Imitation and Joint Attention as Predictors of Language Outcome In Infants at High and Low Risk for Autism Spectrum Disorder

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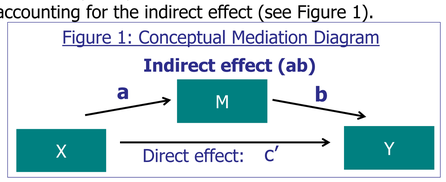
Abstract

Expressive language impairment in infant siblings of children with ASD is predictive of later adaptive functioning. Infants' motor imitation and responding to joint attention (RJA) skills were hypothesized as sequential predictors of later expressive language. A longitudinal model was estimated in which RJA at 15 months mediated the association between motor imitation at 12 months and expressive language at 18 months for both high risk and low risk infants. For low risk infants only, 12-month imitation significantly predicted 18-month expressive language above and beyond the RJA pathway. This study was one of the first to employ a prospective, longitudinal design to study predictors of language in infants at risk for ASD. By increasing our knowledge of the multimodal skills underlying infants' language growth, we can employ early intervention strategies that target those skills.

Background

- **Expressive language impairment** in ASD is prevalent and predictive of children's long-term functioning (Luyster et al., 2008).
- Infant siblings of children with ASD have a 1 in 5 chance of also being diagnosed with ASD (Ozonoff et al., 2011).
- An additional 1 in 5 siblings experiences language impairment or delay (Constantino et al., 2010; Messinger et al., 2013).
- By studying high risk (HR) infants and their typically developing, low-risk peers (LR infants), we can examine developmental precursors and sequences that underlie the emergence of language.
- **Motor imitation** and **responding to joint attention (RJA) are two early emerging behaviors that have been found to predict later expressive language ability** in both LR children and those with ASD (Charman et al., 2000; 2003; Morales et al., 2000; Stone et al., 2001).
- **However, the sequence of these behaviors in predicting language has been little explored.**
- **We hypothesize that imitation predicts RJA, which then predicts language:**
  - Imitative play may promote RJA because it encourages infants to follow others' attention for further chances to imitate (Ingersoll et al., 2008; McDuffie et al., 2007).
- **The strength of this sequence may be stronger for HR infants:**
  - Some studies have found associations between imitation, RJA and expressive language for HR but not LR infants (McDuffie et al., 2007; Presmanes et al., 2007).
- In mediation, the indirect effect, or *ab*, is defined as the path from the predictor (X) to the outcome variable (Y) through the mediator (M). For mediation to occur, only the indirect effect must be significant.
- The direct effect, or *c′*, is the association between X and Y that remains after accounting for the indirect effect (see Figure 1).

Figure 1: Conceptual Mediation Diagram



Research Aims

1. We tested a longitudinal model of language development in which we predict that the relation between motor imitation at 12 months and expressive language at 18 months is mediated by infants' responding to joint attention bids at 15 months.
1. While we predict that the mediational pathway will exist for all infants, we also predict that the both the indirect and direct paths will be conditional on risk group; they will be stronger for HR infants than LR infants.

Method

Sample

- **All infants: *n* = 84**
- **HR infants** (*n* = 50, males = 29) had at least one older sibling who was diagnosed with ASD, verified by the Autism Diagnostic Observation Schedule (ADOS), Autism Diagnostic Interview-Revised (ADI-R), and clinical diagnosis.
- **LR infants** (*n* = 34, males = 16) had at least one typically developing older sibling, verified through parental report and results on the Social Communication Questionnaire (SCQ), and no reported history of ASD in first, second, or third-degree relatives.
- Inclusion criteria for both groups: (1) absence of severe sensory or motor impairments; (2) absence of identified metabolic, genetic, or progressive neurological disorders; (3) gestational age ≥ 37 weeks; (4) birth weight at least 2500 grams.

Table 1: Sample Characteristics

Maternal Level of Education	# (%)
HS diploma only	10 (12)
Associates or Bachelors degree	35 (42)
Masters degree or higher	30 (45)
No Response	9 (11)
Participant Race/ Ethnicity	**# (%)**
Caucasian	66 (79)
Multiracial	11 (13)
Black / African American	3 (4)
Asian	2 (2)
Hispanic/ Latino	1 (1)

Procedure

Infants were assessed at 12, 15, and 18 months of age as part of a longitudinal multisite study investigating the social emotional development of infants at high risk for ASD from 6 – 36 months at Vanderbilt University, University of Miami, and University of Washington. The current sample included infants from VU and UW.

Measures & Variables

Motor Imitation: 12 months

- Total number of passes (range 0-4) on the Imitation domain of the Screening Tool for Autism in Toddlers (STAT; Stone et al., 2008)
- Four actions were modeled: shake rattle, drum hands, roll car, and hop dog.

Responding to Joint Attention (RJA): 12 and 15 months

- Total number of passes (range 0-8) on the RJA items of the Early Social Communication Scales (ESCS; Mundy et al., 2003).
- For each trial, an experimenter directs an infant's attention to posters around the room by simultaneously calling their name and pointing to the posters.

Expressive Language (EL): 12, 15, and 18 months

Expressive language was assessed with the MacArthur-Bates Communicative Development Inventory (MCDI; Fenson et al., 2007). Infants' EL score (range 0-325) represents the number of words that their caregivers report they both understand and say.

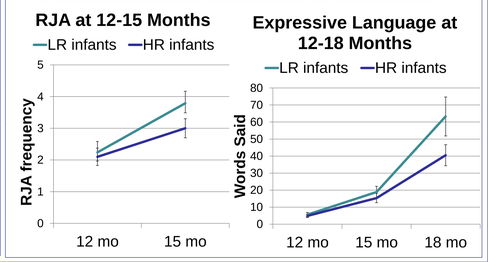
Results: Group Differences

Infants' motor imitation at 12 months did not differ by group, $p > .05$. RJA and EL did not differ significantly by group at any time point, all $ps > .05$, although both RJA and EL increased over time, ($F(2,82) = 64.15$, $p = .00$ and $F(2.164) = 61.45$, $p = .00$, respectively). See Table 2, Figure 2.

