

Mothers' labeling responses to infants' gestures predict vocabulary outcomes*

JANET OLSON AND ELISE FRANK MASUR

Northern Illinois University, USA

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ABSTRACT

Twenty-nine infants aged 1;1 and their mothers were videotaped while interacting with toys for 18 minutes. Six experimental stimuli were presented to elicit infant communicative bids in two communicative intent contexts – proto-declarative and proto-imperative. Mothers' verbal responses to infants' gestural and non-gestural communicative bids were coded for object and action labels. Relations between maternal labeling responses and infants' vocabularies at 1;1 and 1;5 were examined. Mothers' labeling responses to infants' gestural communicative bids were concurrently and predictively related to infants' vocabularies, whereas responses to non-gestural communicative bids were not. Mothers' object labeling following gestures in the proto-declarative context mediated the association from infants' gesturing in the proto-declarative context to concurrent noun lexicons and was the strongest predictor of subsequent noun lexicons. Mothers' action labeling after infants' gestural bids in the proto-imperative context predicted infants' acquisition of action words at 1;5. Findings show that mothers' responsive labeling explain specific relations between infants' gestures and their vocabulary development.

INTRODUCTION

Infants' production of communicative bids to a conversational partner that include gestures has been positively linked with their vocabulary development (Bates, Benigni, Bretherton, Camaioni & Volterra, 1979; Brooks & Meltzoff, 2008; Carpenter, Nagel & Tomasello, 1998; Colonesi,

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Stams, Koster & Noom, 2010; Rowe & Goldin-Meadow, 2009). Infants who gesture earlier, at the beginning of the second year, and/or more frequently have larger vocabularies than those who do not (Blake, Osborne, Cabral & Gluck, 2003; Bates et al., 1979; Brooks & Meltzoff, 2008; Camaioni, Castelli, Longobardi & Volterra, 1991; Goldin-Meadow & Morford, 1985; Iverson & Goldin-Meadow, 2005; Rowe, 2000; Rowe, Ozcaliskan & Goldin-Meadow, 2008). Besides the overall advantages of gesturing, certain kinds of gestural bids are more closely related to lexical acquisition than are others. In particular, gestural bids in proto-declarative contexts with commenting intents have been more strongly linked with vocabulary size than gestural production in proto-imperative or requesting contexts for children developing both typically and atypically (Carpenter et al., 1998; Wetherby, Cain, Yonclas & Walker, 1988).

Researchers have suggested three kinds of explanations for the relations between gesturing and vocabulary, the first correlational and child determined, the second direct and causal, and the third indirect, causal, and adult mediated. More specifically, the correlational approach proposes that the frequencies of infants' early gesturing and their vocabulary sizes could be reflections of the same underlying cognitive capacity (Goldin-Meadow & Wagner, 2005; Iverson & Thelen, 1999). Those infants who are more advanced cognitively are also achieving gesture and language milestones at earlier ages because they are on a generally faster developmental track. If that is the case, gestural development need not be promoted over other early pragmatic and communicative competence but could be looked upon as an early marker of language trajectory. The second proposal is that gesturing may free up cognitive resources to allow infants greater capacity for vocabulary acquisition (Goldin-Meadow, 2007; Goldin-Meadow & Wagner, 2005). Thus, gestural ability would be a direct cause of vocabulary development. In contrast, the indirect causal explanation focuses on adults' responses to infants' gestural bids. Researchers have proposed that infants' communicative bids with gestures, more so than bids without gestures, elicit responses from caregivers that are facilitative of vocabulary growth and, further, that these linguistically beneficial responses may have an indirect causal effect in the relation from gestures to vocabulary acquisition (Brookes & Meltzoff, 2008; Goldin-Meadow, Goodrich, Sauer & Iverson, 2007; Marcos, 1991; Masur, 1982; Olson & Masur, 2011, 2013). If this is the case, mothers' responses to infants' communicative bids that include gestures should mediate the predictive relation of gesture to vocabulary, whereas responses to non-gestural communicative bids should not. The current study is designed to test the assertion that infants' gestures have an indirect, causal role in vocabulary acquisition by influencing mothers' responses.

There is evidence that mothers respond to infants' gestural communicative bids early in the second year in ways likely to facilitate vocabulary acquisition

(Goldin-Meadow et al., 2007; Marcos, 1991; Marcos, Ryckebusch & Rabain-Jamin, 2003; Masur, 1982; Olson & Masur, 2011). Mothers respond with words at very high rates, and those words often include labels that 'translate' the infants' inferred communicative intents (Goldin-Meadow et al., 2007; Olson & Masur, 2011, 2013). There is also evidence that the object labels mothers provide in response to object-referring gestures are likely to enter the children's subsequent lexicons (Goldin-Meadow et al., 2007). However, these studies do not address the hypothesis that infants' gestures are related to their vocabulary outcomes only or mainly because they elicit responses that facilitate vocabulary acquisition. We do not know if maternal responses mediate the relation between infants' gestures and their subsequent vocabularies because the necessary mediation analyses have not previously been completed. A primary goal of the current study is to test this mediation model.

To investigate the role of gesture in vocabulary acquisition, it is also important to consider mothers' responses to infants' gestures versus their responses to other kinds of early communicative bids. There does seem to be something special about mothers' responses to infants' early gestural bids even when infants' non-gestural bids are vocalizations. Olson and Masur (2013) found that mothers respond differently to infants' early gestural bids than they do to early non-gestural communicative bids produced in the same communicative context. Mothers' verbal response rates were higher to infants' gestural than non-gestural communicative bids at the beginning of the second year, and they provided more labeling responses after gestural than non-gestural bids. This provides important empirical support for proposals by Goldin-Meadow (2002) and Brooks and Meltzoff (2008) that mothers are likely to give privileged responses to infants' early gestures. However, Olson and Masur (2013) and Goldin-Meadow and colleagues (2007) did not test whether mothers' responses to gestural versus non-gestural communicative bids were differentially related to infants' vocabulary outcomes. If mothers' responses to infants' gestures are a key mechanism for language development, they should be related to infants' vocabulary outcomes more strongly or differently than responses to communicative bids that do not contain gesture. Therefore, a second purpose of the current study is to determine whether mothers' labeling responses to infants' gestural and non-gestural communicative bids are differentially related to infants' concurrent and subsequent vocabularies. It is predicted that only mothers' responses to infants' gestures will be related to vocabulary and that they will mediate the relation from gesturing to vocabulary.

