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PAPER

Power in methods: language to infants in structured and naturalistic contexts

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Abstract

Methods can powerfully affect conclusions about infant experiences and learning. Data from naturalistic observations may paint a very different picture of learning and development from those based on structured tasks, as illustrated in studies of infant walking, object permanence, intention understanding, and so forth. Using language as a model system, we compared the speech of 40 mothers to their 13-month-old infants during structured play and naturalistic home routines. The contrasting methods yielded unique portrayals of infant language experiences, while simultaneously underscoring cross-situational correspondence at an individual level. Infants experienced substantially more total words and different words per minute during structured play than they did during naturalistic routines. Language input during structured play was consistently dense from minute to minute, whereas language during naturalistic routines showed striking fluctuations interspersed with silence. Despite these differences, infants' language experiences during structured play mirrored the peak language interactions infants experienced during naturalistic routines, and correlations between language inputs in the two conditions were strong. The implications of developmental methods for documenting the nature of experiences and individual differences are discussed.

Research highlights

- Developmental scientists' choice of methods strongly influences the types of data and conclusions that are drawn regarding infant experiences, learning and development.
- Language to infants during structured laboratory tasks and naturalistic routines yield different patterns of input by the same mothers.
- Using language as a model system, we show that maternal language inputs to 13-month-old infants during 5 minutes of 'structured play' is consistently dense from minute to minute, with no breaks, whereas language during naturalistic routines reveals striking fluctuations interspersed with silence.
- Despite these methodological differences, individual differences among infants in their language experiences are stable across methods, and language during structured tasks begins to approach what infants hear during naturalistic, language-dense interactions.

Introduction

A pivotal decision in the study of infant experience and learning rests on which methods to use. Different methodological approaches can produce, at minimum, subtle differences in findings. At the extreme, methodological differences can lead to diametrically opposing conclusions about the nature of learning and development. This reality is historically illustrated in one of the most cited inconsistencies of the field – that of object permanence. In 1952 Piaget observed infants' spontaneous, natural search behaviors in the classic A-not-B task, and concluded that infants are unable to fully

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reason about objects until 18 to 24 months of age. Three decades later, the advent of looking-time experiments resulted in a controversial article entitled 'Object permanence in five-month-old infants' (Baillargeon, Spelke & Wasserman, 1985) that illustrated how a change to methods can challenge long-standing assumptions about development.

Similarly, methodological decisions about *context*, such as whether to observe infants under structured or naturalistic conditions, might alter take-home messages. Over four decades ago, Bronfenbrenner spoke of contextual limitations in the study of infant attachment, noting that 'Much of contemporary developmental psychology is the science of the strange behavior of children in strange situations with strange adults for the briefest possible periods of time' (Bronfenbrenner, 1977, p. 513). Bronfenbrenner's methodological critique readily applies to the study of infant learning and experience across many areas, and has been echoed by scientists who study learning in cultural context (Rogoff, 2003).

Consider the case of infant walking, which looks very different in experimentally manipulated conditions than in naturalistic contexts. When 14-month-old infants are encouraged to walk along a gait mat to an examiner who beckons at the far end, their steps follow a straight path with evenly spaced footfalls. In contrast, infant walking is far from linear and systematic when infants are free to roam. Infants take circuitous paths that are marked by twists and turns, stops and falls (Adolph, Cole, Komati, Garciaguirre, Badaly *et al.*, 2012).

Moreover, laboratory testing of motor behaviors – typically based on brief observations – has led to the standardization of behaviors such as sitting, crawling, and walking into scales such as the Gesell, which is viewed to be a gold standard of motor development. However, when developmental scientists venture outside the laboratory to wade in the murky waters of everyday life, they are often surprised by what they uncover. Five-month-old Cameroonian infants deftly sit on high benches with hands free for up to 30 minutes as their mothers go about daily chores (Karasik, Tamis-LeMonda, Adolph & Bornstein, 2015b), an observation that stands in striking contrast to the sitting onset norms of 7–8 months that have been established in US laboratory-based studies (Martorell, Onis, Martines, Black, Onyango *et al.*, 2006). Conversely, infants in Tajikistan spend up to 21 hours a day in a 'ghavora' cradle, their limbs and torso snugly bound by cords of satin and their vision obstructed by a drape placed over the cradle. In this culture, infant walking is shifted upward by several months relative to US norms, with only two-thirds of 16-month-olds demonstrating walking when outside the cradle (Karasik, Mladenovic, Abraham, Robinson, Tamis-LeMonda *et al.*, 2015a).

Infants' apparent understanding of goal-directed intentions likewise depends on whether they are tested in experimental or naturalistic contexts (Krogh-Jespersen & Woodward, 2016). In laboratory looking-time experiments, infants of 3 to 6 months appear to understand that people's reaching actions are goal-directed (Sommerville, Woodward & Needham, 2005), but it is not until the second year that they respond appropriately to reaches during everyday interactions (Svetlova, Nichols & Brownell, 2010; Warneken & Tomasello, 2006, 2007). One reason for these differences may lie in the nature of the input across contexts – laboratory settings present controlled, slow, and repetitious information to infants, whereas real-time social interactions require infants to keep track of rapid changes in action and to deal with potentially noisy environments where many things are happening at once (Krogh-Jespersen & Woodward, 2016).

Language as a model system

The examples above illustrate the power of methods in affecting conclusions about the nature of infant learning and development. In this study, language is tested as a model system to investigate whether and how different methodological approaches might affect characterizations of infant language experiences.

Questions about the 'nature of the input' underpin hundreds of studies on how infants crack the language code and advance in their language across the first two years. Many such studies involve assessments of infant–caregiver interactions in structured tasks: Examiners position baby and caregiver, determine the objects for play, and then code language, gestures, attention, and so forth. This approach reaps the benefits of experimental control – every dyad shares the same materials for the same amount of time – and therefore limits contextual influences, such as effects of different materials or activities on the language infants hear.

Structured tasks have generated a rich theoretical and empirical knowledge base on the adult inputs that facilitate infant language-learning. Language input that is high in lexical diversity occurs during bouts of joint attention, contains physical cues to meaning (such as gestures), and is contingently responsive to infant exploratory and communicative actions promotes language learning within and over developmental time (Landry, Smith & Swank, 2006; Pancsofar & Vernon-Feagans, 2010; Rader & Zukow-Goldring, 2010; Roseberry, Hirsh-Pasek & Golinkoff, 2014; Song, Spier & Tamis-LeMonda, 2013; Tamis-LeMonda, Bornstein &

Baumwell, 2001; Tomasello & Carpenter, 2007; Yu & Smith, 2012).

