Influences of number of adults and adult: child ratios on the quantity of adult language input across childcare settings

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Abstract
New approaches to examining the language environment are putting greater emphasis on the use of highly naturalistic audio recordings and questions about cross-cultural differences in children's real-world language experiences. These new approaches and questions require careful examination of different kinds of variables that may influence children's language experiences. The current study examines the influence of the number of adults and adult:child ratio on the number of words heard by young children across three childcare settings (home, home daycare and daycare centre). The home setting was characterized by a high number of one-on-one interactions, while children in daycare centres were exposed to larger numbers of adults present. While a linear relationship was found between the number/ratio of adults and words heard in the home setting, these relationships were more complex in daycare centres, and no relationships were found in home daycares.

Introduction

Of crucial importance in the study of child language development is an understanding of the role of linguistic input in the first few years of life. Some central themes emergent

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from the literature include the impact of quantity of speech (e.g. Hart & Risley, 1995; Weisleder & Fernald, 2013), the role of socio-economic status (e.g. Hart & Risley, 1995; Hoff, 2003; Pace, Luo, Hirsh-Pasek, & Golinkoff, 2017; Rowe, 2008) and the relative influence of child-directed and adult-directed speech across cultures (e.g. Cristia, Dupoux, Gurven, & Stieglitz, 2017; Shneidman & Goldin-Meadow, 2012). Although most studies to date have been based on child language recordings of highly constrained dyadic (or sometimes triadic) parent–child interactions, there is a growing recognition that to really understand that linguistic input, the child must be situated in their real-world, everyday environment. This real-world environment includes many as yet poorly understood variables such as changes in location (home, park, supermarket, daycare) and the number of people present. New emerging technologies – notably here, the LENA™ (Language ENvironment Analysis) system (Greenwood, Thiemeann-Bourque, Walker, Buzhardt, & Gilkerson, 2011) – which allow for the collection and analysis of full-day recordings of young children's daily lives in a highly automated fashion, have opened the door to examining the child's real, everyday, linguistic experience more directly. This novel approach raises new questions to be addressed. The current study explores one such question – the relationship between the number of people in an infant/toddler's environment and the quantity of speech to which they are exposed. In addition, three different childcare contexts are examined – at home with a parent, in a small home-based daycare, and in a large childcare centre.

The quantity of speech input a child hears has long been recognized as a key factor in language development (e.g. Campisi, Serbin, Stack, Schwartzman, & Ledingham, 2009; Caskey, Stephens, Tucker, & Vohr, 2011; Hart & Risley, 1995; Hoff, 2003; Hoff & Naigles, 2002; Huttenlocher, Waterfall, Vasilyeva, Vevea, & Hedges, 2010; Rowe, 2008; though see e.g. Hirsh-Pasek et al., 2015; Pan, Rowe, Singer, & Snow, 2005). Some recent studies using LENA have found a strong link between speech heard and measures of language development. For example, Weisleder and Fernald (2013) found that the quantity of speech heard by infants in a low-income Latino American population was highly correlated with their speech processing ability and with vocabulary size at 24 months. Notably, in that study, only child-directed speech, and not speech overheard between two adults, was so correlated. Ramírez-Esparza, García-Sierra, and Kuhl (2014) found that in infancy, one-on-one speech between an adult and child that contained the acoustic characteristics of child-directed speech was related to later measures of language development. However, child-directed speech in a group context, or one-on-one speech that did not contain these characteristics, was not. By 33 months, however, speech with more adult-like properties (but still in one-on-one contexts) had a stronger relationship with a language development measure, word use (Ramírez-Esparza, García-Sierra, & Kuhl, 2017). This study focused primarily on high-speech-volume slices of the recording day, and relative exposure to their four speech input categories as opposed to raw quantities. However, in this context they reported a failure to find a relationship between the overall number of adult words produced and their measure of language development. Therefore, the role of input quality in language development must be sensitive to the type of input being measured.

On the surface, it may seem a straightforward prediction to suggest that quantity of speech heard by a child may be related to the number of adults present – more adults

means more speakers. However, this relationship may not be simple, as the number of adults present may be highly constrained by context. For example, mothers alone with their toddler may well spend a great deal more time speaking with that toddler than when there are other adults in the home to engage with. Similar effects have been found with siblings – in the presence of siblings the quantity of speech directed toward one child decreases (Oshima-Takane & Robbins, 2003). Importantly, these contexts, and their effect on speech input to the child, may vary significantly across different cultural and childcare situations. In addition, the more people present, the greater likelihood of multiple speakers engaging simultaneously, leading to an increase in background noise that may reduce the speech input that the child can meaningfully process. As the child language research community moves toward the examination of much more naturalistic samples of child language environments (e.g. Bergelson et al., submitted), and importantly, toward a comparative cross-cultural perspective involving these naturalistic samples (Cristia et al., 2017), it becomes important to begin to consider directly how hidden third variables, like the number of adults present, may influence these cross-cultural differences. For example, cultures vary not only in their attitudes toward talking to young children, but also in the social structures, physical groupings of individuals over the course of the day and types of activities that would lead to more or less speech being produced (see e.g. Cristia et al., 2017).