Because Carpenter and colleagues (1998) report different relations from infants' gestures in proto-declarative and proto-imperative contexts to their vocabulary outcomes, it is also important to consider communicative context

when testing this mediation model. Therefore, the current study examined mothers' responses to infants' communicative bids in two communicative contexts – proto-declarative and proto-imperative. Consistent with procedures used in previous studies (e.g. Carpenter, Mastergeorge & Coggins, 1983; Harding & Golinkoff, 1979; Liszkowski, Carpenter, Henning, Striano & Tomasello, 2004; Puccini, Hassemmer, Salomo & Liszkowski, 2010; Slaughter, Peterson & Carpenter, 2009) and in clinical procedures to facilitate early identification of autism (e.g. Mundy, Hogan & Doehring, 1996; Mundy, Sigman & Kasari, 1990; Shumway & Wetherby, 2009; Wetherby & Prizant, 1993), six communicative temptations were presented to create four probable situations for commenting and two for requesting. Because interesting items at a distance typically elicit proto-declarative or commenting bids, including pointing gestures (Puccini et al., 2010), four stimuli were presented, accompanied by sound and lights, at far-distal and at medium-distal remove. To elicit proto-imperative or requesting bids, children were given access to two objects that moved, lit up, and/or made noise but then ceased operating. These provided opportunities for the infants to ask their mothers to reactivate those objects, including by extending the objects toward them (Blake, O'Rourke & Borzellino, 1994; Carpenter et al., 1983). These elicitation procedures were selected to increase the chance that infants would communicate and to create contrasting contexts of parent–child interactions during shared activities (cf. Puccini et al., 2010) where it was highly probable that infants were communicating for proto-declarative or proto-imperative purposes. Confirming expectations, these procedures have been shown to elicit divergent gesture-to-context relations, with infants producing commenting gestures such as points in the proto-declarative context and requesting gestures such as object extensions in the proto-imperative context (Olson & Masur, 2011).

Considering communicative context is also important because mothers provide different kinds of responsive labels to gestural bids depending on communicative context. Olson and Masur (2011) found that with children aged 1;1, mothers were most likely to provide object labels (e.g. “That’s the bear”) to infants’ gestures that occurred in a proto-declarative or commenting context. In contrast, action labels (e.g. “Open it?”) were most often produced after proto-imperative requesting gestures, such as object extending. This could begin to explain why researchers have reported proto-declarative gestures and/or pointing to be more strongly related than proto-imperative gesturing to infants’ early vocabulary development. Mothers’ provision of object names at the beginning of the second year should be especially beneficial because this is a time when lexical growth consists primarily of nouns (Blake, Vitale, Osborne & Olshansky, 2005; Carpenter et al., 1998; Goldfield & Reznick, 1990; Nelson, 1973). It is not clear whether action-labeling responses might also be related to infants’

vocabularies. It is possible that mothers' translations of gestural requests for actions may also help infants, especially those more linguistically advanced, add action words to their growing lexicons. Because these suppositions have so far remained untested, the current study will examine mothers' object- and action-labeling responses to infants' gestural communicative bids in proto-declarative versus proto-imperative contexts to determine if they are specifically and differentially related to infants' vocabularies and if they mediate those relations. It is predicted that mothers' object labeling after gestural bids in proto-declarative contexts will be related to the size of the infants' noun vocabularies whereas mothers' action labeling after gestures in a proto-imperative context will be related to infants' action vocabularies.

A final factor to consider is the way to measure mothers' responses to infants' gestural bids. First of all, we would expect infants' vocabulary outcomes to be related to the frequencies of their mothers' labeling responses. Infants who are gesturing more frequently have the potential to receive more responsive labels than infants who gesture infrequently. Several studies have demonstrated that the more often infants hear a word the more likely they are to add that word to their vocabularies and that the frequencies of particular words in maternal input predict which words enter infants' lexicons (Brent and Siskind, 2001; Gershkoff-Stowe, 2002; Gershkoff-Stowe & Hahn, 2007; Girolametto, Pearce & Weitzman, 1996; Storkel, 2004). For these reasons, we expect mothers' object labeling frequencies in response to their children's gesturing in proto-declarative contexts to be especially predictive of initial vocabularies. Thus, this measure of maternal responses will be evaluated first.

In addition to labeling frequencies, it is also important for children to receive reliable, consistent responses regardless of how often they gesture. Mothers' provision of verbal responses to high proportions of their children's communicative overtures has also been linked with positive developmental outcomes, including vocabulary growth from the beginning to the middle of the second year (Baumwell, Tamis-LeMonda & Bornstein, 1997; Bornstein, Tamis-LeMonda & Haynes, 1999; Masur, Flynn & Eichorst, 2005; Rollins, 2003; Tomasello & Farrar, 1986; Yoder & Warren, 1998). Thus, the proportions of infants' gestures that receive maternal labeling responses might be predictive in this interval. The current study will also assess whether rates of maternal labeling responses are related to infants' vocabulary growth.

Therefore, the primary purpose of the current study is to determine whether mothers' responses to infants' gestures mediate the predictive relation between infant gesturing and vocabulary size. Furthermore, we will test the specificity of such a mediational relation in two ways. First, we will examine whether mothers' labeling responses to infants' gestural bids, but not to their non-gestural bids produced in the same

communicative contexts, predict and mediate relations to infants' vocabularies. Such a finding would expand our knowledge by providing divergent validity. In addition, this study will assess whether mothers' object- and action-labeling responses – frequencies and then proportions – in two communicative contexts, proto-declarative and proto-imperative, contribute differentially to noun and action-word acquisition, respectively. Finding that mothers' labeling responses mediate the relation between gesturing and language growth would clarify current theories on the role of infant gestures and maternal responses in vocabulary acquisition.

METHOD

Participants

Twenty-nine mother–infant dyads, thirteen boys and sixteen girls, participated in the study when the infants were 1;1 ($SD = .46$) and 1;5 ($SD = .5$). One dyad was Hispanic; one dyad was African-American; one dyad was Asian-American; and twenty-six dyads were Anglo-American. The average age of mothers was 32.3 years (range = 19–46) and all reported living with the child's father. Seven mothers had a high school diploma and twenty-two had college degrees (11) or higher (11). Fifteen of the infants were only children and twenty-three of the mothers worked outside the home. No families had a history of language or learning difficulties and the native language of all dyads was English. No infants were reported to or had overt signs of developmental delay. Dyads were recruited as part of a larger longitudinal study.

Procedure and stimuli at 1;1

Mother–infant dyads were videotaped as they interacted with a standard toy set in a laboratory for 18 minutes, while experimenters observed from an adjacent room. The toy set included a ball, stacking cups, a shape sorter, a stuffed and plastic bear, three ducks, a car, a toy bottle, a blanket, a busy box, and a tea set. As the dyads played, three pairs of experimental stimuli (i.e. communicative temptations) were presented at predetermined intervals to create two communicative context conditions – proto-declarative (2 far distal: a car and bear that were inaccessible in plastic containers on a high shelf paired with lights and soft music; and 2 moderately distal: bubbles and a ball open on a shelf just out of reach paired with lights and soft music) and proto-imperative (a wind-up toy and a light-up duck in a plastic container that moved, lit up, and/or made noise and then ceased to operate that the child could not open or operate unassisted).

These two context conditions and the communicative temptations presented within them were chosen because they had been successfully

used in previous studies to elicit infant gestural communicative bids reliably judged to be, respectively, proto-declarative (Blake et al. 1994; Carpenter et al., 1983; Carpenter et al., 1998; Franco & Butterworth, 1996; Liszkowski et al., 2004; Olson & Masur, 2011) or proto-imperative (Blake et al., 1994; Carpenter et al., 1983; Carpenter et al., 1998; Harding & Golinkoff, 1979; Olson & Masur, 2011; Wetherby & Prizant, 1993; Wetherby et al., 1988; Yoder, McCathren, Warren & Watson, 2001). In addition, because reduced production of proto-declarative bids is associated with higher risk for autistic spectrum disorder in infancy, these communicative temptations have also been successfully used in standardized clinical protocols to elicit proto-declarative and proto-imperative gestural communicative bids from children with autism and those at risk (Mundy et al., 1996; Wetherby et al., 1988).

