**Developmental Pathways between Infant Gestures and Symbolic Actions, and Children's
Communicative Skills at Age 5: Findings from the All Our Families Pregnancy Cohort**

Elizabeth Morin-Lessard,

Rochelle F. Hentges,

Suzanne C. Tough^a,

Susan A. Graham^a

University of Calgary

^aSusan A. Graham and Suzanne C. Tough share senior authorship on this manuscript.

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Corresponding Authors:

Elizabeth Morin-Lessard, Ph.D.¹ & Susan A. Graham, Ph.D.²

Department of Psychology

University of Calgary

2500 University Dr. NW

Calgary, Alberta, Canada

T2N 1N4

Email¹: elizabeth.morinlessa@ucalgary.ca

Email²: grahams@ucalgary.ca

Abstract

Using data from the All Our Families study, a longitudinal study of 1992 mother-child dyads in Canada (47.7% female; 81.9% White), we examined the developmental pathways between infant gestures and symbolic actions and communicative skills at age 5. Communicative gestures at age 12 months (e.g., pointing, nodding head “yes”), obtained via parental report, predicted stronger general communicative skills at age 5 years. Moreover, greater use of symbolic actions (e.g., “feeding” a stuffed animal with a bottle) indirectly predicted increased communicative skills at age 5 via increased productive vocabulary at 24 months. These pathways support the hypothesis that children’s communicative skills during the transition to kindergarten emerge from a chain of developmental abilities starting with gestures and symbolic actions during infancy.

Keywords: gestures, symbolic actions, communicative skills, productive vocabulary

Developmental Pathways between Infant Gestures and Symbolic Actions, and Children's Communicative Skills at Age 5: Findings from the All Our Families Pregnancy Cohort

Gestures help usher infants into the world of language and communication. Gesture use emerges during the first year of life before infants reliably produce spoken words (Goldin-Meadow et al., 2007; Goodwin & Acredolo, 1998), allowing infants to communicate their wants and needs (Bates et al., 1979). Even when children become more experienced language users, gestures may be used when having difficulty finding a word (Nicoladis, 2002), to augment verbal communication (Iverson et al., 1994; Namy & Waxman, 2002), plan speech (Alibali et al., 2000), and can facilitate lexical access (Krauss, 1998). As one of infants' first communicative tools, gestures may be one of the earliest indicators of later cognitive and language skills (Kuhn et al., 2014; Rowe & Goldin-Meadow, 2009). When children begin to understand objects and how they are used by adults, they also begin using symbolic actions. Symbolic actions involve a pretend component (e.g., pretending to be a parent, imitating adult actions) and show a more advanced understanding of objects by children (Fenson et al., 2007; Goodwyn & Acredolo, 1998). Here, we examined the developmental pathways between infants' communicative gestures and symbolic actions and their communicative skills at 5 years of age, capitalizing on data from a large prospective cohort study. Specifically, we examined whether children's communicative gesture use and symbolic actions at 12 months differentially predicted general communicative outcomes at age 5 and whether these effects were mediated by children's productive vocabulary size at age 24 months.

Gesture use in infancy has been consistently linked with indicators of early language development, particularly vocabulary size (e.g., Acredolo & Goodwyn, 1988; Iverson & Goldin-Meadow, 2005; Rowe et al., 2008; Rowe & Goldin-Meadow, 2009). For example, 14-month-

olds' observed gestures predicted their vocabulary size at age 42 months, even when controlling for the child's and caregiver's vocabulary use at 14 months (Rowe et al., 2008). Furthermore, research suggests that, rather than the number of gestures and speech combinations that children use, it is the number of different meanings conveyed by gestures at 18 months that predicts children's vocabulary at 42 months (Rowe & Goldin-Meadow, 2009). The associations between gestures and vocabulary have also been shown in studies using parent reports of children's gestures (Bavin et al., 2008; Reilly et al., 2009). In one such study, parents of 1447 children were asked about their child's communicative behaviours at 8-, 12- and 24-months (Bavin et al., 2008) using the standardized MacArthur-Bates Communicative Development Inventory (Fenson et al., 2007). Results indicated that the total number of different types of gestures and object manipulations produced at 12 months predicted larger vocabularies at 24 months, consistent with findings from the smaller-scale observational studies.