At the same time, language observed during structured tasks likely differs from the naturally occurring, everyday language experiences of infants. Structured observations are typically brief (5–10 min), infants and adults are positioned to facilitate interaction (such as facing one another at a table), and there is not much else to do or talk about than the materials at hand. Adults are likely to be on their best behavior during these relatively short-lived observations, and to focus their talk on their infants' engagements with the novel objects. Consequently, the tried-and-true structured approach to documenting infant language experiences may yield inflated estimates of the amount, diversity, and temporal structure of language inputs as constant and high.

An alternative approach to characterizing the nature of the input has been to describe infants' language experiences in the natural setting of the home over lengthier periods. Parents and infants are video- or audio-recorded as they go about their routines unconstrained by task, location, position, or materials (e.g. Bornstein, Putnick, Cote, Haynes & Suwalsky, 2015; Hoff, 2003, 2006; Karasik, Adolph, Tamis-LeMonda & Zuckerman, 2012; Roy, 2009; Soderstrom & Wittebolle, 2013; Weisleder & Fernald, 2013). The naturalistic approach forsakes experimental control in exchange for what is viewed to be an ecologically valid and varied picture of infant language experiences. It yields samples of language across a range of contexts, including mealtime, bathtime, dress, play, and so forth, which are shown to affect the amount, content, and/or structure of language to children (Flynn & Masur, 2007; Hoff, 2003, 2006; Hoff-Ginsberg, 1991; Lucariello & Nelson, 1986; Soderstrom & Wittebolle, 2013).

However, the labor-intensive requirements of coding language input from extended, naturalistic interactions can be prohibitive, and the time spent gathering and coding data is critical to consider, particularly if there is limited added benefit to these costly approaches. Moreover, when dyads are unconstrained and left to do whatever they wish, researchers unavoidably sacrifice the experimental rigor that helps ensure that variation among participants is real and is not due to noise and contextual influences.

In short, different methods contain unique strengths and varying limitations and are likely to yield different findings and results about the nature of infants' language experiences. Developmental scientists therefore must recognize whether and how their choice of methods affects findings to avoid inaccurate conclusions and over-interpretation.

Current study

Using language as a model system, we sought to document differences in infants' language experiences during structured tasks and naturalistic routines. During structured play, infants and mothers were video-recorded as they sat on the floor playing with a set of experimenter-provided toys for 5 minutes. In the naturalistic context, the same dyads were video-recorded for 45 minutes as they went about their daily routines at home.

Two overarching goals framed this work. The first was to investigate whether and how structured and naturalistic methods differ in the amount, diversity, and temporal structure of maternal language input. Ancillary analyses compared (a) the first 5 minutes of naturalistic interaction to the first 5 minutes of structured play, and (b) the peak consecutive 5 minutes of language input during naturalistic interaction to language input during the 5 minutes of structured play. These analyses aimed to document *why* methodological context might affect language input. Perhaps differences occur because mothers talk more during the first 5 minutes of *any* interaction, or perhaps structured contexts capture what spontaneously occurs during the densest periods of language input to infants at home. We also compared temporal fluctuations in talk and bouts of silence in the two methods, with silence defined as a minutes absent of language input.

Second, we asked whether individual differences in infants' language experiences are consistent across methods. Although structured tasks are defined by experimenters and typically span a brief period, do they validly capture the individual differences that are seen in naturalistic contexts? Because so much research is based on structured observations, this question is of interest to many developmental scientists. We expected to find cross-method associations, because language data from structured tasks uniformly predict child language and cognitive skills (Hurtado, Marchman & Fernald, 2008; Landry *et al.*, 2006; Olson & Masur, 2015; Pan, Rowe, Singer & Snow, 2005; Pancsofar & Vernon-Feagans, 2006; Tamis-LeMonda, Song, Luo, Kuchirko, Kahana-Kalman *et al.*, 2014), and therefore likely tap into individual differences in infants' everyday language experiences.

Methods

Participants

Participants were 40 first-born, full-term infants (20 girls) age 13½ months (M = 13.7, SD = .40) and their

mothers recruited from private pediatric groups in New York City. Participants were from middle- to upper-middle-class, European-American households. Over 80% of mothers had at least a Bachelors degree. Mothers (M = 33.45 years, SD = 4.75) were native English speakers, self-reported as the primary caregiver of their infants, and averaged 16–17 years of education.

Procedures

Infants and mothers were visited in their homes when infants were alert and rested. Visits were scheduled when only the mother was present (thus, the only speech available to infants was that provided directly to them). Dyads were video-recorded during a structured play session with a standard set of toys (sponge, nesting cups, telephone, truck, people that fit in the truck, blocks, baby doll, tea set, and brush and comb set). A single female researcher conducted the sessions to keep visits as unobtrusive as possible. The researcher positioned herself as far as possible within the constraints of the available space (from 4 to around 10 feet) yet close enough to ensure audible sound on the videos. She zoomed in so that infant and mother took up the majority of the video frames.

The structured play session was followed by 45 minutes of naturalistic interaction, in which mothers were told: 'I'd like to observe what [infant's name] does during his/her everyday routines. You should go about whatever you would do if I was not here. Feel free to tend to your chores, such as laundry, cooking, etc., or interact with your baby, if that's what you would be doing now. You can leave the room, or whatever else would occur if I was not here.' If mother left the room, the researcher panned her departure, and then kept the camera focused on the infant. During the naturalistic routines, infants spent on average 19.9 (SD = 10.12) minutes in play, 8.03 (SD = 6.63) minutes in feeding, 4.45 (SD = 5.21) minutes in book-sharing, and 2.00 (SD = 3.76) minutes in grooming (such as bath time or getting dressed). For the remaining time of 9.82 (SD = 7.78) minutes infants were in unstructured activities such as wandering around or sitting on the floor, couch, etc. without being engaged in any of the other four activities. The two sessions were separated by 15 to 20 minutes.

Coding of language

Maternal language input during the structured and naturalistic play sessions was transcribed at the utterance level using the Codes for the Human Analysis of Transcripts (CHAT), and analyzed through the Child Language Data Exchange Systems (CHILDES; MacWhinney, 2000). The FREQ program within CHILDES was used to generate mother word types (number of different words directed to infant) and word tokens (total number of words directed to infant) from transcripts of home routines and structured play. Word types and tokens were counted at the whole-word level.