The proto-declarative communicative temptations were each presented three times using a 3 seconds on and 10 seconds off schedule at the 6th, 8th, 10th, and 12th minute. The proto-imperative stimuli were presented at the end of the play sample after the toy set was removed. In order to capture infants' initial communicative bids in response to the stimuli, mothers were asked not to react to the communicative temptations unless their infants noticed them, and to play as they typically would.

Coding infants' communicative bids

Researchers coded as COMMUNICATIVE BIDS all infant initial behaviors toward the six experimental stimuli or toward the mother referencing the stimuli that included any of the following: vocalizations (laughter, crying, fussing, and vegetative noises were excluded), words and word approximations (e.g. *cah* for *car*), searching gaze (looks around the room in an apparent effort to locate the sound or object), looking to the object (looks to the target object), gaze to mother (looks to the mother's face), and/or gesture. Communicative bids that included gestures were classified as GESTURAL BIDS; all others were considered NON-GESTURAL BIDS (not including a gesture). For these analyses, only gestural bids with 'indicative' gestures (Leavens & Hopkins, 1999) in the proto-declarative contexts and with requestive gestural bids in the proto-imperative context were analyzed. Other types of gestures (i.e. representational, conventional) were not examined here.

Indicative gestures included arm extensions with either the index finger or whole hand oriented toward the object. Index-finger or 'canonical' pointing (Butterworth, 1998, p. 180) involves extensions of the index finger toward an object and excludes exploratory poking or manipulation. Whole-hand pointing, a more rudimentary form that often appears before canonical pointing (Brooks & Meltzoff, 2008; Leavens & Hopkins, 1999; Liszkowski,

Carpenter & Tomasello, 2008), was defined as extensions of the arm with the hand open, excluding movements that were simply the first phase of grasping an object.¹ Because infants have been shown to use both types of gestures as indicative in proto-declarative contexts during their second year, they were combined for these analyses (Franco & Butterworth, 1996; Leavens & Hopkins, 1999; O'Neill, 1996; Puccini et al., 2010).

The gestural bids analyzed in the proto-imperative context included only object-extending gestures which have been shown in other studies to occur frequently and be requestive in nature (Blake et al., 1994; Carpenter et al., 1983; Carpenter et al., 1998; Crais, Douglas & Campbell, 2004; Harding & Golinkoff, 1979; Masur, 1983; Puccini et al., 2010; Wetherby et al. 1988). Object extensions comprised 92% of all gestures produced in this communicative context, often occurred immediately after the object became available or ceased operating, and were often accompanied by frustration at not being able to successfully open or wind the object. Object extending involved movements of the arm in the direction of the mother while holding an object and included instances where the infants gave objects to mothers. Although object extensions are 'in hand' gestures, they have been recognized as proto-imperative gestural bids for decades by researchers studying both typically developing children (e.g. Bates et al., 1979; Masur, 1982, 1983) and children with autism or other disabilities (e.g. Mundy et al., 1990; Shumway & Wetherby, 2009). Moreover, multiple reports confirm that they occur frequently in mother–infant interactions when objects are accessible, that researchers and mothers judge them to be communicative requests in the specific contexts used in this study, and that mothers respond to them as communicative bids (Crais et al., 2004; Masur, 1983; Olson & Masur, 2011; Puccini et al., 2010; Wetherby et al., 1988).

Because the focus of this study was on the predictive relations of different kinds of infant communicative bids and maternal responses to them to lexical acquisition, infants' frequencies of gestural and non-gestural bids, and maternal responses, described below, in each context were examined separately. Analyses comparing and contrasting the contexts, gestures, and responses are provided in Olson and Masur (2011).

Inter-observer agreement for two coders on records of two boys and two girls, randomly chosen, in classifying infants' communicative bids to the target stimuli as a gestural bid, a non-gestural bid, or no communicative bid was 95% ($\kappa = .91$). Inter-observer agreement for categorizing infant gestures by type (finger points, whole-hand points, object

¹ There were only eight instances where infants' fingers were moving as they produced a whole-hand point. They were produced by only five of the infants, all of whom also produced whole-hand points without movement. To confirm our results, we recalculated the analyses involving proto-declarative gestural bids excluding these instances. All our findings remained significant in the predicted direction ($ps < .05$, one-tailed).

extensions, other) was 97%; Cohen's kappa = .954. Agreement in identifying the presence or absence of vocalization, look to the experimental objects, searching, and gaze to mother ranged from 91% to 100%; kappas ranged from .81 to 1.00. Differences were resolved through discussion.

Coding mothers' responses to infants' gestural and non-gestural communicative bids

Mothers' responses to infants' gestural and non-gestural communicative bids were categorized as No Response, Non-verbal Response, and Verbal Response. Non-verbal responses included vocalizations, gestures, gaze to the infant, and looks to the object. Each verbal response was examined further for the presence of labeling words. Each response containing an object (e.g. *duck, bear, music, light*), action (e.g. *dance, go, wind, turn*), and/or internal state label (e.g. *see, think, want, like*; not analyzed for this study) was recorded. All other verbal responses were counted as non-labeling responses.

For these analyses, we counted the frequencies and proportions of communicative bids in the proto-declarative contexts receiving object-labeling responses and the frequencies and proportions of communicative bids in the proto-imperative context receiving action-labeling responses. Frequencies were calculated as the total numbers of gestural and non-gestural bids in the proto-declarative context followed by responses that included an object label and the total numbers of gestural and non-gestural bids in the proto-imperative context followed by responses that included an action label. Proportions were computed as the percentages of gestural and non-gestural bids in the proto-declarative context followed by responses that included an object label and the percentages of gestural and non-gestural bids in the proto-imperative context followed by responses that included an action label.

Inter-rater agreement between two coders for classifying mothers' behaviors following infants' communicative bids as No Response, a Non-verbal Response, or a Verbal Response was 97%; Cohen's kappa = .93 (2 boys and 2 girls, randomly chosen). When coders agreed that mothers' responses to infants' communicative bids were Verbal, inter-rater agreement for coding Verbal Responses as containing a labeling word or not was as follows: for object labels and internal state labels = 98% (Cohen's kappa = .96); for action labels = 100% (Cohen's kappa = 1). When discrepancies occurred, consensus was reached through discussion.

Expressive and receptive vocabulary measures

Mothers completed the *McArthur-Bates Communicative Development Inventory: Words and Gestures (MCDI)*; Fenson, Marchman, Thal, Reznick &

Bates, 2007) when infants were aged 1;1 and 1;5. For these analyses, expressive noun vocabularies at 1;1 and 1;5 served as outcome measures. Because expressive action words were rare at 1;1, receptive action vocabulary at 1;1 and expressive action vocabulary at 1;5 were the other outcome variables. Expressive noun vocabulary was computed by summing the number of words reported produced (marked 'understands and says') in the animals' names, vehicles, toys, food and drink, clothing, body parts, furniture and rooms, small household items, and outside things and places to go sections of the *MCDI*. Receptive action vocabulary was the total number of words reported comprehended (marked 'understands') in the action words section at 1;1, while expressive action vocabulary was the total number of words reported produced (marked 'understands and says') in the action words section at 1;5.