The research reviewed above highlights the established associations between gesture use in infancy and language outcomes during the preschool years. Building upon this research, we investigated the question of whether children's first communicative gestures and symbolic actions are more broadly linked with general communicative skills at 5 years of age. In particular, we addressed two key questions. First, we examined whether greater gesture use in infancy is associated with communicative skills at age 5, using a scale that assesses language and communicative skills (e.g., speech, syntax, semantics), and pragmatic aspects of communication (e.g., context, non-verbal communication, social relations). Given that the pathway between gestures and vocabulary is well-established, we investigated whether one of children's earliest communicative tools predicts their later communicative skills, and whether vocabulary underlies this potential long-term relation. Children's language abilities impact a variety of school

readiness domains (Lee, 2011; Prior et al., 2011), and general communicative skills are important not only for children's academic development, but also for their social and emotional development (e.g., Hebert-Myers et al., 2006; McCabe & Meller, 2004). As such, clarifying the developmental precursors of general communicative skills can shed light on the processes that can promote positive outcomes as children prepare for kindergarten entry.

Second, to test the unique predictive ability of communicative gestures and symbolic actions, we simultaneously examined the effects of social communicative gestures and symbolic actions with real or pretend objects (e.g., "drinking" tea from a toy tea set) on communicative skills at age 5 within the same analytical model. Our measure of social communicative gestures includes both "deictic" gestures that establish reference (e.g., pointing to objects and showing them to adults; Bates et al., 1979; Caselli et al., 2012; Liszkowski et al., 2004) and gestures that are culturally appropriate routines and means of communication (e.g., shaking head "no", blowing kisses). Deictic gestures can help children refer to entities and help provide referential information during communication (Caselli et al., 2012; Gliga & Csibra, 2009; Goldin-Meadow, 1999; Werner & Kaplan, 1963). Other communicative gestures show an early understanding of social norms and conventions, which is important for productive socio-emotional interactions (Denham & Brown, 2010). Symbolic actions, on the other hand, are thought to appear in children's communicative repertoire once they gain a better knowledge of objects and their uses by adults. We use the term "symbolic actions" to refer to actions and gestures (e.g., symbolic gestures) that are symbolic in nature, and that involve pretense and an element of play. These symbolic actions represent actions with real and pretend objects and imitations of adult behaviours (e.g., pretending to make a toy plane "fly", feeding a doll with a bottle, blowing to indicate something is hot), and are thought to reflect a more complex understanding of objects

and how they are used by adults (Fenson et al., 2007; Goodwyn & Acredolo, 1998). Symbolic acts are evidence that children have achieved a more enhanced level of communication with their caregivers (Acredolo & Goodwyn, 1988), and can use their hands and bodies to represent events or entities (e.g., actions, people, and objects; Volterra & Erting, 1994).

When considering communicative gestures, direct links have been found between pointing and language, for both language comprehension and production (e.g., Colonnese et al., 2010; Iverson & Goldin-Meadow, 2005; Rowe & Goldin-Meadow, 2009; Salo et al., 2019). For example, a longitudinal study of infants aged 6 to 18 months demonstrated that children who pointed had larger vocabularies than children who did not point, in both cross-sectional and longitudinal observations (Moore et al., 2019). Since more rudimentary communicative gestures (e.g., pointing, reaching for objects, nodding head “no”) are a predictor of later language (e.g., vocabulary; Bavin et al., 2008), they may serve as a foundation for and indicator of later communicative skills (Liszkowski, 2008). As such, they may not only predict later productive vocabulary in children but may also predict more general communication abilities later on.