Total language and diversity of language

Word types and tokens were calculated for the 45 minutes of home routines and 5 minutes of structured play. Because the two contexts were based on different amounts of time, types-per-minute and tokens-per-minute were calculated for certain analyses. Word types and tokens were also calculated for each minute of the interaction to examine temporal fluctuations in language across the play and naturalistic routine sessions.

Language during the first 5 minutes and peak 5 minutes

We then generated the number of word types and tokens across the 'first 5 minutes' of the naturalistic interaction. To calculate types and tokens for the 'peak 5 minutes' of the naturalistic session we generated values for total types and tokens for each consecutive 5-minute block: minutes 1–5, 2–6, 3–7 and so forth, through minutes 41–45. The time block with the highest type/token values was used in analyses to represent peak language input to infant.

Unique and redundant words

Measures of the number of unique and redundant words directed to infants each minute were calculated by taking into account all words that mother had directed to her infant to that point. For example, if mother said 'this is a ball' in the first minute, and 'this is a cat' in the second minute, the first minute would be coded as containing four unique words (this, is, a, ball), and the second minute would be coded as containing one unique word (cat) and three redundant words (this, is, a).

Minutes of silence

For each minute of interaction in structured play and naturalistic routines, if no language was directed to the infant, it was coded as 'silence'. The minutes of silence across each session were summed.

Results

We compared differences in the diversity (types) and total amount (tokens) of language inputs in structured play and naturalistic routines, followed by comparisons of temporal fluctuations within each of the contexts. Finally, we examined the association between language inputs in the two methods. Prior to analyses, we confirmed that all measures of language input were normally distributed (skewness of variables ranged from .03 to .67). All but one comparison was based on paired *t*-tests since variances in language input did not differ in the two contexts. The comparison between average word tokens in the first 5 minutes of naturalistic routines and average word tokens during structured play was the one exception that warranted the use of Wilcoxon non-parametric test since there was a non-normal distribution of differences between the paired samples.

Language diversity and amount

Do infants hear different amounts and diversity of language during structured play and naturalistic home routines? Structured play yielded nearly double the amount of talk (M = 63.85 word tokens per minute, SD = 24.15) on average as did naturalistic routines (M = 36.61, SD = 17.97; $t(39) = 8.16$, $p < .001$), resulting in a large effect size difference (Cohen's d = 1.28). Structured play also yielded a greater diversity of words per minute (M = 34.30 word types, SD = 11.00) than did naturalistic routines (M = 22.28, SD = 10.18; $t(39) = 8.04$, $p < .001$; see Figure 1a), again resulting in a large effect size difference (Cohen's d = 1.13).

To test whether the advantage in diversity and amount of language input reflected more talk during the start of interactions, we compared word types and word tokens in the first 5 minutes of naturalistic routines to the first 5 minutes of structured play. These analyses compared total word tokens and total word types across 5 minutes (rather than words per minute), since observation times were now equivalent. In these analyses, structured play continued to produce more word types and more word tokens (M = 101.85, SD = 26.70 and M = 313.50, SD = 117.20, respectively) than did naturalistic routines (M = 82.30, SD = 49.91 and M = 193.78, SD = 140.21, respectively), $t(39) = 2.53$, $p = .015$ for word types and $Z = 4.14$, $p < .001$ for word tokens. The effect sizes for the difference in word types across the two methods was moderate (Cohen's d = .49) and the effect size for word tokens was large (Cohen's d = .93). These findings are

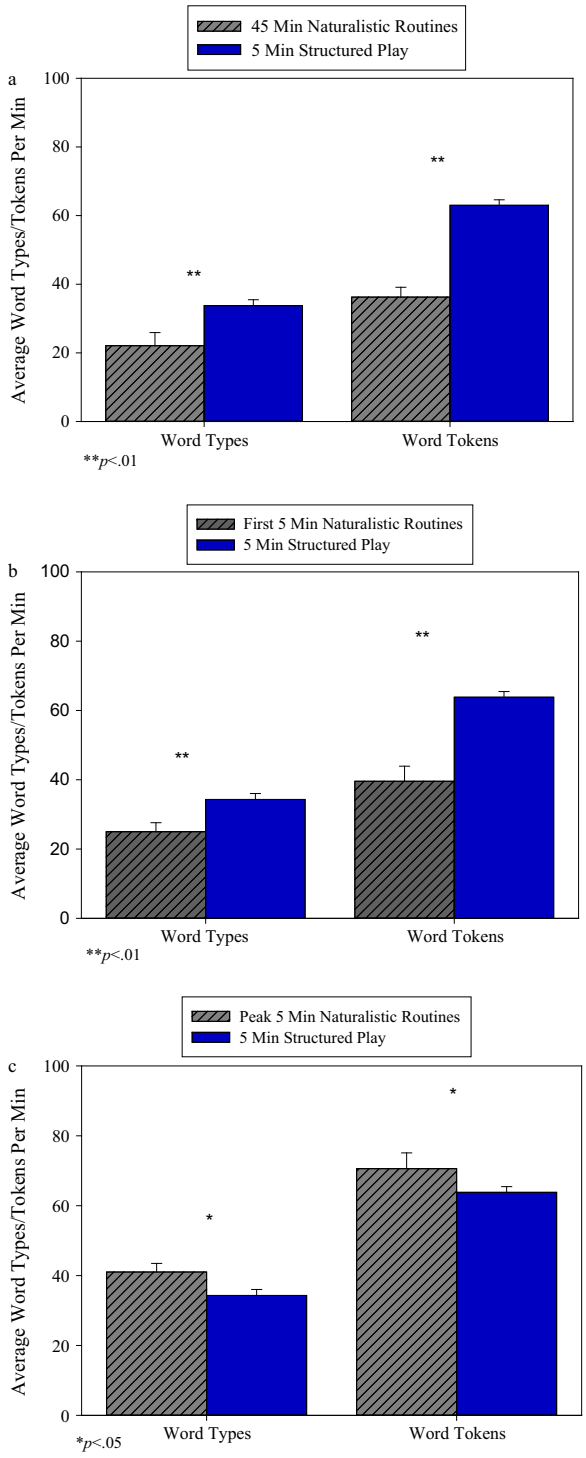


Figure 1 *Maternal word types and tokens per minute (a) during 45-min naturalistic routines and 5-min structured play with standard errors of the mean; (b) during the first 5 min of naturalistic routines and 5 min structured play with standard errors of the mean; and (c) during the consecutive peak 5 min of naturalistic routines and 5 min structured play with standard errors of the mean.*

illustrated in Figure 1b, which depict data for words per minute for purposes of visual comparison to Figure 1a.

