

Talking Tots: Unraveling the ABCs of Children's Linguistic Development

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Introduction:

Language is perhaps the most fundamental act to us as humans, quintessential to expressing ourselves, our problem-solving abilities, communicating, learning, and interacting with one another. Given such, it seems remarkable that, at one point, we all started with a minimal capacity (Pelaez & Monlux, 2018) for spoken communication. This dramatic shift in our development begs the question: how do we transition from a state of no prior linguistic proficiency to becoming heavily reliant on it within such a relatively brief period (see Figure 1)?

Background Literature:

Language development in children is a journey marked by several linguistic milestones - making noises, first words, forming sentences, etc. - with each building upon the previous one. Among these linguistic milestones, the phenomenon of babbling¹ is a particularly fascinating development. Previous research in the field of language acquisition has primarily concentrated on establishing relationships between various facets of linguistic development, including communicative acts (Bergey et al., 2022; Ninio et al., 1994), speech act usage (Snow et al., 1996), and humor (Addyman et al., 2018), and that individual's social utility². However, within this context, the role of babbling as a communicative tool has received relatively limited attention. While studies on babbling have underscored its significance in the trajectory of language acquisition (Vihman, 1996) and its occurrence across species (Snowdon et al., 1998),

¹ An early stage of language development in infants characterized by consonant-vowel or vowel-consonant sounds.

² A measure of the extent to which the good or service is useful in satisfying a person's want or need

there has been a tendency to treat babbling and peer interactions as separate domains, thereby overlooking the intricate interplay that occurs at the intersection of these two phenomena.

Rationale:

Accordingly, this paper will seek to fill the gap in understanding of the linguistic development where these two phenomena converge: what role do peer-interactions play in shaping the diversity and complexity of babbling in infants? More specifically, this paper will investigate whether exposure to various peer models results in more diverse and complex babbling patterns in infants when compared to infants exposed to a single peer model. In this exploratory analysis, the specific rationale for this proposed study is to explore the potential for a causal relationship between social interaction and early language acquisition, and to better understand precisely how exposure to peer models may enhance the linguistic repertoire of infants.

Hypotheses:

At the core of this investigation are two primary variables: peer models (independent variable) and babbling diversity and complexity (dependent variables). Peer models, representing the network of children (either single or multiple nodes) with whom infants interact, are pivotal to the study. Likewise, the constructs of babbling diversity and complexity will be operationalized through the quantification of the following speech-like-features: number of different consonant-vowel (CV) combinations, ratio of vowels to consonants, presence of consonant clusters, use of non-native sounds, variability in intonation patterns, phonetic inventory size, and diversity of syllable structures. Within this study, the hypotheses put forth are two-fold: (1) Infants exposed to multiple peer models will demonstrate more diverse babbling patterns relative to their counterparts who interact with a single peer model and (2) Infants exposed to multiple peer

models of verbal interaction will exhibit increased phonetic complexity in their babbling, compared to their counterparts who interact with a single peer model.

Proposal:

This paper adopts a two-phase research methodology to evaluate the effect of peer relationships in influencing the diversity and complexity of babbling in infants. The first stage is observational research, which is then followed by an experimental inquiry to determine causation.

During the observational phase, 30 infants aged 4 to 12 months will have their natural interactions documented at daycare centers during a 6-week period. The study cohort is made up of typically developing children with no known linguistic difficulties, with careful adherence to ethical rules and data anonymization and encryption. The observation approach includes audio and video recording equipment carefully positioned in daycare settings to capture any spontaneous encounters. For phonetic diversity and complexity, research assistants will note observed behaviors as well as peer relationships in terms of frequency and duration. Through a variety of linguistic and social characteristics, this non-experimental, longitudinal approach tries to investigate the relationship between peer interactions and babbling diversity and complexity. To study the relationships between these variables, statistical procedures such as correlation and regression will be used.