Symbolic actions may also be linked to language outcomes. For example, children’s symbolic actions at 19 months (e.g., sniffing a flower) are linked with their productive vocabulary, both concurrently and at 24 months (Acredolo & Goodwyn, 1988). Furthermore, caregivers who are encouraged to use symbolic gestures while talking have children who show advantages in receptive and productive language development (Goodwyn et al., 2000). In older children, performance on a symbolic telephone task (pretending to call a friend on a toy phone) at age four predicts receptive vocabulary at age five (Kızıldere et al., 2020). Symbolic actions (e.g., actions that reflect pretend play, imitating of parents) are thought to be closely linked to language, since both are symbolic (Quinn et al., 2018; Werner & Kaplan, 1963), and symbolic

actions carry meaning by representing actions that others would perform in real life. As such, symbolic actions may also be important for later communicative language development, since they are more complex and reflect a better symbolic understanding of objects.

In summary, we examined the associations between the use of gestures and symbolic actions in infancy and communicative outcomes at age 5. Although communicative gestures (e.g., deictic gestures) and symbolic actions have been examined independently as precursors of later language abilities, no prior study, to our knowledge, has examined how both sets of skills, measured at the same time point in infancy, might independently predict later language and communicative abilities. Using longitudinal data from the All Our Families study, a large-scale prospective cohort study, we obtained parent reports of the number of different types of gestures produced by children (e.g., whether a child points, reaches, waves goodbye). This contrasts with previous research that has examined how the number of different meanings accompanying each gesture predicts language development (i.e., pointing to a dog and pointing to a shoe would reflect two different gestural meanings; Rowe & Golden-Meadow, 2009) as well as with research that has examined the frequency of a given gesture being produced during an observational task. We also obtained parent reports of symbolic actions produced by their child. We addressed two research questions. First, we examined the unique predictive utility of children's first communicative gestures and symbolic actions produced at 12 months directly on communicative skills at age 5. Second, in accord with developmental cascade approaches to development (Masten & Cicchetti, 2010), we examined whether first communicative gestures and symbolic actions would have an indirect effect on later communicative abilities through their effect on increased productive vocabulary at 24 months. In keeping with prior research, we expect that both gestures and symbolic actions will predict vocabulary size one year later, and vocabulary

size is hypothesized to predict future communicative abilities. Due to the lack of longitudinal research examining the unique predictive ability of gestures versus symbolic actions produced in infancy on communicative abilities at age 5, we do not make specific a priori hypotheses about the direct effects of early gestures and symbolic actions on later communicative abilities: these analyses are exploratory. In our analyses, we controlled for environmental factors and medical variables that are known to affect language development: Household income, maternal education, child's gender, birthweight, parental reading to the infant and primary language spoken in the home (Flack et al., 2018; Hentges et al., 2019; McKean et al., 2015; Reilly et al., 2007; Reilly et al., 2009; Rowe et al., 2008). As a rigorous test of our model, we also controlled for receptive and productive vocabulary at 12 months. Together, this rich and large dataset represents a new opportunity to look at whether children's earliest communicative behaviors predict their general communicative outcomes at age 5 using a scale that assesses language skills (e.g., speech, syntax, semantics), and pragmatic aspects of communication (e.g., non-verbal communication, social relations).

Method

Participants

Participants were mother-child dyads drawn from the All Our Families study, a longitudinal prospective pregnancy cohort examining associations between prenatal and early life variables, and outcomes for mothers and their children living in Calgary, a large city in western Canada (Tough et al., 2017). In total, 3387 pregnant women aged 19 to 47 years ($M = 31.4$, $SD = 4.4$) were recruited from primary health care facilities and via posters and ads strategically placed in the community between 2008 and 2011. To be included in the cohort, mothers had to be at least 18 years old, be able to fill out questionnaires in English, and have a

gestational age of less than 25 weeks at the beginning of the study (see Tough et al., 2017 for the full cohort inclusion criteria). Although the All Our Families study was originally funded only for a 4-month postnatal assessment period, additional funds were subsequently acquired to continue following the cohort through early childhood. Because of the timing of funding attainment and ethics approval, some participants had aged out of subsequent assessment periods. Thus, sample sizes at 12 months, 24 months, and 5 years were smaller compared to the initial assessment at 4 months. For the purposes of the present study, we only included children whose mothers had completed the communication outcome questionnaire at age 5, resulting in a sample size of 1992 children, with 1041 males (52.3%) and 950 females (47.7%) (and $n = 1$ not reported). See Table 1 for sample characteristics (ethnic background, maternal education, family income). Procedures were approved by the University of Calgary Research Ethics Board.