To our knowledge, only one recent study has directly examined the question of how number of adults relates to quantity of speech heard by a young child (Shneidman, Arroyo, Levine, & Goldin-Meadow, 2013). In this study, the language experiences of toddlers hearing speech from one or a few household members were compared with those toddlers hearing speech from multiple household members. Overall, the language development of the two groups did not differ at 3 years, nor did the quantity of speech directed at the child in a 1.5 hour sample at 2 years. Despite the fact that children in the multi-member group heard significantly more overheard speech in the sample, only speech directed at the child predicted language development, similarly to the Weisleder and Fernald (2013) study. While this study compared the impact of number of family members across participants, our analysis expands on this study by examining how variation in number of people present in the experience of a *given* child influences quantity of speech input. In addition, we use a contextual variation within the North American context (childcare setting) to explore how different caregiving situations influence quantity.

A related question, that of the impact of the *ratio* of adults to children, has also been studied, but from a much different literature, focused on measures of quality within a daycare setting. Unsurprisingly, lower teacher:child ratios are generally considered indicators of higher quality childcare and are associated with better communication and language development (e.g. Burchinal, Roberts, Nabors, & Bryant, 1996; McCartney, 1984; Vandell, 1996). However, even in this literature, few studies that we have found have looked specifically at the effects of group size or adult:child ratios on the quantity of speech produced. One study examining teachers' interaction with toddlers in a structured play setting found a significant increase in total speech produced by the teacher to toddlers in a 1:4 teacher to toddler ratio than a one-on-one context, however speech directed at a *given* child was significant reduced to less than a third in the 1:4 context compared

with 1:1 (Schaffer & Liddell, 1984). Similarly, Pellegrino and Scopesi (1990) examined teachers interacting with groups of children of different sizes (1, 3 or 7) in an Italian daycare centre in an unstructured play setting. They found a *reduction* of total speech in the 1:7 ratio context compared with the 1:1 and 1:3 contexts – again, there was more total speech in the 1:3 compared with 1:1, but significantly less per child (in both studies, relatively little of the teacher's speech was directed at the group).

In both of the aforementioned studies, group size was artificially manipulated. The current study takes a different approach, by allowing the numbers of adults and children to vary naturally with the real-world experiences of the toddlers and measuring quantity over a large sample of toddlers' auditory experience. We seek to bring together divergent studies and ideas about the impact of the quantity of input on language development and child ratios as measures of quality in childcare, and to directly compare those experiences at home and in daycare settings. This analysis is part of a larger study comparing the linguistic experiences of toddlers across different childcare settings. More specifically the current analysis examines the following questions: (1) How do the number of adults and the ratio of adults to children in a child's daytime experience vary across childcare settings? (2) How does the quantity of adult speech heard by toddlers change as a function of the number of adults present? (3) How does the quantity of adult speech heard by toddlers change as a function of the ratio of adults to children? (4) To what extent are these effects the same or different across childcare settings?

To our knowledge, we are the first to measure the number of adults and ratio of adults to children in infants/toddlers' real-world experiences. Our expectation with respect to raw numbers is that daycare centres will have more adults present compared with homes and home daycares. With respect to ratio, home daycares and daycare centres will have relatively fixed ratios while home ratios will vary more, but will have more 1:1 time periods.

With respect to the relationship between number of adults and quantity of speech (questions 2 and 4), while one previous study did not find differences across children in the quantity of speech heard depending on family size, our analysis examines this relationship capturing variance both within and between children. We therefore expect to see a positive linear relationship between the number of people present and the quantity of speech. While we have no specific predictions regarding differences across childcare settings (to our knowledge this has never been studied), our analysis will allow us to explore whether such differences may exist.

With respect to the relationship between ratio of adults to children and quantity of speech (questions 3 and 4), the existing studies, where ratio was artificially manipulated, suggest that a straightforward relationship may not exist in daycares between ratio of adults to children and quantity of speech heard by the child. To our knowledge, this has not been studied before in the home environment and we do not have reason for a specific prediction about this relationship.