In the second phase, 60 infants aged 4-48 months will participate in an experimental study at the University of Wisconsin-Madison's Waisman Center daycare. Participation in this phase will require assent and consent. The study will involve infants who are already babbling as part of their language development. These infants will be randomized at random to one of four conditions, with the number and age of interaction partners varying. During playtime, audio recordings will capture babbling sessions, chats, and vocalizations. Trained observers will record

the start of the conversation, its duration, and the number of distinct partners. Follow-up data will be collected to determine infants' preferences for engaging with other children during playtime.

The study adopts a randomized controlled trial design with four separate experimental conditions, with the extent and age of interaction partners being the emphasis. The data will be analyzed using a variety of babble diversity and complexity measurements, conversational metrics, and partner preferences. To investigate significant differences and causal linkages, statistical tests such as ANOVA and linear regression will be utilized. To protect the welfare of the participants, ethical factors such as informed consent, participant safety, confidentiality, and adherence to IRB guidelines would be stressed throughout the project.

Methods I

Participants:

To first investigate this research question, I will observe and record the behavior of 30 infants 4-12 months old for a period of 6 weeks. The relevant population are U.S. infants. This age range has been selected by building off past work establishing this as a critical period in linguistic development (Locke & Pearson, 2009). Participants will be recruited from, and in cooperation with, local daycare centers. The population I will be sampling from is Dane County infants within the selected age range. The criteria for inclusion are conditional insofar as participants are Typically Developing (TD) (Hutchins et al., 2021) children without any known language impairments. The study will strictly adhere to ethical guidelines and consideration for research and privacy throughout the whole study. Data will be anonymized and encrypted.

Data Collection:

The data collection process is facilitated by several essential materials. Firstly, strategically positioned audio and video recording equipment within the daycare setting will capture the natural interactions of the participants. These recordings serve as the cornerstone of the observational data. Additionally, research assistants will rely on standardized ethogram sheets to meticulously log timestamps and provide descriptions of observed behaviors in the recorded footage. Furthermore, demographic questionnaires administered to parents or guardians will yield vital information about the children's ages, genders, and cultural, racial, and socioeconomic backgrounds, ensuring the validity and generalizability of findings.

The observational approach begins with the discreet setup of audio and video recording equipment within the daycare facility. This setup is executed with precision to avoid any disruption to the children's spontaneous interactions. The data collection process will during

regular daycare hours, encompassing a wide range of activities such as playtime, meals, and group activities. Trained research assistants will then transcribe and code the infants' babbling episodes for phonetic diversity and complexity, as well as peer interactions for frequency and duration. This coding process adheres to established protocols to guarantee the consistency and reliability of behavioral analysis.

Design:

This study adopts a non-experimental, longitudinal design. The primary predictor variable centers on the extent and duration of exposure to peer interactions. In tandem, the criterion variables encompass diverse facets of babbling diversity and complexity, each thoroughly detailed in the data analysis section.

Data Analysis:

Data analysis will encompass a comprehensive examination of various linguistic and social dimensions. For babbling analysis, I will explore several key variables, including the number of unique CV combinations, which quantifies the distinct consonant-vowel combinations produced during babbling episodes; the vowel-to-consonant ratio, calculated as the proportion of vowel sounds to consonant sounds within babbling sequences; the identification of consonant clusters, denoting consecutive consonants within babbling; non-native sound recognition, aimed at detecting non-native or less common speech sounds within babbling; evaluation of variability in intonation patterns used during babbling; quantification of the phonetic inventory size, which represents the number of distinct phonetic elements present; and categorization of babbling into different syllable structures, such as CV or CVC, to gauge diversity. Similarly, the exploration of peer interaction analysis encompasses the quantification of several variables. I will determine total minutes spent with others, providing insight into the duration of peer interactions for each

child. Additionally, I will count the unique peer interactions, measuring the number of peer-initiated conversations engaged in by each child. Finally, statistical analyses, including correlation and regression analysis, will be employed to investigate whether statistically significant relationships exist between these variables