Measures

Data were collected as follows: The initial recruitment period began in 2008, and the 5-year follow-up began in 2013 and ended in 2017 (Tough et al., 2017).

Communicative Gestures

At 12 months post-partum, mothers completed the American English MacArthur-Bates Communicative Development Inventory – Words and Gestures (MCDI-WG; Fenson et al., 2007). The MCDI-WG asks parents to report on their infants' production of gestures as well as their receptive and productive vocabulary. For the purposes of this study, we examined children's first communicative gestures. This *First Communicative Gestures* component comprises 12 items (see Table 2), and asks parents about their child's first communicative gestures and their frequency of production (with answer options "Not Yet", "Sometimes", or "Often"). The First Communicative Gestures scale includes deictic gestures (e.g., pointing at

some interesting object or event) and social or conventional gestures (e.g., shaking head “no”). Consistent with MCDI-WG scoring guidelines (Fenson et al., 2007), a gesture counted as being produced (“1”) if a parent answered that their child either produced the gesture “Sometimes” or “Often”. A gesture did not count as being produced if the parent selected “Not Yet” (“0”). The final score represents a sum of the different types of gestures produced by children. Internal reliability was satisfactory, $\alpha = .75$.

Symbolic Actions

The *Symbolic Actions* component comprises 33 items, and was created by combining subscale items from the MCDI-WG (see Table 2). Specifically, all items from the MCDI-WG subscales “Pretending to be a Parent” (e.g., putting stuffed animals or dolls to bed; 13 items) and “Imitating other Adult Actions” (e.g., “driving” a car by turning the steering wheel; 15 items) were included as indicators of symbolic actions. In addition, we included 5 items from the “Actions with Objects” scale that involved pretend actions: Lay head on hands and squeeze eyes shut as if sleeping, blow to indicate something is hot, hold a toy plane and make it “fly”, pour a pretend liquid from one container to another, stir a pretend liquid in a cup or pan with a spoon. However, we excluded 12 items from this subscale that were more indicative of motor development (e.g., putting on a hat, throwing a ball) as opposed to being truly symbolic in nature. The resulting 33 items were used to create a sum score of symbolic actions. Symbolic Actions were counted as being produced if a parent answered that their child engaged in the action by selecting “Yes” (vs. “No” if the child did not engage in the action). This scale showed good internal reliability, $\alpha = .87$.

Both the gesture and symbolic action measures in the MCDI-WG have shown good agreement with observed gestures in children (e.g., Blake et al., 2003) and predict later language skills (e.g., expressive language at 24 months; Laakso et al., 1999).

Productive Vocabulary

At the 24-month assessment period, mothers completed the MacArthur-Bates Communicative Development Inventory – Words and Sentences (MCDI-WS; Fenson et al., 2007), which assesses 16- to 30-month-old children's expressive vocabulary, resulting in total productive vocabulary scores ranging from 0 to 680.

Communicative Skills

When children were 5 years old, mothers completed the Children's Communication Checklist-2 (CCC-2; Bishop, 2003). The CCC-2 is a 70-item measure divided into 10 scales, which is used to assess overall language (e.g., speech, syntax, semantics, coherence) and social communicative skills (e.g., nonverbal communication, social relations) in children ages 4 to 16 years who can speak in sentences and whose primary language is English. For example, items ask caregivers whether their child leaves out "is" (e.g., says "Mommy going to work" instead of "Mommy is going to work"; syntax) and forgets words they know (e.g., says "the green animal with a shell that walks slowly..." instead of saying "turtle"; semantics). Mothers completed the Caregiver Response Form of the CCC-2 and rated the frequency with which their child demonstrated a particular communication behavior on a 4-point scale ranging from "0" (Less than once a week (or never)) to "3" (Several times (more than twice) a day (or always)). Once completed, the measure yielded an age-standardized communication composite score ($M = 100$, $SD = 15$) to assess children's general communicative abilities.