Analyses

Analyses testing the mediation hypothesis employed regression and correlation to assess the presence or absence of the four requirements specified by Baron and Kenny (1986) and Holmbeck (1997) as necessary to demonstrate mediation: (1) a relation between the predictor and outcome measures; (2) a relation between the predictor and the hypothesized mediator; (3) an association between the hypothesized mediator and outcome measures; and (4) elimination or reduction in strength of the relation between predictor and outcome measures when the hypothesized mediator is also entered into the predictive equation. Because preliminary analyses showed that neither child gender nor maternal education was significantly related to any measure of maternal labeling, those factors were not included in analyses. All results were evaluated with 2-tailed tests of significance.

RESULTS

Testing the mediation hypothesis for noun vocabulary development

Table 1 displays descriptive statistics in three parts. The first part presents the proposed predictor variable and its contrasts – infants' frequencies of gestural bids in the proto-declarative context, non-gestural bids in the proto-declarative context, and gestural bids in the proto-imperative context. The second includes descriptive statistics for the hypothesized mediator variables and their contrasts – mothers' frequencies and proportions of object-labeling responses to those bids. The final section describes the outcome variables – infants' expressive noun vocabularies at 1;1 and 1;5. As Table 1 shows, confirming previously reported findings (Olson & Masur, 2013), object-labeling responses were provided more often following gestural than non-gestural bids in the proto-declarative

TABLE 1. *Descriptive statistics for variables relating to prediction of variance in infants' noun vocabularies*

Measure	<i>M</i>	<i>SD</i>	<i>Range</i>
Predictor and 2 Contrasts at 1;1: Infant Behaviors			
P-D Gestural Bid Frequencies	5.21	5.64	0-20
P-D Non-gestural Bid Frequencies	7.41	3.08	0-12
P-I Gestural Bid Frequencies	3.21	1.49	0-6
Hypothesized Mediators and their Contrasts at 1;1: Maternal Responses			
Object-Labeling Frequencies to P-D Gestural Bids	2.29	2.77	0-11
Object-Labeling Proportions to P-D Gestural Bids	35	32	0-100
Object-Labeling Frequencies to P-D Non-gestural Bids	1.38	2.02	0-8
Object-Labeling Proportions to P-D Non-gestural Bids	15	20	0-67
Object-Labeling Frequencies to P-I Gestural Bids	0.18	0.40	0-1
Object-Labeling Proportions to P-I Gestural Bids	6	12	0-33
Outcome Measures: Infant Noun Vocabulary			
Expressive Noun Vocabulary at 1;1	4.79	6.91	0-22
Expressive Noun Vocabulary at 1;5	32.38	37.84	0-155

NOTES: P-D = proto-declarative; P-I = proto-imperative.

context. In addition, only five mothers provided object labels after their children's gestural bids in the proto-imperative context. Regression and correlation analyses of the relations among these variables are presented in the following sections as they test the mediation hypothesis and contrasting alternative possibilities.

Predicting noun vocabulary at 1;1. The first step toward investigating whether maternal labeling responses mediate the association between gesturing and language development was to assess whether infants' production of gestural bids in the proto-declarative context was a significant predictor of their noun vocabularies at 1;1. As Analysis 1 in Table 2 shows, that relation was significant. Thus, the first requirement for demonstrating mediation – the association between predictor and outcome – was met. This result is in keeping with findings by others (e.g. Bates et al., 1979; Carpenter et al., 1998) that infants' proto-declarative gesturing is associated with their vocabulary acquisition.

The next two requirements are that the predictor variable must be related to the hypothesized mediator and the hypothesized mediator must be related to the outcome. A second regression analysis showed that infants' production of gestural bids in the proto-declarative context was indeed related to their mothers' frequencies of object-labeling responses to those bids ($B = 0.37$, $SE B = 0.07$, $\beta = 0.76$, $p < .001$; Adjusted $R^2 = .55$). This is not surprising since maternal response frequencies are necessarily influenced by the opportunities provided by their children's gesturing frequencies. Third, a regression analysis found that mothers' object

TABLE 2. *Regression analyses predicting variance in expressive noun vocabularies at 1;1*

Measure	<i>B</i>	<i>SE B</i>	β
Analysis 1			
Infants' P-D Gestural Bids	0.55	0.21	0.44*
Adjusted R^2 for Analysis 1 = .16.			
Analysis 2			
Infants' P-D Gestural Bids	-0.40	0.25	-0.33
Mothers' Object-Labeling Frequencies to P-D Gestural Bids	2.51	0.51	1.01***
Adjusted Total R^2 for Analysis 2 = .59.			

NOTES: P-D = proto-declarative. * $p < .05$, two-tailed; *** $p < .001$, two-tailed.

labeling frequencies – the hypothesized mediator – was also strongly related to the outcome variable, accounting for 56% of the variance in infants' expressive noun lexicons at 1;1 ($B = 1.90$, $SE B = 0.34$, $\beta = 0.76$, $p < .001$; Adjusted $R^2 = .56$).

In the fourth and final step, a regression analysis was conducted to assess whether the relation between the predictor – infants' gestures in the proto-declarative context – and the outcome – noun lexicons at 1;1 – would be diminished or eliminated if both the predictor and the hypothesized mediator were entered simultaneously into the equation. As Analysis 2 in Table 2 shows, the results demonstrated complete mediation. When infants' gestural bids in the proto-declarative context and mothers' frequencies of object-labeling responses to those gestural bids were simultaneously entered as predictors, only maternal object-labeling frequencies were significantly related to infants' noun lexicons at 1;1.

Predicting noun vocabulary growth from 1;1 to 1;5. The next set of analyses were designed to investigate the role of maternal object labeling in contributing to growth in infants' expressive noun lexicons from 1;1 to 1;5. First, as might be expected, noun vocabulary at 1;1 significantly predicted subsequent noun vocabulary; see Analysis 1 in Table 3. Next, because infants' gestural bids in the proto-declarative context and mothers' frequencies of object-labeling responses had already been shown to contribute to predicting the variance in noun lexicons at 1;1, we examined whether the proportions of gestural bids in the proto-declarative context receiving maternal object-labeling responses would make a further contribution to vocabulary growth during this interval. To test this, we then assessed whether the proportions of object-labeling responses were related to expressive noun lexicons at 1;5. The regression analysis confirmed that there was a significant relation ($B = 65.45$, $SE B = 21.31$, $\beta = 0.55$, $p < .01$; Adjusted $R^2 = .27$). Furthermore, a third regression analysis revealed that greater expressive noun vocabulary at 1;1 was

TABLE 3. *Regression analyses predicting variance in infants' expressive noun vocabularies at 1;5*

Measure	<i>B</i>	SE <i>B</i>	β
Analysis 1			
Expressive Noun Vocabulary at 1;1	2.40	1.07	0.44*
Adjusted R^2 for Analysis 1 = .16.			
Analysis 2			
Expressive Noun Vocabulary at 1;1	1.34	1.07	0.25
Mothers' Object-Labeling Proportions to P-D Gestural Bids	52.61	23.40	0.44*
Adjusted Total R^2 for Analysis 2 = .29.			

NOTES: P-D = proto-declarative. * $p < .05$, two-tailed.

associated with higher proportions of maternal object-labeling responses to infants' gestural bids in the proto-declarative context ($B = 0.02$, SE $B = 0.01$, $\beta = 0.44$, $p < .05$; Adjusted $R^2 = .15$).