Methods II

Participants:

The study will entail the participation of infants aged 4-24 months, selected from the Waisman Center daycare at the University of Wisconsin-Madison. This choice is deliberate, as the center is well-versed in adhering to Institutional Review Board (IRB) protocols, and its facilities are purposefully designed to support research related to children's developmental processes (e.g., one-way mirrors). The relevant population are U.S. infants. Parental consent will be obtained to ensure their infants' participation. It's important to note that this study will include infants who are already engaging in babbling behavior as part of their normal language development. A total of 60 infants will be included in the study, with 15 per level to find an effect given a power of .8.

Materials:

Materials will include a controlled setting for the dyadic interactions and audio recording equipment for capturing babbling sessions. All materials used will ensure the safety, comfort, and confidentiality of the infants.

Procedure - Exposure Phase: During the exposure phase, infants will be randomly assigned to one of four conditions, where both the number of agents and the age of agents are manipulated: Same Age, One Other Infant Interaction (SA-OO): In this condition, infants in the experimental group will engage in daily one-hour playtime sessions over the span of five days, interacting with one other infant of the same age (4-24 months). Older Age, One Other Infant Interaction (OA-OO): In this condition, infants in the experimental group will participate in daily one-hour playtime sessions over five days, engaging with one other infant of older age (24-48 months). Same Age, Nine Other Infants Interaction (SA-NO): In this condition, infants in the experimental group will have daily one-hour playtime sessions for five days, interacting with

nine other infants of the same age (4-24 months). Mixed Age, Nine Other Infants Interaction (MA-NO): In this condition, infants in the experimental group will engage in daily one-hour playtime sessions for five days, interacting with nine other infants comprising both the same age (4-24 months) and older age (24-48 months).

Procedure - Data Collection Phase:

Throughout the study, audio recordings will be continuously made during the infants' playtime interactions in both the experimental and control conditions. These recordings will capture a wide range of verbal exchanges, including babbling, conversations, and other vocalizations. Additionally, trained observers will record the number of conversations initiated by each infant, the total duration of conversations, and the number of unique conversation partners. Beyond the immediate study period, follow-up data will be collected during the week following the exposure phase. This data will focus on assessing how many children each infant expresses a desire to interact with during their playtime sessions.

Design:

This study adopts a randomized controlled trial (RCT) design with four distinct between-group levels. The independent variables (IV) encompass the level of exposure to diverse dyadic interactions and the age range of the infants with whom the study participants interact.

Data Analysis:

The data analysis will involve a comprehensive assessment of babbling diversity and complexity, along with various conversational metrics, in all four experimental conditions. In addition to the measures from the initial study, I will also measure the number of conversations initiated, the duration of these conversations, the age of partners, and the distinct number of partners involved, all documented during the initial week of the study. Subsequently, during the following week,

the number of partners engaged with during playtime will be documented to measure inclination towards further linguistic exposure.

Statistical analysis will include appropriate tests, such as ANOVA, to determine significant differences among the four experimental conditions, and linear regression will be employed to explore causal relationships, particularly concerning longitudinal data. This approach will provide a comprehensive understanding of how the manipulated variables influence infant language development and social interaction preferences.

Ethics Statement:

Ethical considerations for this study include obtaining informed consent from the infants' parents or legal guardians, ensuring minimal risk to the participants, maintaining confidentiality of all collected data, and providing a debriefing to parents after the study's completion. Additionally, infants' comfort and safety during the interactions will be prioritized throughout the study. The research will be conducted in accordance with ethical guidelines and protocols established by the institutional review board (IRB) to safeguard the welfare of the participants.