Covariates

Five socio-demographic and medical variables that are known to be associated with vocabulary development and language outcomes were added as covariates in this study: family income, maternal education, primary language spoken in the home, child's gender, and child's birthweight (Collison et al., 2016; Hentges et al., 2019; McKean et al., 2015; Reilly et al., 2007; Reilly et al., 2010). We also included receptive and productive vocabulary at 12 months as covariates, due to their links with gestures and language (e.g., Caselli et al., 2012; Bavin et al., 2008). Finally, we also controlled for book-reading to the child as a proxy for parental language input. During the first assessment period of the study (i.e., less than 25 weeks gestation), mothers completed demographic questionnaires and reported their education level, total household income, and primary language(s) spoken at home. Maternal education was reported on a scale of 1 (some elementary or high school) to 6 (completed graduate school), and total household income was reported in increments of \$10,000 Canadian dollars, from 1 (\$10,000 or less) to 11 (\$100,000 or more). Primary language spoken in the home was recoded as a dichotomous variable with "1" for English and "0" for other, non-English languages. Child gender was reported as male ("1") or female ("2"). To assess parental reading, mothers responded to the following statement at 12 months of age: "I look at or read children's books to my child" with either not very often ("1"), sometimes ("2"), or often ("3"). Finally, child birthweight data were obtained from medical records at delivery and were reported in grams. See Tables 1 and 3 for a breakdown of these and other sample characteristics.

Statistical Analysis Plan

Analyses of predictive pathways were performed in SPSS AMOS version 26.0. We conducted path analysis models to examine the effect of First Communicative Gestures and Symbolic Actions at 12 months on communicative development at 5 years via productive

vocabulary at 24 months. The use of a path analysis model was chosen as an approach to establish mediation (Fairchild & McDaniel, 2017), with this study's longitudinal design providing a more robust test of mediation than a cross-sectional design. The covariates described above (income, maternal education, child's birthweight, primary language spoken in the home, gender, reading, receptive vocabulary, and productive vocabulary) were included in all the models. To maximize the sample size of children with available data, all analyses used full information maximum likelihood (FIML). FIML was chosen to handle missing data since it maintains the original structural association between variables in the model, minimizes bias due to sampling error from missing data, and is considered superior to list-wise and pair-wise deletion (Enders & Bandalos, 2001). The resulting sample on which analyses were performed included 1992 children in total.

Results

Descriptive data and bivariate correlations at Time 1 (12 months), Time 2 (24 months), and Time 3 (5 years) are reported in Table 3.

We ran two models: Results of Model 1 with First Communicative Gestures and Symbolic Actions as predictors are presented in Figure 1, and results of Model 2 with First Communicative Gestures and Symbolic Actions as predictors with Productive Vocabulary as an intermediary mechanism are presented in Figure 2. Although only the pathways of interest are shown in the figures, all possible predictive pathways between exogenous variables (i.e., not predicted by other variables) and endogenous variables (i.e., predicted by other variables) were estimated. All possible covariances between the covariates in the model were also estimated. Because the models were fully saturated, model fit indices reflected perfect model fit, $\chi^2(0, N = 1992) = .00$,

CFI = 1.00, TLI = .00). Additional analyses with deictic gestures only (4 items) instead of the First Communicative Gestures scale are reported online as Supporting Information.

Model 1 investigated the direct effect of 12-month First Communicative Gestures and Symbolic Actions on 5-year communicative skills. Both predictors were included in the same model to test the unique predictive utility of First Communicative Gestures and Symbolic Actions on communicative skills; thus, the effect of First Communicative Gestures on communicative skills controls for the association between Symbolic Actions and communicative skills (and vice versa). As shown in Figure 1, First Communicative Gestures at 12 months directly predicted communicative skills at age 5, $\beta = .07, p = .045$. Symbolic actions, however, did not exert a direct effect on general communicative skills at age 5, $\beta = .005, p = .89$.