Finally, we assessed the relative strength of vocabulary at 1;1 versus mothers' object-labeling proportions in predicting infants' vocabularies at 1;5. As Analysis 2 in Table 3 presents, when both predictors were entered simultaneously, only the proportions of object-labeling responses mothers provided to their infants' gestural bids in the proto-declarative context was a significant independent predictor of children's expressive noun lexicons at 1;5.

Testing contrasting alternatives. To examine the specificity of the relations between mothers' object-labeling responses to infants' gesturing in the proto-declarative context and vocabulary acquisition, we assessed whether similar associations might hold for mothers' object-labeling responses to non-gestural bids in the proto-declarative context or to gestural bids in the proto-imperative context. In line with previous reports of the privileged relation between proto-declarative gesturing and language development (e.g. Carpenter et al., 1998), correlational analyses established that neither infants' non-gestural bids in the proto-declarative context nor their gestural bids in the proto-imperative context were significantly related to expressive noun vocabulary at 1;1 or at 1;5 ($r_s \leq 0.25$, $p_s \geq .12$). Furthermore, maternal object-labeling frequencies and proportions in response to those infant bids were not significantly related to infants' expressive noun lexicons at either 1;1 or 1;5 ($r_s \leq 0.24$, $p_s \geq .12$).

As an additional conservative check, we also tested infants' non-gestural bids in the proto-declarative context that included accompanying vocalizations. They were not significantly associated with noun lexicons at either time ($r_s \leq 0.22$, $p_s \geq .15$). Associations between mothers' object labeling following non-gestural bids with vocalizations and infants' vocabulary levels were not computed because only three mothers provided

TABLE 4. *Descriptive statistics for variables relating to prediction of variance in infants' action vocabularies at 1;5*

Measure	<i>M</i>	<i>SD</i>	<i>Range</i>
Predictor and Contrast at 1;1: Infant Behaviors			
P-I Gestural Bid Frequencies	3.21	0.18	0-6
P-I Non-gestural Bid Frequencies	0.90	0.82	0-2
Hypothesized Mediators and their Contrasts at 1;1: Maternal Responses			
Action-Labeling Frequencies to P-I Gestural Bids	0.81	1.08	0-4
Action-Labeling Proportions to P-I Gestural Bids	0.21	0.28	0-100
Action-Labeling Frequencies to P-I Non-gestural Bids	0.22	0.55	0-2
Action-Labeling Proportions to P-I Non-gestural Bids	0.17	0.38	0-100
Outcome Measures: Infant Action Vocabulary			
Receptive Action Vocabulary at 1;1	11.64	11.49	0-4
Expressive Action Vocabulary at 1;5	4.10	6.53	0-25

NOTE: P-I = proto-imperative.

any object labels following those bids. Thus, none of the contrast variables showed any association with vocabulary acquisition.

Predicting action vocabulary development from 1;1 to 1;5

Table 4 presents descriptive data for analyzing the contribution of mothers' provision of action labels to infants' action vocabulary development. In these analyses we contrasted the frequencies and proportions of maternal action labels in response to infants' gestural bids in the proto-imperative context with those following non-gestural bids in the proto-imperative context. Although most infants produced gestural bids in the proto-imperative context (27 out of 29) and nearly half of their mothers (12 out of 27) provided at least one action-labeling response, only eighteen infants produced non-gestural bids in the proto-imperative context and only three mothers provided action-labeling responses to those bids. Furthermore, because only four infants had any action words in their expressive vocabularies at 1;1, we examined links from receptive action lexicons at 1;1 to expressive action lexicons at 1;5.

Role of action-labeling responses to gestural bids in the proto-imperative context. Not surprisingly, infants' receptive action lexicons at 1;1 predicted their expressive action lexicons at 1;5; see Table 5. However, in keeping with other findings that proto-imperative gesturing is less often associated with vocabulary (e.g. Carpenter et al., 1998), infants' frequencies of gestural bids in the proto-imperative context were not associated with their receptive action lexicons at 1;1 ($r = 0.12$, $p = .54$), or with their expressive action lexicons at 1;5 ($r = 0.30$, $p = .12$). In contrast, both mothers'

TABLE 5. *Regression analyses predicting variance in infants' expressive action vocabularies at 1;5*

Measure	<i>B</i>	SE <i>B</i>	β
Analysis 1			
Receptive Action Vocabulary at 1;1	0.22	0.10	0.39*
Adjusted R^2 for Analysis 1 = .12.			
Analysis 2			
Receptive Action Vocabulary at 1;1	0.17	0.10	0.29
Mothers' Action-Labeling Frequencies to Infants' P-I Gestural Bids	2.28	1.11	0.38*
Adjusted Total R^2 for Analysis 2 = .22.			
Analysis 3			
Receptive Action Vocabulary at 1;1	0.16	0.10	0.29
Mothers' Action Labeling Proportions to P-I Gestural Bids	9.04	4.19	0.39*
Adjusted Total R^2 for Analysis 3 = .23.			

NOTES: P-I = proto-imperative. * $p \leq .05$, two-tailed.

frequencies and their proportions of action-labeling responses were predictive of expressive action lexicons at 1;5 ($B = 2.72$, $SE B = 1.09$, $\beta = 0.45$, $p < .05$; Adjusted $R^2 = .17$ for frequencies; $B = 10.69$, $SE B = 4.10$, $\beta = 0.46$, $p < .05$; Adjusted $R^2 = .18$ for proportions).

Finally, we assessed the relative strength of receptive action vocabulary at 1;1 versus both mothers' action-labeling frequencies and proportions in predicting infants' expressive action vocabularies at 1;5. As Analysis 2 in Table 5 shows, when both earlier receptive action lexicons and maternal action frequencies were entered simultaneously, only the frequencies of action-labeling responses mothers provided to their infants' gestural bids in the proto-imperative context was a significant independent predictor. Similarly, as Analysis 3 in Table 5 displays, when both receptive action lexicons and maternal action-labeling proportions at 1;1 were entered together, only the proportions of action-labeling responses mothers produced following infants' gestural bidding in the proto-imperative context was a significant independent predictor of infants' action-word vocabularies at 1;5.

Testing contrasting alternatives. In these analyses, we tested whether infants' non-gestural communicative bids in the proto-imperative context and their mothers' action-labeling responses to those bids would also be related to expressive action vocabularies at 1;5. Although infants' non-gestural bidding in the proto-imperative context was associated with their expressive action lexicons at 1;5 ($r = 0.36$, $p = .05$), this relation no longer held when receptive action lexicons at 1;1 were taken into account ($r = 0.32$, $p = .11$). Moreover, given the rarity of action-labeling responses to non-gestural bids in the proto-imperative context, it is not surprising that neither mothers' frequencies nor their proportions of action-labeling

responses to these non-gestural bids was predictive of infants' expressive action vocabularies at 1;5 ($r_s = -0.26$, $p_s \geq .29$).