***** Discussion Section – Start Grading Here *****

Anticipated Results: Study 1

I anticipate a strong positive correlation between peer interactions and babbling diversity and complexity. The regression analysis is expected to predict that infants engaging in more interactions will exhibit greater diversity and complexity in their babbling patterns. Specifically, I anticipate observing a greater variety of consonant-vowel combinations, a higher vowel-to-consonant ratio, more frequent occurrence of consonant clusters, increased recognition of non-native speech sounds, greater variability in intonation patterns, a larger phonetic inventory size, and a comparatively more diverse range of syllable structures in infants exposed to multiple peer models. Figure 4, which represents the anticipated babbling patterns in infants exposed to various levels of peer models, visually depicts the expected outcomes. This figure illustrates the diverse and complex linguistic features that are anticipated to emerge as a result of increased exposure to varied peer interactions.

Anticipated Results: Study 2

Infants in the Same Age, One Other Infant Interaction (SA-OO) condition are expected to exhibit a significant increase in babbling diversity and complexity compared to the control group. The one-on-one interaction within the same age range is likely to foster linguistic exploration, resulting in varied babbling patterns (Figure 5). In the Older Age, One Other Infant Interaction (OA-OO) condition, where infants interact with an older peer, a unique dynamic is anticipated. The older partner may serve as a linguistic model, influencing the babbling patterns of the younger infants, demonstrating a potential balance between imitation and individual exploration (Figure 6). In the Same Age, Nine Other Infants Interaction (SA-NO) condition, infants engaging with a larger group within the same age range are expected to display heightened social interaction during playtime. This increased social exposure may lead to a broader range of linguistic interactions, impacting babbling diversity and complexity (Figure 6). The Mixed Age, Nine Other Infants Interaction (MA-NO) condition, where infants interact with a diverse group, is expected to result in the most diverse and complex babbling patterns among all conditions.

Additionally, Figure 7 represents the anticipated results in the follow-up measure conducted during the week following the exposure phase in Study 2. I expect that infants exposed to more infants, regardless of age, during the initial playtime sessions will exhibit a preference for interacting with a higher number of peers in subsequent playtime sessions.

Discussion

This comprehensive exploration in both studies effectively fills a previously identified gap in the literature, as delineated in the introduction. Prior research in the field of language acquisition had predominantly focused on establishing relationships between various facets of linguistic development, such as communicative acts, speech act usage, and humor, while largely overlooking the role of babbling as a communicative tool within the context of peer interactions. Although previous studies acknowledged the significance of babbling in language acquisition, there was a tendency to treat babbling and peer interactions as separate domains (). This separation disregarded the intricate interplay that occurs at the intersection of these two phenomena. Consequently, this research bridges this gap by investigating the role of peer interactions in shaping the diversity and complexity of babbling in infants, thereby providing a more holistic understanding of early language development within social contexts. This discovery reinforces the notion that peer interactions act as catalysts for linguistic development, nurturing a more extensive repertoire of speech-like features in infants. However, it also challenges the conventional notion of babbling as a solitary, self-contained developmental phase.

Discussion: Comparison of Advantages and Disadvantages

Study I's non-experimental approach allowed the research to immerse itself in the naturalistic context of daycare peer interactions, providing valuable insights into real-world social exchanges. However, this authenticity came at the cost of limited control over variables.

In contrast, Study II's experimental design offered precision and control over infants' exposure to peer interactions, enabling us to explore causal relationships more definitively. However, there remains a challenge in exerting full control over the extent of exposure to peer interactions. While it might have been possible to pair two infants together, I hesitated to impose

interaction artificially, preferring it to occur organically. My solution was to employ a randomized design, aiming to account for this variability. Additionally, the incorporation of primary caregivers in Study II introduced a potential factor influencing babbling diversity and complexity. This inclusion, while enhancing ecological validity, raised questions about generalizability, as infants may exhibit distinct linguistic engagement patterns with caregivers compared to their interactions with peers. Finally, the methodological rigor of Study II also sacrificed some degree of ecological validity. In sum, Study I laid the foundation by highlighting associations between peer interactions and babbling, while Study II, with controlled exposure, delved deeper into establishing causal relationships.