Table 2: Mean (SD) for Imitation, RJA, and EL: all *ps* > .05

Variable	HR Infants	LR Infants
Imitation, 12 mo	1.78 (0.84)	1.91 (0.90)
RJA, 12 mo	2.10 (1.93)	2.24 (2.00)
RJA, 15 mo	3.00 (2.13)	3.79 (2.20)
Ex. Lang., 12 mo	4.88 (6.99)	5.59 (7.50)
Ex Lang., 15 mo	15.34 (19.13)	18.88 (19.60)
Ex. Lang., 18 mo	40.50 (43.77)	63.26 (66.65)

Figure 2: RJA and Expressive Language over Time



Results: Mediation Analysis

Model settings and covariates:

- Coefficients were derived with two multiple regression models, one predicting 15-month RJA and one predicting 18-month expressive language (see Table 3).
- Earlier levels of RJA (at 12 months) and EL (at 12 and 15 months) were included in the regression models as covariates to control for growth in these skills that occurred before effects of interest.
- Indirect effect inferences tests were calculated with bias-corrected, bootstrap-generated 95% confidence intervals (10,000 samples; PROCESS macro; Hayes, 2013).

Research Aim 1: Longitudinal mediation.

- As hypothesized, the indirect effect was significant for all infants such that:
  - For each additional item infants imitated at 12 months, they were estimated to speak an average of 1.64 more words at 18 months.
  - This association occurred as a result of imitation's influence on RJA, which then influenced EL (see Table 4, Figure 3).

Research Aim 2: Moderation of the pathways by ASD risk.

- Both conditional indirect and direct effects were estimated. The direct, but *not* the indirect, effect differed by risk group.
- A more parsimonious model was estimated in which only the direct effect was specified as conditional on ASD risk.
- The direct effect was present such that for LR infants but not HR infants, infants with one additional imitation pass at 12 months were estimated to speak 12.67 more words on average at 18 months, independent of the indirect effect (see Table 4, Figure 3).

Table 3: Final model regression coefficients

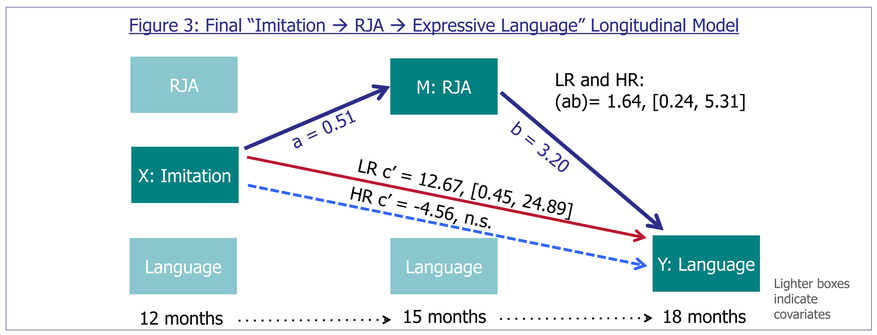
	Mediator: RJA, 15 months				Outcome: EL, 18 months			
	Path	Coeff (B)	SE	*p*	Path	Coeff (B)	SE	*p*
Imitation, 12 mo	*a*	0.51	0.26	0.05	*c′*	-4.56	5.25	0.39
RJA, 15 mo	-	-	-	-	*b*	3.20	1.75	0.07
Constant	-	0.50	0.40	0.22	-	5.07	7.50	0.50
RJA, 12 mo	-	0.45	0.11	0.00	-	-0.18	1.92	0.93
EL, 12 mo	-	0.04	0.04	0.29	-	-1.60	0.60	0.01
EL, 15 mo	-	-0.01	0.01	0.47	-	2.55	0.23	0.00
group	-	-	-	-	-	28.97	10.57	0.01
*group*imitation*	-	-	-	-	-	17.22	7.94	0.03
	$R^2 = .20$				$R^2 = .72$			
	$F(4, 79) = 5.07$, $p = .001$				$F(7,76) = 27.77$, $p = .00$			

Table 4: The indirect effect is significant for all infants. The direct effect is conditional on ASD risk

	Group	Coeff (B)	SE	*t*	*p*	LLCI	ULCI
Conditional direct effect of imitation on EL (*c′*):	HR	-4.56	5.26	-0.87	0.39	-15.00	5.89
	LR	**12.67**	**6.14**	**2.06**	**0.04**	**0.45**	**24.89**
Indirect effect of imitation on EL (*ab*):	-	**1.64**	**1.09**	-	-	**0.24**	**5.31**

Note: All coefficients are unstandardized regression coefficients. LLCI/ ULCI = lower/ upper limit of the confidence interval.

Figure 3: Final "Imitation → RJA → Expressive Language" Longitudinal Model



Conclusions

These findings support the concept of a developmental sequence in which infants' early imitation ability leads to higher levels of later expressive language in part through their intermediate RJA behaviors. Many interventions aim to improve infants' early social communication abilities to foster later language growth; this study suggests that targeting imitation before, or along with, RJA skills may be an efficient approach for infants at risk for ASD.

Results suggest that infants at risk for ASD may gain language specifically through the imitation → RJA pathway, whereas for low-risk infants, imitation affects expressive language both indirectly, through RJA, and directly. This study was one of the first to examine the sequential contribution of infants' early skills to their later language ability in a prospective, longitudinal design. Further analyses will be conducted as diagnostic visits and behavioral coding continue.

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