Perhaps then, structured play captures infants' peak language experiences – that is, the diversity and amount of language infants are likely to hear at home during language-dense bouts of interaction. To test this possibility, we compared language input during the peak consecutive 5 minutes of the 45 minutes of naturalistic routines to language input during the 5 minutes of structured play.

In this comparison, language input during structured play interactions no longer exceeded language directed to infants during naturalistic routines. In fact, mothers used more types and tokens during the peak 5 minutes of naturalistic routines (types $M = 126.88$, $SD = 43.77$; tokens, $M = 355.25$, $SD = 136.90$) than they did during the 5 minutes of structured play (types, $M = 101.85$, $SD = 26.71$; $t(39) = 4.27$, $p < .001$; tokens, $M = 313.50$, $SD = 117.20$; $t(39) = 2.04$, $p = .048$). However, the effect size differences were only moderate for word types and small for word tokens (Cohen's $d = .69$ and .33, respectively), in contrast to the generally large effect size differences in prior analyses. These diminished effect size differences can be seen when comparing Figure 1c (which depicts words types and tokens per minute in the two methods) to Figures 1a and 1b.

Perhaps activity/routine effects may explain why language input during structured play no longer surpassed language input during the peak 5 minutes. Infants may have been more likely to be engaged in play during the peak 5 minutes of naturalistic interactions than during the first 5 minutes, and conversely, more likely to be engaged in feeding, grooming, booksharing, and unstructured activities during the first 5 minutes of naturalistic interactions than during the peak 5 minutes. If so, the diminished 'language-input advantage' of structured play might be due to matching structured play with play interactions during naturalistic routines. However, this was not the case: The numbers of infants (50%, $N = 20$) engaged in play was slightly *higher* in the first 5 minutes compared to the peak 5 minutes (40%, $N = 16$) of naturalistic routines, with both rates roughly mirroring the overall percentage of time infants spent in play (44% of the naturalistic session). The other half of infants experienced peak language inputs during a variety of routines: 10% ($N = 4$) during feeding, 7.5% ($N = 3$) during grooming, 32.5% ($N = 13$) during booksharing, and 10% ($N = 4$) during unstructured activities.

In addition, the number of word types and tokens infants experienced per minute for play during naturalistic routines was compared to word types and tokens per minute during structured play. Infants were exposed to an average of 19.54 ($SD = 10.0$) word types per minute and 34.10 ($SD = 19.89$) tokens per minute in play during naturalistic routines, which was substantially lower than the 34.30 ($SD = 11.0$) word types and 63.85 ($SD = 24.15$) word tokens per minute they were exposed to during structured play (as reported above).

Collectively, these findings indicate that language input is substantially higher during structured play than it is on average during naturalistic routines, and these differences cannot be attributed to what infants were doing. However, the language that infants experience during structured play begins to look similar to the *peak moments of naturalistic routines*. In fact, structured play actually results in a slight underestimation of the language input that is observed during those peak interaction minutes.

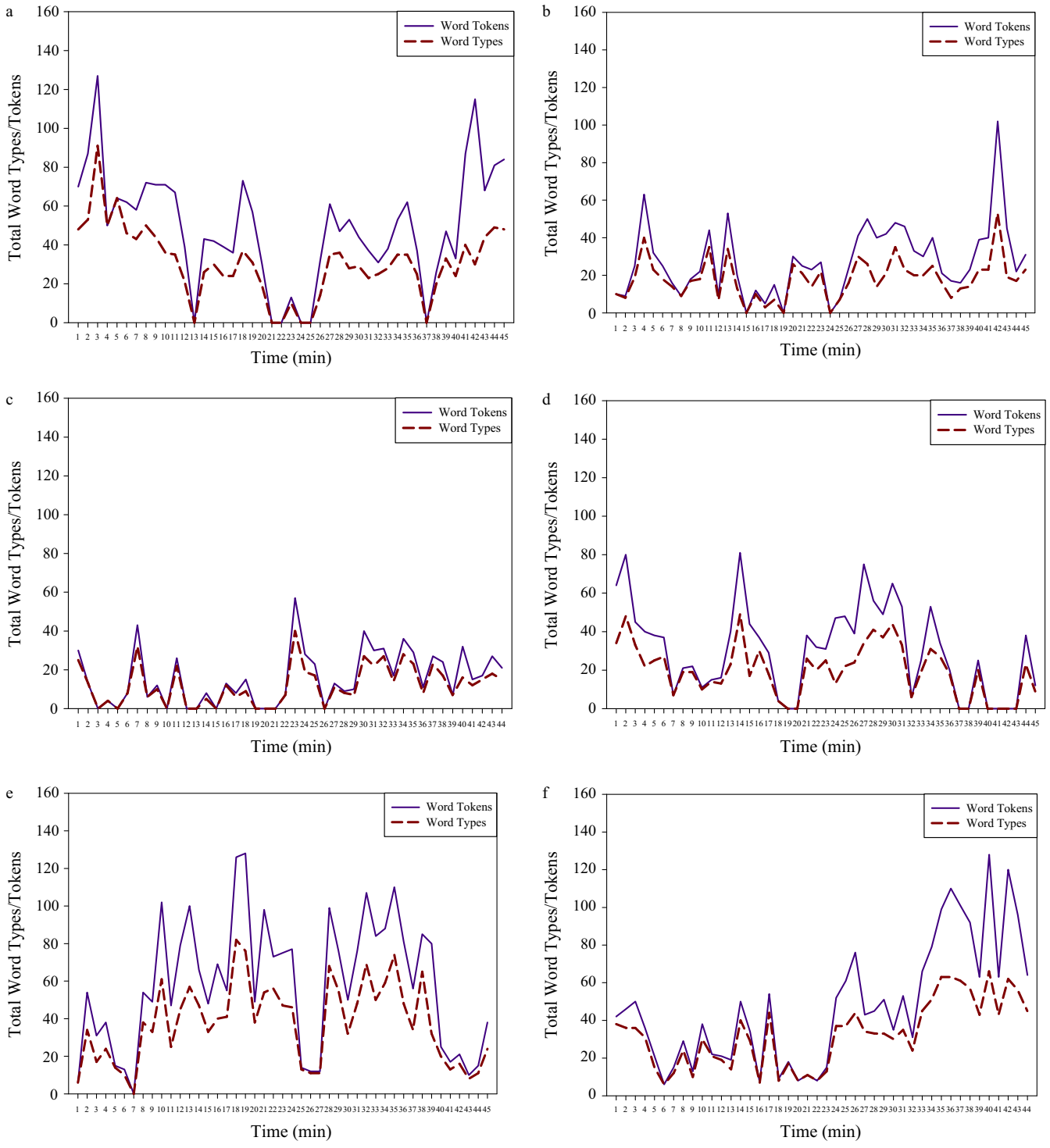
Intra-individual variability and temporal fluctuation

Naturalistic interactions were characterized by striking intra-individual variability in the diversity and amount of language input from minute to minute, compared to a relatively flat and consistently high amount of talk during structured play.