Limitations

Firstly, both studies primarily draw their samples from infants attending daycare centers, which might constrain the generalizability of potential findings to infants in diverse caregiving environments, such as those primarily cared for at home. Additionally, practical constraints during data collection, including variations in the frequency of peer interactions, could influence the construct validity of peer interaction, warranting careful consideration when interpreting the results. Lastly, while Study II's experimental design effectively controls exposure levels to peer interactions, it may not fully encapsulate the intricacies of real-world social interactions, which can be influenced by a multitude of contextual factors. These limitations emphasize the importance of approaching any findings with prudence and acknowledging the potential boundaries of their applicability.

Future Directions

Just as investigations into babbling and its relationship with social interactions have offered fertile ground for research, I envision numerous avenues for further exploration in this domain. Within this context, I highlight three research directions. Firstly, while these studies delved into babbling's connection with peer interactions, babbling itself represents a broader aspect of early language development. It would be valuable to extend research into how infants communicate non-verbally, especially among deaf infants, emphasizing the role of multi-nodal peer models of manual babbling (Petitto & Marentette, 1991) in their language acquisition journey. Secondly, this research has touched upon a potential convergence phenomenon (Abel & Babel, 2017) observed among infants exposed to single-peer interactions. Expanding upon this aspect by investigating the mechanisms underlying such convergence could reveal new insights into the dynamics of early peer influence on language acquisition. Thirdly, considering the complex nature of social interactions during infancy, integrating neuroimaging techniques into potential research design(s) may provide a deeper understanding of the neural processes underpinning these interactions and their impact on language development.

Importance

This study carries significant meaning in deepening our understanding of how infants learn language and the crucial influence that interactions with peers have on shaping their early linguistic skills. By uncovering the link between exposure to a variety of peer models and the enhancement of diverse and complex babbling, these investigations bring a valuable perspective to the ongoing conversation about the early stages of language development. These results emphasize the vital role of social interactions in fostering linguistic diversity and complexity

right from the start of language acquisition, challenging traditional views that regard babbling as a purely individual effort.

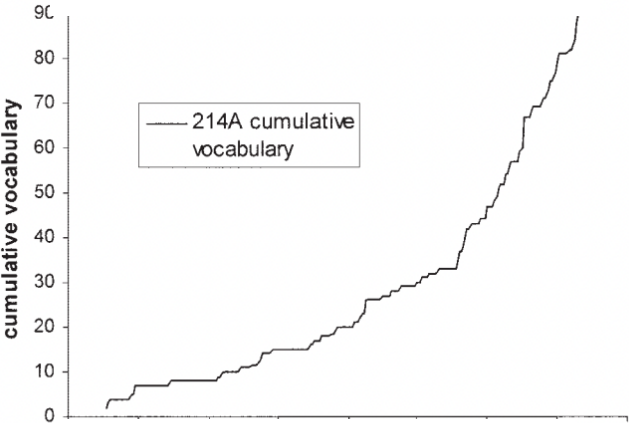
***** Discussion Section – End Grading Here *****

Figures:

Commented [MO1]: add x axes, y-axes, descriptions, and tables or design matrix

Figure 1:

Cumulative vocabulary as a function of time (Ganger and Brent 2004)



Note: Ganger, J., & Brent, M. R. (2004). Reexamining the Vocabulary Spurt. *Developmental Psychology*, 40(4), 621–632. <https://doi.org/10.1037/0012-1649.40.4.621>

Figure 2

Design Matrix

DVs:		IV: Number of Interlocutors	
Study I		One	Nine Other
Babbling diversity, complexity, and level of interaction with other infants.			
Study II			
Measures from study one plus the number of other children they play with the following week.			
IV: Interlocuter Age	Older (24-48months)	Group 1 (One, older interlocuter) N=15	Group 3 (Nine, older interlocuters) N=15
	Same age (6-24months)	Group 2 (One, same age) N=15	Group 4 (Nine, same age) N=15

