise comparisons confirmed these differences, $ps < .05$. In contrast, there were no differences in mothers' response types when infants bid from stationary positions. Mothers were equally likely to affirm infants' behaviors ($M = .28$, $SD = .24$), to describe the object ($M = .22$, $SD = .19$), use an action directive ($M = .21$, $SD = .24$), or not to respond ($M = .29$, $SD = .30$).

Perhaps differences in how mothers respond to the different bid forms also explain the greater prevalence of action directives to walkers. Indeed, a three-way interaction indicates that the high use of action directives in response to moving bids was more pronounced in mothers of walkers than mothers of crawlers due to the more frequent displays of moving bids of walking infants. Mothers of walkers were more than twice as likely to offer an active directive to their walkers after a moving bid ($M = .69$, $SD = .33$) than after a stationary bid ($M = .28$, $SD = .25$) (Figure 3). Post-hoc, Sidak-corrected pairwise comparisons confirmed these differences, $ps < .05$.

To further test whether infant bid types explain differences in the responses of mothers of crawlers versus walkers, we re-analyzed data for the five of 26 crawlers who demonstrated moving bids during the session. When data for these five crawlers were examined separately and compared with data for the walkers (Figure 3), mothers of crawlers and walkers were indistinguishable in the responses they offered their infants: The high rates of action directives paralleled those seen in mothers of walking infants. That is, as seen for mothers of walkers, mothers of crawlers were more likely to offer action directives in response to crawlers' moving bids ($M = .83$, $SD = .24$) than in response to their stationary bids ($M = .21$, $SD = .16$). Mothers of the five crawlers always offered verbal information when crawlers approached them with objects to share. But when the five crawlers bid from a stationary position, their mothers were just as likely not to respond verbally ($M = .19$, $SD = .23$) as were mothers of walkers ($M = .20$, $SD = .26$).

To verify that bid type – rather than locomotor status – affects mothers' use of action directives, we followed up the 2 (locomotor status) \times 2 (bid form) \times 4 (response type) ANOVA with a Generalized Estimating Equation (GEE) model with a binomial probit function (Hardin & Hilbe, 2003). This analysis treats the unit of analysis as the bid rather than treating the unit of analysis as the child (proportion of maternal responses), thereby providing a robust way to confirm the effects obtained from the ANOVA. Mothers' verbal responses were recoded as either 'action directives' or 'other' statements and were used as the dependent variable in the model.

Infants' locomotor status and bid type were used as predictors. The GEE showed only a main effect of bid type, Wald $\chi^2(1, N = 783) = 35.96, p < .001$. Mothers were more likely to offer action directives to moving bids than to stationary bids. The lack of a significant interaction indicates that although walkers exhibited moving bids more often than crawlers, when either locomotor group exhibited moving bids mothers were likely to provide action directives.

Discussion

At the start of the second year, infants display notable changes in the frequencies and forms of their social bids to mothers, reflecting their heightened appreciation that others are social partners who can share attention and intention around objects and events. Around the same time, infants transition from crawling to upright locomotion, which frees up their hands for carrying (Karasik, Adolph, Tamis-LeMonda & Zuckerman, 2012), provides a more efficient means for getting around, and offers infants a new visual vantage point, including the ability to monitor their mothers' whereabouts (Kretch, Franchak, Brothers & Adolph, 2012). In an illustration of developmental cascades, we showed that the seemingly disparate skills of sharing objects and upright locomotion are functionally connected and have implications for the types of verbal information that infants receive from their mothers. Although correlational in nature, this study offers a process account of how locomotor status may affect infants' social experiences.

Specifically, we examined mothers' verbal responses to the bids of their crawling and walking infants in the context of everyday interactions at home. When bidding with objects, infants remained in place or approached mothers to share (Karasik *et al.*, 2011). Mothers could affirm infants' bid ('Thank you'), reference the object ('That's a blue ball'), offer an action directive ('Let's stack it'), or offer no verbal response. Overall, mothers responded to infant bids at high rates, indicating that bids are salient social signals that elicit rich verbal information. However, mothers of crawlers and mothers of walkers differed in the *types* of responses they provided their infants, and differences in the bid forms of crawlers and walkers explained mothers' response types.

Bids are salient social signals

Infant bids were salient social signals: Almost all mothers (94%) responded to at least one bid and the majority (84%) never missed an opportunity to respond. When responding, mothers provided infants with encouragement,

referential statements, and action directives. These findings accord with other studies that have documented high maternal responsiveness to infant bids, and highlight infants' active role in their development and experiences (Bornstein *et al.*, 2008; Tamis-LeMonda, Bornstein & Baumwell, 2001). When infants bid to their mothers, they are likely to elicit verbal information that is relevant to the focus of their attention, a condition that facilitates word learning (Tomasello & Farrar, 1986) and may explain associations between infant gestures and productive language (Brooks & Meltzoff, 2008).

Locomotor status and bid forms

Mothers of crawlers and mothers of walkers differed in the frequencies and types of responses they provided their infants. Mothers of crawlers were twice as likely not to respond as were mothers of walkers and mothers of walkers were three times as likely to provide action directives as were mothers of crawlers. Infants' communicative abilities or locomotor status *per se* did not explain these differences. Crawlers and walkers did not differ on language or gestural vocabularies, and analyses controlled for infants' vocabulary sizes.

Rather, the forms of infants' bid explained differences in the responses of mothers of walkers versus crawlers. Walkers were more likely to engage in moving bids than were crawlers, whereas crawlers were more likely to bid from stationary positions. Mothers, in turn, were more likely to respond with action directives to moving bids than to stationary bids. Sub-analyses on the five crawlers who engaged in moving bids indicated that when crawlers displayed moving bids, their mothers offered action directives at similar rates to mothers of walkers. Conversely, when walkers bid from stationary positions, their mothers displayed responses that mirrored the responses seen in mothers of crawlers.

Why did mothers differentially respond to the two bid forms? Moving bids may be especially salient communicative signals. An infant who carries an object over to mother for sharing is clearly inviting the adult to participate, and this gesture may be unavoidable. Moving bids may thus be an important form of social exchange: mothers are less likely to miss these chances to offer a verbal message, and they are more likely to respond to these bid forms with action directives than they are to bids that do not require as much effort on the infant's part.

Developmental cascades

Previous research shows that with the onset of independent walking, infants increase their interactions with mothers (Clearfield, 2011; Clearfield, Osborne &

Mullen, 2008; Gustafson, 1984) and increase displays of both positive and negative affect (Biringen, Emde, Campos & Appelbaum, 1995, 2008). The current findings add to this literature by providing a process account of how a change in infants' locomotor status – walking – has consequences for object sharing (Karasik *et al.*, 2011), which in turn has implications for the types of verbal response that infants receive from their mothers. Had we only focused on differences in the responses of mothers' of crawlers versus walkers, without examining the intervening measure of social bids, we might have narrowly concluded that differences in mothers' responses were explained by infants' locomotor posture *per se*. Instead, it appears that benefits associated with walking – including freeing up of the hands and the ability to locate the mother and move in her direction (Karasik *et al.*, 2011) – sets in motion a cascading effect that ultimately affects the language that infants hear.

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