Naturalistic routines

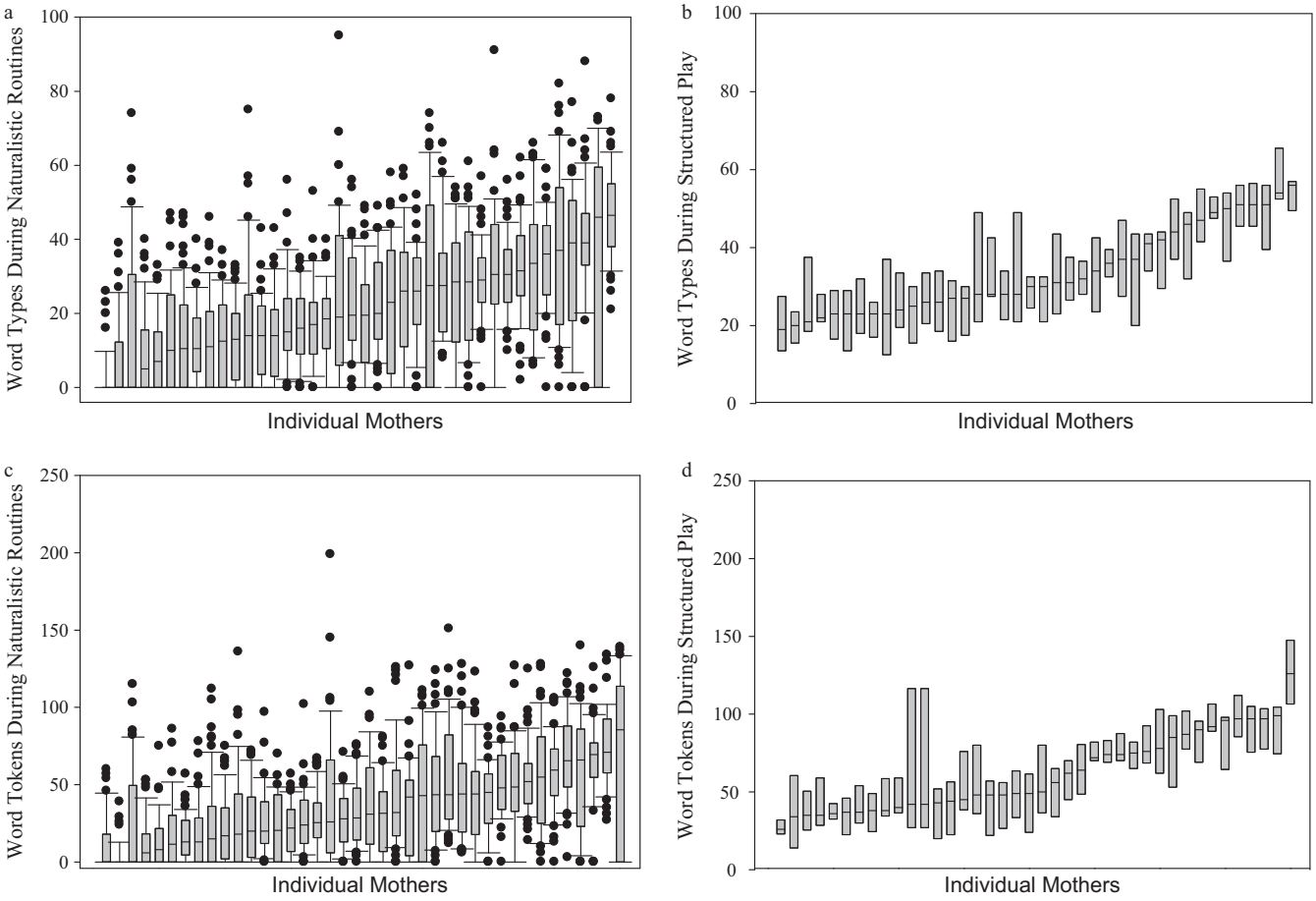
The intra-individual ranges for language input – based on subtracting the minute with the fewest word types and fewest word tokens from the minute with the most word types and word tokens – averaged 55.55 types ($SD = 16.72$) and 101 tokens ($SD = 32.00$). Figures 2a–f illustrate the minute-to-minute fluctuations in language input for six infants during 45 minutes of naturalistic routines, and Figures 3a and 3c present boxplots on the intra-individual variability for each of the 40 infants (who are presented in ascending order based on mothers' median talk). Each boxplot in the figures represents the range of language inputs to one infant across the 45 minute session. The grey plot area depicts the 25th to 75th quartiles of language inputs to that infant, with median word types (Figure 3a) or tokens (Figure 3c) represented by the horizontal line through the shaded area. The 'whiskers' represent the upper 75th and lower 25th quartiles, with dots depicting moments of language input that are minimally 1.5 times the interquartile range. These boxplots illustrate enormous intra-individual variability, and show sporadic moments of extremely high and low language input.

However, in the context of these substantial fluctuations, infants experienced a sprinkling of unique



Figures 2 *(a–f) Temporal fluctuations of word types and tokens per minute during 45 min naturalistic routines for six randomly selected mothers.*

words in any given minute (based on the history of words directed to them up to the target minute). On average, infants experienced 7.03 unique words per minute (SD = 2.56) against an average of 36.61 total words per minute (SD = 17.97). Thus, 81% of words in any given minute were redundant, with unique words