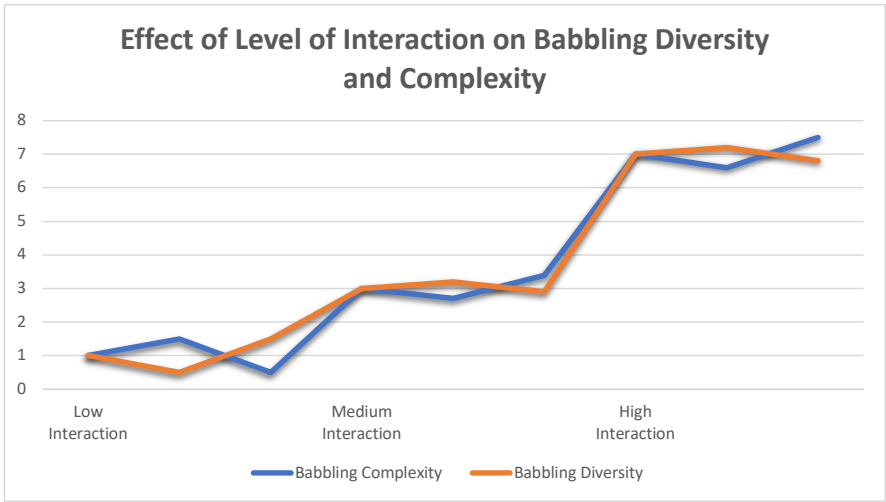
Note: This table is meant to characterize the dependent variables of the studies as well as the independent variables and their respective levels, ultimately encapsulating the four groups used in the study and their characteristics.

Figure 3
ANOVA Results Showing Main Effects and Interaction

DV: Babbling Complexity and Diversity (operationalized in figure 2)		IV: Number of Interlocuters		
		One Other	Nine Other	Main Effect for IV: Number of Interlocuters
IV: Age of Interlocuters	Older	Group 1: 1.5%	Group 3: 3.5%	2.5%
	Same Age	Group 2: .5%	Group 4: 2%	1.25%
Main Effect for IV: Age of Interlocuters		2%	2.75%	

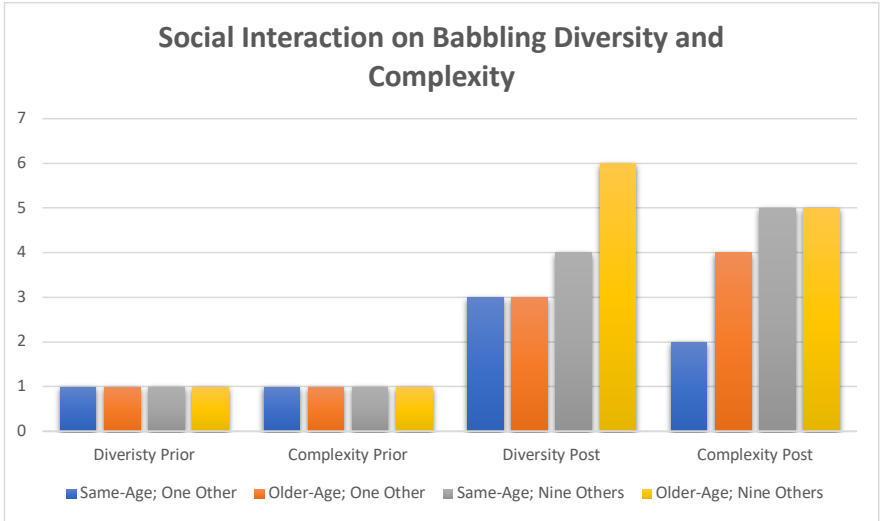
Note: Mean percentage increase in babbling diversity and complexity is reflective of the data graphed in Figure 5. The ANOVA shows significant main effects of age ($p < .04$) and number of interlocuters ($p < .01$), but no a significant interaction between interlocuter age and number of interlocuters.