In Model 2, both First Communicative Gestures and Symbolic Actions at 12 months were again in the same model, but we also included productive vocabulary at 24 months as a potential mediator. Results of this model are presented in Figure 2. Supporting the role of productive vocabulary as a potential mediator, the direct effect between First Communicative Gestures and communicative skills at age 5 became non-significant with the inclusion of productive vocabulary in the model, $\beta = .047, p = .16$. Specifically, the effect size was reduced by 33% with the inclusion of productive vocabulary in the model. In addition, First Communicative Gestures predicted higher productive vocabulary at 24 months, $\beta = .082, p = .01$, which in turn predicted better communicative skills at age 5, $\beta = .303, p < .001$.

Next, we calculated indirect effect estimates using the online package RMediation (Tofighi & MacKinnon, 2011; <https://amplab.shinyapps.io/MEDCI/>). To further support the role of productive vocabulary as a mediator in the association between First Communicative Gestures at 12 months and communication skills at age 5, bootstrapping tests using RMediation (Tofighi &

MacKinnon, 2011) revealed a significant indirect effect, $IE = 0.163$ ($SE = 0.055$), 95% confidence interval $[0.059, 0.273]$.

Although Symbolic Actions did not directly predict general communication skills in either model, Symbolic Actions predicted higher productive vocabulary at 24 months, $\beta = .084$, $p = .02$, which in turn predicted better communicative skills at age 5, $\beta = .303$, $p < .001$. Bootstrapping tests revealed a significant indirect effect, $IE = 0.063$ ($SE = 0.027$), 95% confidence interval $[0.012, 0.117]$. An indirect effect without a direct effect can be interpreted as a chain of events or developmental cascade (Masten & Cicchetti, 2010) that links the predictor (i.e., Symbolic Actions) to the dependent variable (i.e., communicative skills) via a third, more proximal and intervening variable (i.e., productive vocabulary).

Discussion

By analyzing data from a large prospective cohort study and by controlling for key environmental and genetic factors that influence language development and receptive vocabulary at 12 months, our results highlight a developmental pathway whereby gestures at 12 months, but not symbolic actions, directly predict communicative outcomes at 5 years of age, a key transition period as children begin entering kindergarten. Further, our results demonstrated that both gestures and symbolic actions predicted communicative skills four years later, via productive vocabulary at 24 months.

First Communicative Gestures directly predicted higher communicative skills at 5 years. Since communicative gestures show an understanding of objects and social conventions via gestures, this foundational use of gestures in infancy may signal that the child is a skilled vocabulary learner (i.e., of gestural vocabulary, in the case of gestures), and that they can socially engage with their caregivers to communicate (Rowe & Goldin-Meadow, 2009).

Critically, we found that these first communicative gestures predict children's communicative skills many years later, which broadens previous links with vocabulary to communicative skills more generally.

Our finding that productive vocabulary size acts as an intermediary mechanism between gestures and later communicative outcomes adds to research documenting the association between infant gesture use and vocabulary size during the preschool years (e.g., Acredolo & Goodwyn, 1988; Rowe & Goldin-Meadow, 2009; Rowe et al., 2008). Our results extend this research by demonstrating a developmental pathway of unfolding and increasingly complex communicative skills: from gestures at 12 months to expressive vocabulary at 24 months, to general communicative abilities (i.e., semantics, syntax, coherence) at 5 years of age. Thus, we both replicate the gesture-vocabulary link that has been found in previous research (e.g., Iverson & Goldin-Meadow, 2005; Rowe & Goldin-Meadow, 2009) and extend this literature by documenting that it predicts later communicative skills in children aged 5 years.

In contrast to the direct effect between first communicative gestures and later communicative skills, symbolic actions did not directly predict communication skills at age 5. Instead, symbolic actions were indirectly associated with later communicative skills via increased productive vocabulary at 24 months. Symbolic actions reflect more complex, symbolic meanings and thus, may be more likely to be paired with verbal utterances (e.g., "dishes" with the action of pretending to wash the dishes), which could account for the finding that symbolic actions was linked with increased vocabulary size at 24 months. This possibility is in keeping with research showing relations between producing more symbolic gestures and larger productive vocabulary at 24 months (Acredolo & Goodwyn, 1988), and with results from a

recent comprehensive meta-analysis indicating robust associations between symbolic play and language abilities (Quinn et al., 2018).