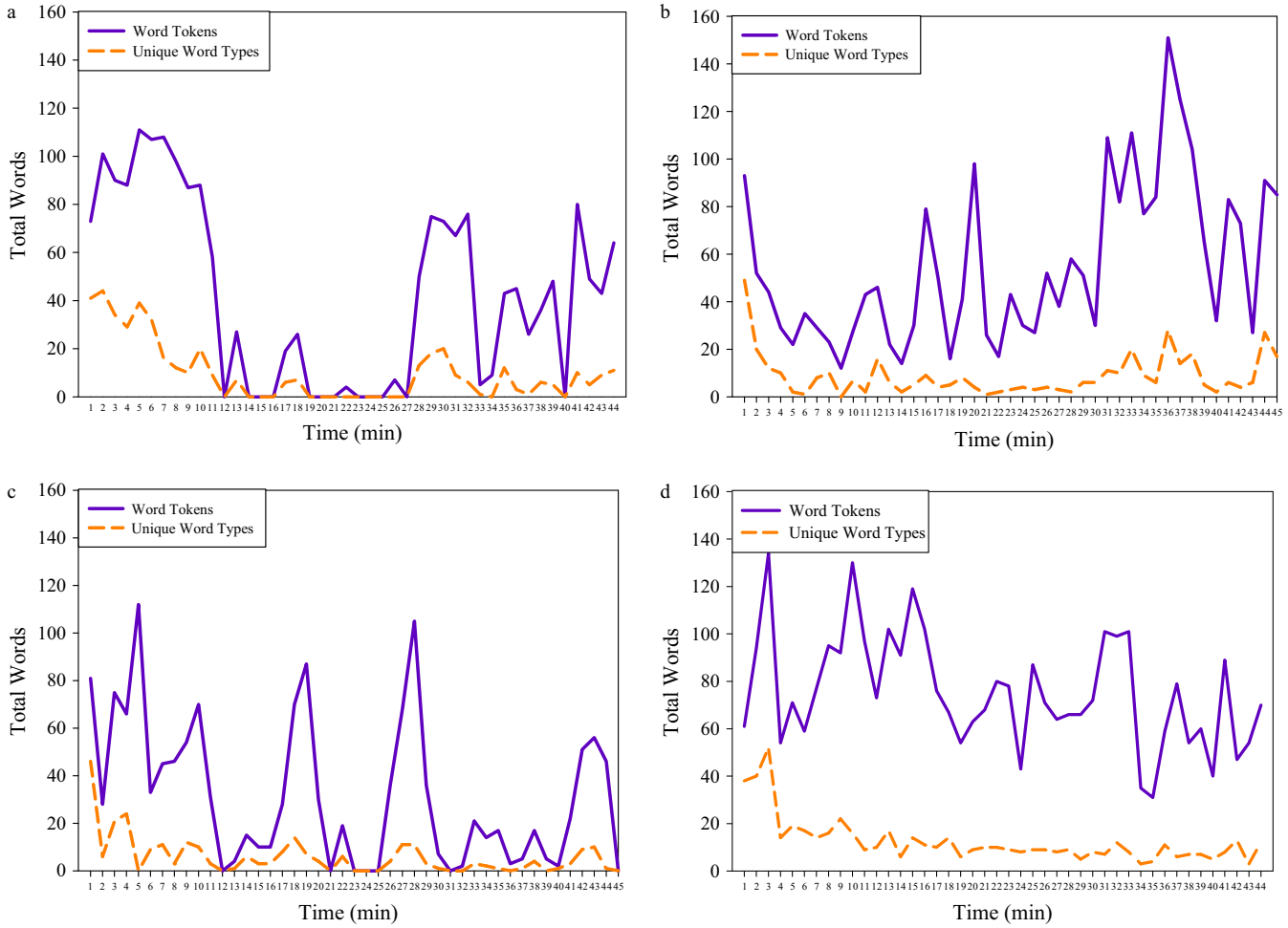
Figures 3 *(a–d) Intra-individual variability in word tokens and word types for 40 mothers during 45 min of naturalistic routines (Figures 3a and 3c) and 5 min of structured play (Figures 3b and 3d).*

appearing against this backdrop of familiarity (see Figures 4a–d).

Structured routines

In contrast to the substantial fluctuations of infants' language experiences during naturalistic routines, intra-individual ranges for structured play were much smaller, producing a generally flat profile for language input across the 5 minutes. Across all infants, the intra-individual ranges for types averaged about 20 words (SD = 7.38) and for tokens averaged about 43 words (SD = 19.69). Figures 5a–d illustrate the minute-to-minute fluctuations in language input for four infants during the 5 minutes of structured play, and Figures 3b and 3d present boxplots that illustrate the intra-individual variability across the structured play session for all 40 infants. As can be seen, the boxplots for the structured play sessions are tighter, and 'float' substantially above the X-axis at the Y-axis value of 0 (in contrast to boxplots of naturalistic routines that uniformly originated at the Y-axis value of 0). This separation from 0 indicates no minutes of silence in structured play (also discussed below). Consequently, the ranges of language inputs (both types and tokens) were much smaller during structured play than during naturalistic routines, $t(39) = 8.90$ and 12.49, respectively, $ps < .001$.

Although the relatively high and flat profiles of language input seen in structured play diverged from the substantial fluctuations that characterized naturalistic routines, a different story emerged when comparing the 5 minutes of peak language input during naturalistic routines to the 5 minutes of structured play. When peak consecutive talk during naturalistic routines was superimposed onto infants' language experiences during the 5 minutes of structured play, there was substantial overlap (see Figures 5a–d). This overlap demonstrates



Figures 4 *(a–d) Temporal fluctuation of unique words relative to total words (tokens) during 45 min of naturalistic routines for four randomly selected mothers.*

that structured play interactions may in part capture the language experiences of infants during word-dense talk during naturalistic routines.