Relations between infants' noun and action vocabularies

Because our analyses found links from both mothers' object naming to noun acquisition and mothers' action labeling to action-word growth, we checked to see whether these findings reflected correspondences within infants and/or mothers. Correlational analyses revealed significant relations across infants' vocabularies: infants with greater expressive noun lexicons at 1;1 also had greater receptive action-word lexicons at 1;1 ($r = 0.47$, $p = .01$). Similarly, infants who produced more nouns at 1;5 also produced more action words at 1;5 ($r = 0.92$, $p < .001$). Mothers' responses in different contexts also evidenced correspondences: Mothers who provided more object labels in response to gestural bids in the proto-declarative contexts also produced both greater frequencies and greater proportions of action-labeling responses to their children's gestural bids in the proto-imperative context ($r_s = 0.57$ and 0.55 , respectively, $p_s < .01$).

DISCUSSION

Infants' earlier and more frequent gestural production, and especially their production of proto-declarative or commenting rather than proto-imperative or requesting gestures, has been repeatedly shown to be associated with greater vocabulary acquisition in children with typical and atypical language development (Bates et al., 1979; Brooks & Meltzoff, 2008; Carpenter et al., 1998; Rowe & Goldin-Meadow, 2009; Watson, Crais, Baranek, Dykstra & Wilson, 2013). Yet researchers have not been certain of the reason for these relations and have suggested explanations in two broad categories—infant focused or adult mediated (Brooks & Meltzoff, 2008; Goldin-Meadow, 2002, 2007; Goldin-Meadow & Wagner, 2005; Iverson & Thelen, 1999; Olson & Masur, 2011). The major goal of the present study was to assess the viability of the second of these hypotheses—that mothers' responses to infants' communicative gestural bids facilitate their vocabulary acquisition (Brooks & Meltzoff, 2008; Goldin-Meadow et al., 2007; Masur, 1982; Olson & Masur, 2011). To explore this question, infants at 1;1 and their mothers were asked to interact in two experimentally elicited communicative contexts: proto-declarative and proto-imperative. Relations between mothers' verbal responses to infants' gestures produced in proto-declarative and proto-imperative contexts and their vocabulary sizes at 1;1 and 1;5 were then examined. Importantly, our findings confirm the contributions of mothers' labeling responses to explaining the link between infants' gesturing and their vocabulary development.

In order to demonstrate maternal mediation, one must first establish that infants' gestural bids are related to their lexicons. Supporting the results of several studies (e.g. Brooks & Meltzoff, 2008; Carpenter et al., 1998; Rowe & Goldin-Meadow, 2009), we confirmed that gestural bids in the proto-declarative context, but not those in the proto-imperative context, were correlated with vocabulary. Moreover, expanding beyond previous studies, we found that non-gestural bids in the same context were unrelated to vocabulary. Infants' proto-declarative gestural bids at the beginning of the second year predicted their concurrent expressive noun repertoires, which, in turn, predicted their subsequent expressive noun lexicons in the middle of the second year. Noun lexicon is an appropriate measure to examine in this situation for two reasons. First, for many children, vocabulary growth in the first half of the second year is predominantly noun acquisition (Goldfield & Reznick, 1990; Nelson, 1973). In addition, mothers' responses to infants' gestures in the proto-declarative context are highly likely to include object labels (Olson & Masur, 2011), thus providing an avenue for noun acquisition in those infants who gesture often.

As hypothesized, mothers' labeling responses to infants' gestural communicative bids were concurrently and predictively related to infants' vocabularies. In marked contrast, their responses to infants' non-gestural communicative bids were not related to infants' lexicons, a result providing divergent validity. These findings support the idea that the labels mothers give to infants' gestures are particularly helpful to vocabulary building, and begin to explain why early gesturers have an advantage for word acquisition (Brooks & Meltzoff, 2008; Goldin-Meadow et al., 2007; Olson & Masur, 2011, 2013). This could be because infants' gestures give mothers a unique opportunity to match their responses more accurately to infants' underlying communicative intents and foci of attention. An infant's gesture directs a mother to the child's attentional focus and adds emphasis to the communicative bid. Such follow-in labeling by mothers in other contexts has also been found to be beneficial for vocabulary acquisition (Baldwin, 1991; McDuffie & Yoder, 2010; Tomasello & Farrar, 1986).

Furthermore, gestures may also serve to disambiguate infants' communicative intent, eliciting a maternal response that is finely tuned to the infant's early communicative intent. Olson and Masur (2013) found this disambiguation most noticeably in the proto-imperative context, where mothers often responded to object extensions with action labels, whereas they were more likely to respond to non-gestural communicative bids with object rather than action labels. The added gesture seemed to signal that infants were requesting an action rather than simply communicating interest in the object. As a result, mothers acknowledged the gestural requests with action labels, arguably better linguistically

mapping what infants intended to communicate. In support of this interpretation, we found that mothers' labeling responses to infants' non-gestural bids were not related to infant vocabulary outcomes and that the kinds of labels mothers produced in each context were differentially related in very specific ways to vocabulary outcomes.

In the proto-declarative contexts, maternal labeling following gestural bids was most likely to include the name of the object indicated (Olson & Masur, 2011, 2013). Mothers' provision of object labels following infants' gestures in the proto-declarative context fully mediated the association from infants' proto-declarative gesturing to their concurrent noun lexicons and was the most powerful predictor from their concurrent to subsequent noun lexicons. In line with prior reports of links from proto-declarative gesturing, but not from proto-imperative gesturing, to vocabulary (Carpenter et al., 1998), we found larger initial noun vocabularies at 1;1 in infants who produced more gestural bids in the proto-declarative contexts. However, regression analyses fulfilling all the conditions for demonstrating mediation established that mothers' frequencies of object-labeling responses to those gestural bids completely mediated the significant predictive relation from infants' gesturing to their concurrent lexicons. It is not surprising that mothers' object-naming frequencies are predictive of their infants' noun vocabularies because a number of researchers have established links from maternal input frequencies to children's word acquisition (Brent & Siskind, 2001; Gershkoff-Stowe, 2002; Gershkoff-Stowe & Hahn, 2007; Girolametto et al., 1996; Storkel, 2004). The contribution of the current study is to demonstrate that this maternal object labeling following infants' gestures mediates and explains the association from infants' gestures to their early vocabularies.

Furthermore, although, as expected, infants who produced more nouns at 1;1 also produced more nouns at 1;5, when both initial noun lexicons and mothers' rates of object-labeling responses following children's gesturing in the proto-declarative context were tested simultaneously as predictors of noun lexicons at 1;5, maternal object labeling proved to be the sole significant and independent predictor. These results are in keeping with previous findings of greater vocabulary growth from the beginning to the middle of the second year in children of mothers who produce higher rates of verbal responses (Baumwell et al., 1997; Bornstein et al., 1999; Masur et al., 2005; Rollins, 2003; Tomasello & Farrar, 1986; Yoder & Warren, 1998).

It is noteworthy that the influence of maternal labeling following infants' gesturing was demonstrated even in a sample that was relatively homogeneous. Although diversity in a sample is generally desirable (e.g. Tamis-LeMonda, Song, Leavell, Kahana-Kalman & Yoshikawa, 2012), these mostly middle-class mothers varied enough in their responses to

infants' gestures to exhibit these relations between object labeling and noun acquisition. Moreover, preliminary analyses showed that mothers' production of object-labeling responses was not significantly associated with either child gender or maternal education. In addition, the contrasting analyses we conducted ruled out the possibility that there was something special about these mothers' provision of other kinds of verbal responses as well. Neither their object-labeling responses to non-gestural bids in the proto-declarative context nor their object-labeling responses to object-extending gestures in the proto-declarative context were predictive of their children's noun lexicons. Thus, the findings in this study reflect the role of object labeling after infants' proto-declarative gestures specifically, rather than some other verbal characteristics of the mothers. Divergent validity is supported by the contrast between the positive relations for maternal object labeling and the null findings for the tested alternatives.