These results beg the question of why productive vocabulary would act as an intermediary mechanism between both communicative gestures and symbolic actions on general communicative skills assessed four years later. One possibility is that child gestures and symbolic actions elicit increased responsiveness in caregivers (Vallotton, 2009), and parental responsivity is further linked with better language outcomes in children (Madigan et al., 2019). Another possibility is that infants' gestures and symbolic actions lead caregivers to translate their child gestures by assigning words onto the gestures or actions (Goldin-Meadow et al., 2007; LeBarton et al., 2015). For example, if a child is pretending to vacuum the house, their caregiver might say "Are you *vacuuming*? Thank you for helping me clean the house with a *vacuum*!". This labelling by caregivers in response to infant gestures and actions reinforces action words and nouns (Olson & Masur, 2015), which could then explain why gesture-rich interactions lead to larger vocabularies in children (Goldin-Meadow et al., 2007), and this richer vocabulary in turn fosters better overall communicative skills. This proposal is in line with both the ideas that the child's early learning environment has a cascading effect on later skills by school entry (e.g., Tamis-LeMonda et al., 2019), and that skills beget skills (e.g., Blair et al., 2015).

Limitations

Some limitations of this research must be acknowledged. First, this cohort is a relatively low-risk community sample and thus these results may not generalize to high-risk populations (e.g., low-income, developmentally delayed), atypical populations, and speakers of languages other than English or individuals of other cultures (e.g., Tamis-LeMonda et al., 2012). Second, since measures were obtained via questionnaires filled out by mothers, we cannot exclude the

possibility of bias in caregivers' reports. For example, perceived desirability may influence parental report of a child's language knowledge and exposure (e.g., parents may overestimate the words that their child produces; Byers-Heinlein et al., 2019). Given that only mothers filled out questionnaires at each wave, any reporting biases should affect reporting consistently across timepoints. Moreover, the measures used in this study (i.e., MCDI Questionnaires, CCC-2) are known to be reliable and valid, and show high correlations with observational and standardized assessments in the vocabulary and gestural domains (Blake et al., 2003; Fenson et al., 1993). Third, some of the variables used in this study – reading to the child, in particular – may fail to capture the richness of language interactions. While we used frequency of reading to the child as a proxy of parental input, the single question and limited answer options (i.e., not very often, sometimes, often) may not capture the variability in reading frequency for different families (e.g., daily vs. weekly; Sénéchal et al., 1996), the richness of the literacy environment at home (e.g., access to various books; Payne et al., 1994), or other important forms of parental language input during infancy. Lastly, child characteristics such as temperament have been linked with gesturing in infancy (Ollas et al., 2020). This raises the possibility that other child and environmental factors not explored here, for example the richness of the home environment, may play a role in the relation between gestures and communicative skills. Future research should explore these other factors to help us further understand the mechanisms at play behind the role of gestures on communicative development.

Conclusion

Using a large-scale longitudinal prospective pregnancy cohort, and controlling for many child and caregiver variables affecting language outcomes, this study showed that gestures in infancy remain a key entry point into the world of human communication. The current study

presents evidence of strong developmental links between children's gestures, symbolic actions, and vocabulary knowledge, and highlights their critical roles for successful communicative development over the course of children's most formative years in early childhood. Moreover, the present research further reinforces that a rich repertoire of gestures and symbolic actions early in life could be an important precursor to monitor, as they lay the foundation for later language and communicative skills that are important building blocks for children's successful transition into the social and academic demands of formal schooling.

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Table 1

Sample Demographic Characteristics

Variable	<i>N</i> (%)
Ethnic background	
White/Caucasian	1623 (81.89)
Asian	213 (10.73)
Latin American	31 (1.56)
Black/African North American	24 (1.21)
Indigenous	10 (0.5)
Arab	21 (1.06)
Mixed or other	60 (3.03)
Maternal education	
Some elementary or high school	35 (1.7)
Graduated high school	112 (5.7)
Some college, trade, university	257 (13.0)
Graduated college, trade, university	1255 (63.4)
Some graduate school	52 (2.6)
Completed graduate school	269 (13.6)
Total family income (in CAD)	
Less than \$40,000	111 (5.8)
\$40,000 – \$80,000	401 (20.95)
More than \$80,000	1402 (73.25)

Note. CAD = Canadian dollars.