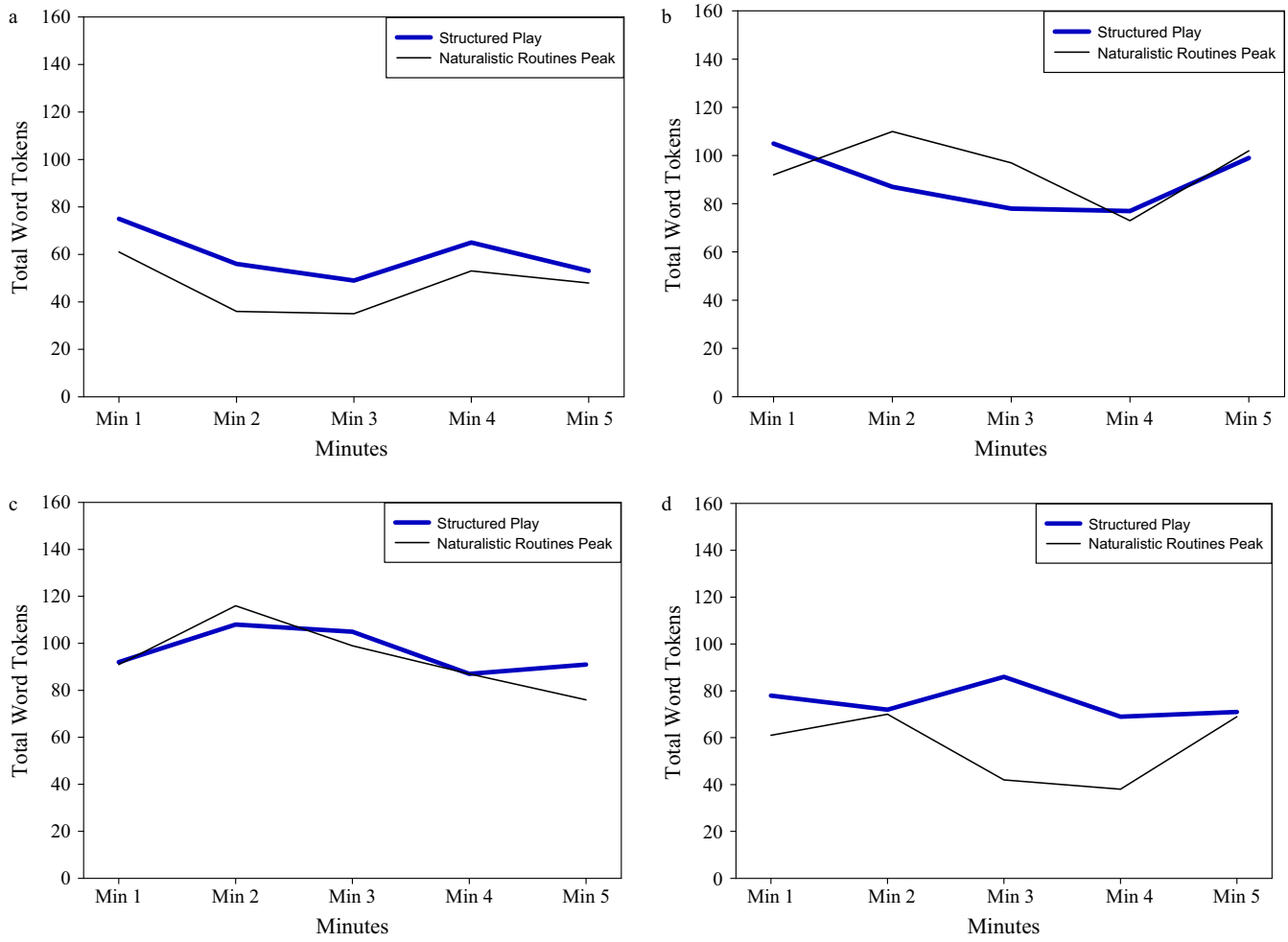
Minutes of silence

The relatively large fluctuations in language input during naturalistic routines in part reflected a pattern in which bouts of silence or low levels of talk were interspersed with spurts of language high in amount and diversity. The vast majority of infants, 88%, experienced silence for at least 1 minute of the 45-minute session. Specifically, mothers averaged 8 minutes of silence in naturalistic routines (nearly 20% of intervals) with a range of 0 to 38. The infant at the upper extreme who experienced silence over 80% of the time largely engaged in unstructured activity (71%) while mother went about her chores. In contrast, there were *no minutes of silence* (0% of intervals) during any of the structured play sessions: Mothers were constantly talking, a pattern that diverges from infants' naturalistic routines (see Figure 6).

Associations across contexts

Although several characteristics of language input differed markedly when assessed during structured play and naturalistic routines, this does not undermine the validity of individual differences, because correlations are statistically independent of averages. In the final analyses, we investigated whether language input in the two contexts correlated.

Word types during structured play was strongly correlated with word types during the entire 45 minutes of naturalistic routines (r = .62, p < .001), and word tokens during structured play was strongly correlated with word tokens during 45 minutes of naturalistic routines (r = .58, p < .001). Moreover, when two bivariate outliers were removed from analyses based on absolute values of



Figures 5 *(a–d) Temporal fluctuations of word tokens during 5 min of structured play overlaid on the consecutive peak 5 min of naturalistic routines for four randomly selected mothers.*

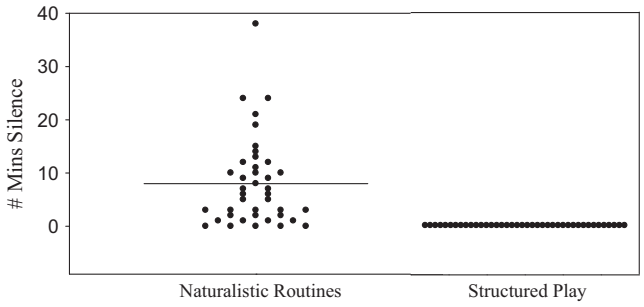


Figure 6 *Min of silence for individual mothers during naturalistic routines and structured play. Each dot represents a mother and the horizontal bar represents the group average.*

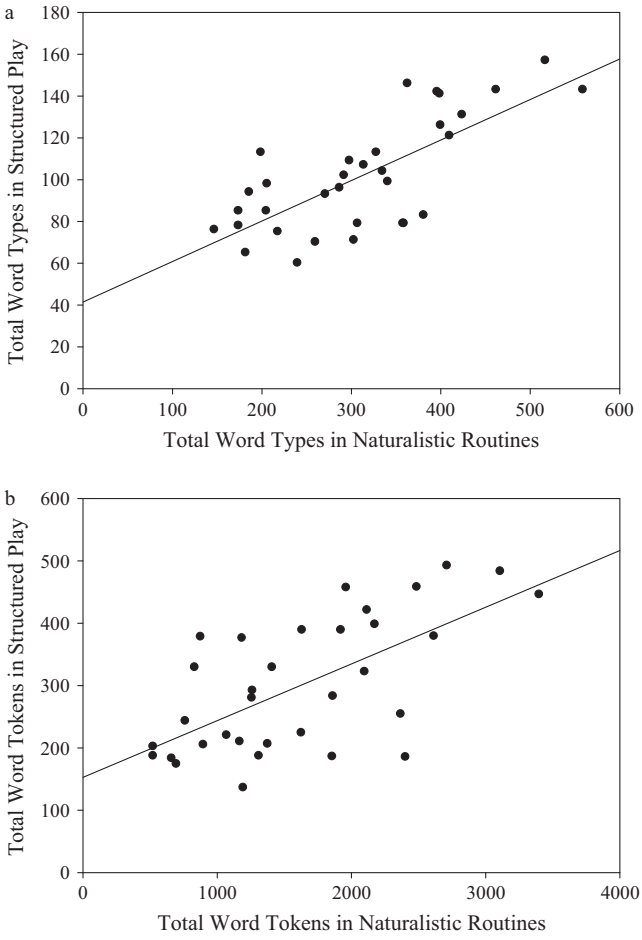
standardized residuals being greater than 2, associations were even stronger (types, $r = .77$, $p < .001$; tokens, $r = .69$, $p < .001$; see Figures 7a and 7b).