Figure 4



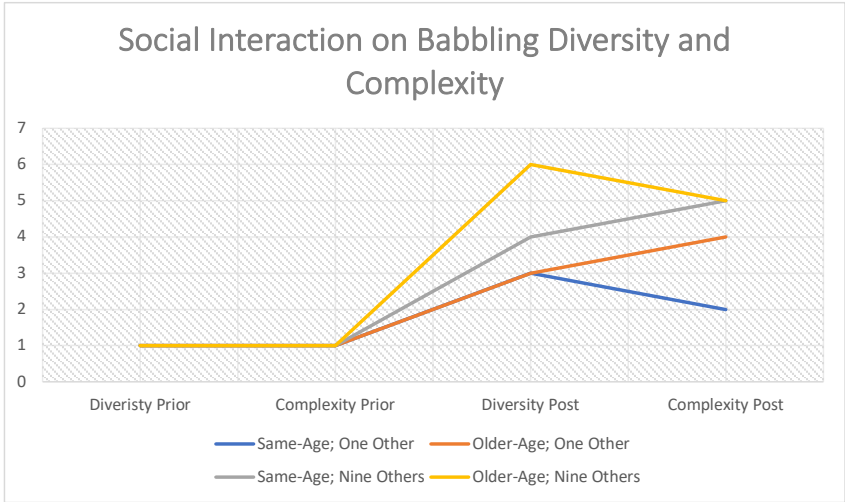
Note: This graph demonstrates the results from study I: there is a significant positive correlation between level of interaction pattern with other infants and infant's babbling complexity and diversity levels.

Figure 5



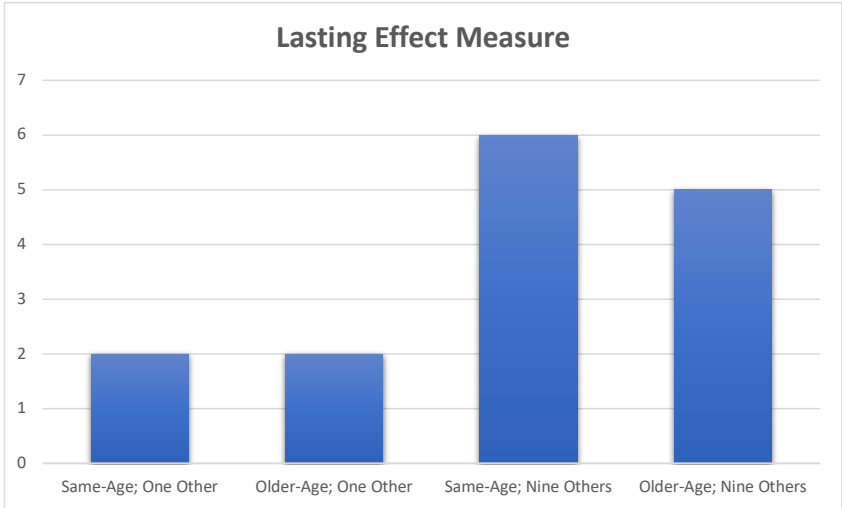
Note: This graph serves as a line graph visualization of the study II results: while all children had more complex and diverse babbling patterns in the posttest measure (likely reflecting infant’s rapid linguistic development in this critical period), infants who were placed with older and more interlocutors had higher percentage increases in these same measures than children in the control condition.

Figure 6



Note: This graph serves as a line graph visualization of the study II results: while all children had more complex and diverse babbling patterns in the posttest measure (likely reflecting infant’s rapid linguistic development in this critical period), infants who were placed with older and more interlocutors had higher percentage increases in these same measures than children in the control condition.

Figure 7



Note: This graph characterizes the expected results from the study II posttest follow-up measure the following week: regardless of age, children who had interacted with more infants the week prior were more likely to continue to play with more children the following week.

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