Table 2

Scales created from subscales and items in the MacArthur-Bates Communicative Development

Inventory – Words and Gestures (MCDI-WG) with sample items

Scale	MCDI-WG Subscale(s)	Sample Items
First Communicative Gestures (12 items total)	First Communicative Gestures (all 12 items selected)	<ul style="list-style-type: none"> • Points (with arm and index finger extended) at some interesting object or event. • Nods head “yes”.
Symbolic Actions (33 items total)	Actions with Objects (only 5 items selected)	<ul style="list-style-type: none"> • Hold plane and make it “fly”. • Pour pretend liquid from one container to another.
	Pretending to be a Parent (all 13 items selected)	<ul style="list-style-type: none"> • Put [stuffed animal or doll] to bed. • Try to put diaper on [stuffed animal or doll].
	Imitating other Adult Actions (all 15 items selected)	<ul style="list-style-type: none"> • “Drive” car by turning steering wheel. • “Read” (opens book, turns pages).

Table 3

Descriptive data and bivariate correlations between covariates and main variables of interest

	<i>M</i>	<i>SD</i>	Range	1	2	3	4	5	6	7	8	9	10	11	12
1. Maternal education	4.0	1.0	1-6	1.00											
2. Family income	9.4	2.4	1-11	0.30*	1.00										
3. Child birthweight	3357.7	517.4	595-5074.6	0.00	0.04	1.00									
4. Primary language	0.9	0.3	0-1	-0.02	0.28*	0.10*	1.00								
5. Child gender	1.5	0.5	1-2	0.01	0.00	-0.08*	0.02	1.00							
<u>Time 1 (12 months)</u>															
6. First Communicative Gestures	7.8	2.1	0-12	-0.10*	-0.10*	0.01	-0.05	0.21*	1.00						
7. Symbolic Actions	8.7	5.5	0-31	-0.10*	-0.06	0.05	-0.04	0.08*	0.54*	1.00					
8. Comprehension Vocabulary	100.3	78.9	0-396	-0.19*	-0.14*	-0.04	-0.01	0.08*	0.47*	0.53*	1.00				
9. Productive Vocabulary	9.7	22.4	0-350	-0.03	-0.05	0.01	-0.05	0.03	0.32*	0.40*	0.45*	1.00			
10. Reading to child	2.6	0.6	1-3	0.06*	0.19*	-0.03	0.22*	0.01	0.04	0.06	0.12*	0.01	1.00		
<u>Time 2 (24 months)</u>															
11. Productive Vocabulary	295.4	180.4	0-680	-0.00	0.23	0.06*	0.12*	0.15*	0.28*	0.30*	0.36*	0.26*	0.20*	1.00	
<u>Time 3 (5 years)</u>															
12. Communicative Skills (5 years)	108.0	13.6	57-143	0.15*	0.14*	0.05*	0.12*	0.14*	0.11*	0.08*	0.07*	0.07*	-0.06*	0.34*	1.00

Note. Range denotes the range observed in the data, not the range of all possible values. Larger Communicative Skills (CCC-2) scores indicate better communicative skills compared to lower scores. Child birthweight is in grams. Primary language: 0 = Non-English language, 1 = English. Child gender: 1 = male, 2 = female. Reading to child: 1 = Not very often, 2 = Sometimes, 3 = Often. * $p \leq .05$.

Figure 1. Results of Model 1: Path analysis of First Communicative Gestures and Symbolic Actions on Communicative Skills. Standardized estimates are reported. The full line shows a statistically significant pathway. The level of statistical significance of pathways is indicated with asterisks. * $p \leq .05$; ** $p \leq .01$; *** $p \leq .001$.

Figure 2. Results of Model 2: Path analysis model of First Communicative Gestures and Symbolic Actions on communicative skills via productive vocabulary size. Standardized estimates are reported. Full lines show statistically significant pathways, while dotted lines shows non-significant pathways. The level of statistical significance of pathways is indicated with asterisks. * $p \leq .05$; ** $p \leq .01$; *** $p \leq .001$.