The specificity of the relations between mothers' labeling practices after infants' gestures and infants' vocabulary development was evident as well in our findings of links between mothers' provision of action labels in response to infants' gestural bids in proto-imperative contexts and their children's acquisition of action words by 1;5. Although infants are typically adding common nouns most rapidly to their lexicons in the first half of the second year (Goldfield & Reznick, 1990), those children with the most advanced vocabularies are also likely to be acquiring action words as well (Masur & Eichorst, 2002; Tomasello, 1995). In fact, the infants' expressive noun and action-word lexicons were highly related at 1;5. Similarly, the mothers who produced the most object labels in response to their children's gestural bids in the proto-declarative context were the same mothers who provided greater frequencies and proportions of action labels following their children's gestures in the proto-imperative context. The presence of a proto-declarative or proto-imperative communicative context and the signal of infants' commenting or requesting gestural bid affords responsive mothers the information they need to provide input appropriate and advantageous for children's language development. This study confirms relations between these facilitative maternal labeling patterns and children's greater linguistic advancement.

This paper explores the specificity of relations from mothers' responses following infants' gestures to their vocabulary acquisition. Mothers' provision of object labels after gestures in a proto-declarative context was related to their acquisition of nouns, and mothers' provision of action labels after gestures in a proto-imperative context was related to infants' acquisition of action words. These findings provide exciting evidence of a finely tuned dyadic interaction. However, because this study included infants at 1;1 and 1;5, it cannot resolve issues about the origins of these

children's gestural propensities or their mothers' labeling practices. Nor can it answer questions about future patterns. Additional research will be required to determine if the specificity of relations uncovered here continues to exist as infants become older and the composition of their vocabulary changes (cf. Parlade & Iverson, 2011). For example, it would be useful to investigate how the internal state labels mothers provide after infants' gestures (Olson & Masur, 2011, 2013) might be related to their acquisition of internal state words and to their early understanding of the internal states of others (Slaughter et al., 2009; Taumoepeau & Ruffman, 2008). Mothers' responses to infants' gestures may also mediate those relations.

REFERENCES

- Baldwin, D. (1991). Infants' contribution to the achievement of joint reference. *Child Development* 62(5), 875–890.
- Baron, R. M. & Kenny, D. A. (1986). The moderator–mediator variable distinction in social psychological research: conceptual, strategic and statistical considerations. *Journal of Personality and Social Psychology* 51, 1173–82.
- Bates, E., Benigni, L., Bretherton, I., Camaioni, L. & Volterra, V. (1979). *The emergence of symbols: cognition and communication in infancy*. New York: Academic Press.
- Baumwell, L., Tamis-LeMonda, C. S. & Bornstein, M. H. (1997). Maternal verbal sensitivity and child language comprehension. *Infant Behavior and Development* 20(2), 247–58.
- Blake, J., O'Rourke, P. & Borzellino, G. (1994). Form and function in the development of pointing and reaching gestures. *Infant Behavior and Development* 17, 195–203.
- Blake, J., Osborne, P., Cabral, M. & Gluck, P. (2003). The development of communicative gestures in Japanese infants. *First Language* 23, 3–20.
- Blake, J., Vitale, G., Osborne, P. & Olshansky, E. (2005). A cross-cultural comparison of communicative gestures in human infants during the transition to language. *Gesture* 5, 201–17.
- Bornstein, M. H., Tamis-LeMonda, C. S. & Haynes, M. (1999). First words in the second year: continuity, stability, and models of concurrent and predictive correspondence in vocabulary and verbal responsiveness across age and context. *Infant Behavior and Development* 22(1), 65–85.
- Brent, M. R. & Siskind, J. M. (2001). The role of exposure to isolated words in early vocabulary development. *Cognition* 81, B33–44.
- Brooks, R. & Meltzoff, A. N. (2008). Infant gaze following and pointing predict accelerated vocabulary growth through two years of age: a longitudinal, growth curve modeling study. *Journal of Child Language* 35, 207–20.
- Butterworth, G. E. (1998). What is special about pointing? In F. Simion & G. E. Butterworth (Eds.), *The development of sensory motor and cognitive capacities in early infancy: from perception to cognition*. Hove: Psychology Press.
- Camaioni, L., Castelli, M. C., Longobardi, E. & Volterra, V. (1991). A parent report instrument for early language assessment. *First Language* 11, 345–59.
- Carpenter, R., Mastergeorge, A. & Coggins, T. (1983). The acquisition of communicative intentions in infants 8 to 15 months of age. *Language and Speech* 26(2), 101–16.
- Carpenter, M., Nagell, K. & Tomasello, M. (1998). Social cognition, joint attention, and communicative competence from 9 to 15 months of age. *Monographs of the Society for Research in Child Development*, Serial 255 63(4), 1–174.
- Colonnese, C., Stams, G., Koster, I. & Nboom, M. (2010). The relation between pointing and language development: a meta-analysis. *Developmental Review* 30, 352–66.