Discussion

Methods wield great power. They can affect fundamental conclusions about infant development that span topics as diverse as reasoning about objects, walking, understanding others' intentions, and learning language. Using language as a model system, we found that naturalistic and structured methods yielded differences in certain features of mothers' talk to infants, yet despite those differences, individual variation among mothers was stable across methods – suggesting that data obtained from brief observations validly captures infants' everyday language experiences.

Methodological differences

Infants' language in the natural settings of their homes, as they went about their everyday routines, was highly



Figures 7 *(a–b) Scatterplot of maternal word types during naturalistic routines against maternal word types in structured play (Figure 7a), and maternal word tokens during naturalistic routines against maternal word tokens in structured play (Figure 7b). Figures exclude two outliers.*

dynamic: Dense and fluctuating periods of language input were interspersed with bouts of silence. In contrast, language during structured play was less variable – the amount and diversity of language input were consistently high and yielded a flat profile that was absent of silence.

What are the implications of these methodological differences for socio-cultural accounts of early language learning? Many prominent studies on the social context of early language development are based on data gathered during structured interactions, in which examiners position dyads across from one another, typically with objects, books, or toys that are within reach. These stage-set social interactions do not capture the ebbs and flows of infant experiences, and may produce both false alarms and misses in the characterization of language input.

In terms of false alarms, structured tasks are likely to spotlight certain features of language interactions that may be less frequent during everyday routines. Experimenter-controlled methods elicit consistently high amounts and diversity in language (as shown here), and are also likely to elicit high levels of shared attention, contingent responsiveness, talk about objects, and specific language forms (such as nouns and adjectives).

Conversely, in terms of misses, experimenter-controlled methods are unlikely to reveal intriguing temporal features of language, including the relatively substantial periods of time when infants hear few or no words, transitions from bouts of quiet to periods of dense language input, or the ways that language changes across routines to yield new forms and amounts of language for infants to process. These temporal features of language – how inputs change from minute to minute over the course of a day – are rarely studied by developmental scholars.

Yet, temporal fluctuations of language input may provide serendipitous benefits to the language-learning infant, because language is distributed over time. Bouts of quiet may offer infants time to consolidate and learn new information, as shown by the benefits of distributed versus massed practice (Ambridge, Theakston, Lieven & Tomasello, 2006) and the finding that word learning is enhanced when input is distributed over time (Childers & Tomasello, 2002). Moreover, during minutes when infants hear a lot of talk, they experience a context of familiarity and hear few unique words, which may create a pop-out effect for novel words similar to that seen in classic tests of perception (Julesz, 1981; Treisman & Gelade, 1980). That is, odd elements in a set of similar or familiar elements are detected at early processing stages. Finally, changes to language inputs align with changes in everyday routines, thereby providing infants with opportunities to hear different words across activities. Fluctuations in language forms and functions offer key lessons in the pragmatics of language (Tamis-LeMonda & Song, 2012).

Notably, the correspondence between structured play and peak 5 minutes could not solely be attributed to common activities, since different infants experienced peak language inputs during different routines – play, booksharing, grooming, feeding, and unstructured time. In fact, when peak language experiences were considered, they actually surpassed the language infants experienced during structured play.

Methodological similarities

Although differences were seen in the amount and flow of language in the two methods, language input during

structured interactions validly captures the essence of infants' everyday language experience at the individual level. Five minutes of language during structured play and 5 minutes of language during peak language input overlapped substantially for individual infants when examining overlay graphs, and correlations between language variables in the two methods were strong. This lends some support to the idea that 5 minutes of structured activity may reflect what is going on during the time when infants are naturally hearing the most talk at home. The convergence of findings should instill confidence in language researchers that what is seen in a laboratory or controlled setting validly represents individual differences in infants' home language experiences at least in terms of how many words and different words they hear.

Of course, features of language input beyond sheer words are critical to consider as well, and we are currently investigating whether convergence across methods is seen for joint attention and contingent responsiveness. Nonetheless, the generally strong associations found at the individual level likely explain why variation in language input during structured tasks relates to language and cognitive skills concurrently and over developmental time.

Limitations

This study contains several limitations that bear mention. Forty-five minutes falls short of capturing the naturalistic inputs that individual infants commonly receive during everyday interactions, and an ideal comparison would be based on a more extended time frame. Developmental researchers have begun to capitalize on new technology such as the LENA system to obtain naturalistic data on language to infants over protracted periods of time, and these types of data are providing new insights into the fluctuations of language input and child vocalizations that occur across contexts such as play, storytime, booksharing, feeding, and so forth (Soderstrom & Wittebolle, 2013).

Second, although we strived to obtain a 'naturalistic' window onto infants' everyday experiences, instructing mothers to be natural and do what they would ordinarily do, our presence likely affected their behaviors, which is another reason for the growing use of unobtrusive systems such as LENA (Soderstrom & Wittebolle, 2013). However, audio-recordings without accompanying video also have the limitation of forcing researchers to guess about the routine that is taking place. We have some confidence, however, that mothers felt comfortable with our presence since we saw mothers doing laundry, working on computers, talking on the telephone and so forth during the naturalistic routines, and they rarely spoke to us. In addition, we consider data on the bouts of silence, and the continued fluctuations and points of low talk to infants as evidence of their comfort.

Finally, we compared 5 minutes of structured play to 45 minutes of naturalistic interactions. A logical question is whether language would differ if we had compared 45 minutes of structured play with 45 minutes of naturalistic interaction. We have found, however, that 1-year-old infants quickly peter out during structured tasks, and that it is nearly impossible to get them to sit and play with a set of predetermined toys for extended periods of time. We therefore chose to take the alternative and feasible approach by comparing 5 minutes to 5 minutes.

Conclusions

Different approaches to the study of infants' language experiences paint pictures that are simultaneously different and the same, depending on whether the focus is on the magnitude of language input, temporal structure, or individual differences. This does not imply that certain methods are better than others, are flawed or should be abandoned. Rather, developmental scientists must be aware of methodological differences if they are to avoid drawing inaccurate conclusions and over-interpretation of data, particularly when describing how much language infants hear, how many unique words enter the system, and how language inputs are distributed over time, all of which have implications for theoretical models of word learning. However, if the goal is to describe and understand whether and how variation in infants' language experiences contribute to individual differences in word learning or other outcomes, a brief observational period may go a long way in capturing the essence of everyday social interactions, while simultaneously ensuring experimental control over contextual influences.

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