- Crais, E., Douglas, D. D. & Campbell, C. C. (2004). The intersection of the development of gestures and intentionality. *Journal of Speech, Language, and Hearing Research* **47**, 678–94.
- Fenson, L., Marchman, V. A., Thal, D., Reznick, J. & Bates, E. (2007). *MacArthur Communicative Developmental Inventories: user's guide and technical manual*, 2nd ed. Baltimore, MD: Paul H. Brookes Publishing Co.
- Franco, F. & Butterworth, G. (1996). Pointing and social awareness: declaring and requesting in the second year. *Journal of Child Language* **23**, 307–36.
- Gershkoff-Stowe, L. (2002). Object naming, vocabulary growth, and the development of word retrieval abilities. *Journal of Memory and Language* **46**, 665–87.
- Gershkoff-Stowe, L. & Hahn, E. R. (2007). Fast mapping skills in the developing lexicon. *Journal of Speech, Language, and Hearing Research* **50**, 682–97.
- Girolametto, L., Pearce, P. S. & Weitzman, E. (1996). Interactive focused stimulation for toddlers with expressive vocabulary delays. *Journal of Speech and Hearing Research* **39**, 1274–83.
- Goldfield, B. A. & Reznick, J. S. (1990). Early lexical acquisition: rate, content, and the vocabulary spurt. *Journal of Child Language* **17**(1), 171–83.
- Goldin-Meadow, S. (2002). Constructing communication by hand. *Cognitive Development* **17**, 1385–405.
- Goldin-Meadow, S. (2007). Pointing sets the stage for learning language and creating language. *Child Development* **78**(3), 741–5.
- Goldin-Meadow, S., Goodrich, W., Sauer, E. & Iverson, J. (2007). Young children use their hands to tell their mothers what to say. *Developmental Science* **10**(6), 778–85.
- Goldin-Meadow, S. & Morford, M. (1985). Gesture in early child language. *Merrill Palmer Quarterly* **31**(2), 145–76.
- Goldin-Meadow, S. & Wagner, S. M. (2005). How our hands help us learn. *Trends in Cognitive Science* **9**, 230–41.
- Harding, C. & Golinkoff, R. (1979). The origins of intentional vocalizations in prelinguistic infants. *Child Development* **50**(1), 33–40.
- Holmbeck, G. N. (1997). Toward terminological, conceptual, and statistical clarity in the study of mediator s and moderators: examples from child-clinical and pediatric psychology literatures. *Journal of Consulting and Clinical Psychology* **65**(4), 599–610.
- Iverson, J. & Goldin-Meadow, S. (2005). Gesture paves the way for language development. *Psychological Science* **16**(5), 367–71.
- Iverson, J. & Thelen, E. (1999). Hand, mouth and brain: the dynamic emergence of speech and gesture. *Journal of Consciousness Studies* **69**(11), 19–40.
- Leavens, D. & Hopkins, W. (1999). The whole-hand point: the structure and function of pointing from a comparative perspective. *Journal of Comparative Psychology* **113**(4), 417–25.
- Liszkowski, U., Carpenter, M., Henning, A., Striano, T. & Tomasello, M. (2004). Twelve-month-olds point to share attention and interest. *Developmental Science* **7**(3), 297–307.
- Liszkowski, U., Carpenter, M. & Tomasello, M. (2008). Twelve-month-olds communicate helpfully and appropriately for knowledgeable and ignorant partners. *Cognition* **108**(3), 732–9.
- Marcos, H. (1991). How adults contribute to the development of early referential communication. *European Journal of Psychology of Education* **6**(3), 271–82.
- Marcos, H., Ryckebusch, C. & Rabain-Jamin, J. (2003). Adult responses to young children's communicative gestures: joint achievement of speech acts. *First Language* **23**(2), 213–37.
- Masur, E. F. (1982). Mothers' responses to infants' object-related gestures: influences on lexical development. *Merrill-Palmer Quarterly* **9**, 23–30.
- Masur, E. (1983). Gestural development, dual-directional signaling, and the transition to words. *Merrill-Palmer Quarterly* **12**(2), 93–109.
- Masur, E. F. & Eichorst, D. L. (2002). Infants' spontaneous imitation of novel versus familiar words: relations to observational and maternal report measures of their lexicons. *Merrill-Palmer Quarterly* **48**(4), 405–26.

- Masur, E. F., Flynn, V. & Eichorst, D. L. (2005). Maternal responsive and directive behaviours and utterances as predictors of children's lexical development. *Journal of Child Language* **32**, 63–91.
- McDuffie, A. & Yoder, P. (2010). Types of parent verbal responsiveness that predict language in young children with autism spectrum disorder. *Journal of Speech, Language & Hearing Research* **53**, 1026–39.
- Mundy, P., Hogan, A. & Doehring, P. (1996). A preliminary manual for the abridged Early Social Communication Scales (ESCS). Coral Gables, FL: University of Miami.
- Mundy, P., Sigman, M. & Kasari, C. (1990). A longitudinal study of joint attention and language development in autistic children. *Journal of Autism and Developmental Disorders* **20**, 115–28.
- Nelson, K. (1973). Structure and strategy in learning to talk. *Monographs of the Society for Research in Child Development* Serial 255, **38**(1/2).
- Olson, J. & Masur, E. F. (2011). Infants' gestures influence mothers' provision of object, action and internal state labels. *Journal of Child Language* **38**, 1028–54.
- Olson, J. & Masur, E. F. (2013). Mothers respond differently to infants' gestural versus nongestural communicative bids. *First Language* **33**(4), 372–87.
- O'Neill, D. K. (1996). Two-year-old children's sensitivity to a parent's knowledge state when making requests. *Child Development* **67**, 659–77.
- Parlade, M. & Iverson, J. (2011). The interplay between language, gesture, and affect during communicative transition: a dynamic systems approach. *Developmental Psychology* **47**(3), 820–33.
- Puccini, D., Hassemer, M., Salomo, D. & Liszkowski, U. (2010). The type of shared activity shapes caregiver and infant communication. *Gesture* **10**(2/3), 279–96.
- Rollins, P. (2003). Caregivers' contingent comments to 9-month-old infants: relationships with later language. *Applied Psycholinguistics* **24**, 221–34.
- Rowe, M. L. (2000). Pointing and talk by low-income mothers and their 14-month-old children. *First Language* **20**, 305–30.
- Rowe, M. L. & Goldin-Meadow, S. (2009). Early gesture selectively predicts later language learning. *Developmental Science* **12**(1), 182–7.
- Rowe, M., Ozcaliskan, S. & Goldin-Meadow, S. (2008). Learning words by hand: gesture's role in predicting vocabulary development. *First Language* **28**(2), 182–99.
- Shumway, S. & Wetherby, A. (2009). Communicative acts of children with autism spectrum disorders in the second year of life. *Journal of Speech, Language, and Hearing Research* **52**, 1139–56.
- Slaughter, V., Peterson, C. C. & Carpenter, M. (2009). Maternal mental state talk and infants' early gestural communication. *Journal of Child Language* **36**, 1053–72.
- Storkel, H. (2004). Do children acquire dense neighborhoods? An investigation of similarity neighborhoods in lexical acquisition. *Applied Psycholinguistics* **25**, 210–21.
- Tamis-LeMonda, C. S., Song, L., Leavell, A. S., Kahana-Kalman, R. & Yoshikawa, H. (2012). Ethnic differences in mother–infant language and gestural communications are associated with specific skills in infants. *Developmental Science* **15**(3), 384–97.
- Taumoepeau, M. & Ruffman, T. (2008). Stepping stones to others' minds: maternal talk relates to child mental state language and emotion understanding at 15, 24, and 33 months. *Child Development* **79**, 284–302.
- Tomasello, M. (1995). Pragmatic contexts for verb learning. In M. Tomasello & W. E. Merriman, *Beyond names for things*, 115–46. Hillsdale, NJ: Lawrence Erlbaum Associates.
- Tomasello, M. & Farrar, M. (1986). Joint attention and early language. *Child Development* **57**, 1454–63.
- Watson, L., Crais, E., Baranek, G., Dykstra, J. & Wilson, K. (2013). Communicative gesture use in infants with and without autism: a retrospective home video study. *American Journal of Speech-Language Pathology* **22**, 25–39.

RESPONSES TO INFANT GESTURES PREDICT VOCABULARY

- Wetherby, A., Cain, D., Yonclas, D. & Walker, V. (1988). Analysis of intentional communication of normal children from the prelinguistic to the multiword stage. *Journal of Speech and Hearing Research* **31**(2), 240–52.
- Wetherby, A. & Prizant, B. (1993). *Communication and Symbolic Behavior Scales – Normed Edition*. Chicago, IL: Applied Symbolix.
- Yoder, P. J., McCathren, R. B., Warren, S. F. & Watson, A. L. (2001). Important distinctions in measuring maternal responses to communication in prelinguistic children with disabilities. *Communication Disorders Quarterly* **22**(3), 135–47.
- Yoder, P. J. & Warren, S. (1998). Maternal responsivity predicts the prelinguistic communication intervention that facilitates generalized intentional communication. *Journal of Speech, Language, and Hearing Research* **41**, 1207–19.