Method

LENA recording system and AWC measure

The LENA device (DLP) is a small, durable, child-friendly recording device, which is placed into the pocket of specially designed clothing worn by the child under study (the

'target child'). The DLP allows naturalistic audio recordings of up to 16 hours, thereby capturing the child's everyday real-world experiences (Greenwood et al., 2011; Oller et al., 2010; Zhang et al., 2015). Importantly, the LENA system comes with a software suite (LENA Pro) which provides automated analysis of the language environment. Specifically in our case, we used LENA to provide an estimate of the number of 'near and clear' words (called the adult word count, or AWC, by LENA), i.e. words spoken in the vicinity of the target under sufficiently quiet conditions that LENA is able to process the speech signal. In brief, LENA Pro uses automated speech-processing algorithms to detect speech and assign each segment of speech to various categories of speaker (e.g. adult female, other child), from which further processing can take place. The AWC measure is calculated only over speech segments from the *adult male* and *adult female* categories. While there is room for improvement in LENA's classification system, the AWC in particular has been found to have high reliability in LENA's own analyses (LENA Technical Report #5) and independent peer-reviewed analyses, with correlations often above $r = .8$, particularly for English samples (e.g. Canault, Le Normand, Foudil, Loundon, & Thai-Van, 2016; Oetting, Hartfield, & Pruitt, 2009; Soderstrom & Wittebolle, 2013 and references therein). Reliability is still very good under conditions of noise (Soderstrom & Wittebolle, 2013). Further information about LENA can be found in their technical reports (see https://www.lena.org/research/) and peer-reviewed publications (e.g. above citations, VanDam & Silbert, 2016).

Participants

Participants (part of a larger study) included 45 children across all three childcare settings, ages ranging from 12 to 36 months, in Winnipeg, Manitoba. There were 16 children recorded in Daycare Centres, 14 in Home Daycares and 19 in Home settings. Four children contributed separate data to both the Home Daycare and Home settings. In addition, for three Daycare Centres, we recorded two separate children, one in each of the infant and toddler rooms. Since the separate rooms meant entirely different sets of staff and children in different physical spaces from each other, they were treated as separate participants for analysis. Licensed childcare in Manitoba is highly regulated with respect to staff:child ratios, group sizes and staff training, and daycares can receive government funding. All of the sample daycare centres and most of the home daycares were licensed.

In the Daycare Centre group, there were seven males and nine females, with a mean age of 22.5 months (range 14–36). Since three Daycare Centres contributed data from both their 'infant' room and 'toddler' room, 13 separate Daycares were recorded in the study. In the Home Daycare group there were six males and eight females recorded, with a mean age of 21.9 months (range 14–30), and in the Home group there were 12 males and seven females, with a mean age of 20.3 months (range 12–31). See Table 1 for sample characteristics and Table 2 for family size information. Reported daycare centre sizes ranged from 8 to 96 children (mean 69.3 children) and 3 to 30 for staff (mean 15.6). For home daycares, sizes ranged from 5 to 13 children (mean 7.8). Two listed 2 staff members while the rest listed only 1. The majority of staff were formally trained, even in the home daycares where some were unlicensed.

Table 1. Sample characteristics. For each childcare setting, the number of participants, mean age of participant and number of male participants is provided. For daycare centres, the number of separate centres is also provided (each centre may have contributed more than one room/participant to the sample).

Childcare setting	n (centres)	n (participants)	Mean age (months)	n (male)
Total		45	21.6	23
Home		19	20.3	12
Daycare Centre	13	16	22. 5	7
Home Daycare		14	21.9	6

Table 2. Family size for home group participants.

Participant	Adults in home	Siblings in home	Total family size
C003	2	0	3
C004	2	1	4
C005	2	0	3
C006	missing	missing	missing
C007	2	2	5
C023	2	1	4
C031	2	0	3
C036	2	0	3
C042	2	2	5
C043	2	0	3
C056	2	1	4
C057	2	0	3
C074	2	0	3
C085	2	0	3
C113	2	0	3
C116	2	1	4
C121	2	1	4
C122	2	1	4
C161	2	0	3
Average	2	0.56	3.56

Recording collection

Daycare Centres as well as Home Daycares were recruited using an online database provided by the government of Manitoba's listing of licensed childcare programmes in the Winnipeg area. A 'target child' at each Daycare or Home Daycare was identified and recruited based on several criteria. We required that the primary language at home be English or French. (However, one daycare participant whose home environment was primarily Arabic speaking was accidentally included. Since the focus was on the language by the English-speaking daycare staff, we did not exclude this participant from the

sample.) There were two French/English bilingual Daycare Centres, where the target child also spoke French and English at home. One Home Daycare was French speaking, and the target child also spoke primarily French at home. Another Home Daycare was French/English bilingual and the child spoke only English at home. In addition, we looked for a participant who typically stayed for at least 8 hours in the daycare setting, and who the daycare staff thought would be willing and interested. In addition, we loosely age-matched across the childcare environments, although recruitment considerations limited the ability to create exact age matches. Although we treated all parents, teachers and children who associated with the daycare room being recorded as participants with respect to informed consent, due to the nature of the LENA recording system, the child wearing the device was considered the participant for research purposes (i.e. the language environment being recorded was that child's language environment). For home recordings, we instructed participants to make sure that anyone in range of the device was aware they were being recorded but we did not collect explicit consent for anyone other than the target child. We requested that the child be recorded on three to five different days, for a minimum of 8 hours each day. However in practice many of the daycare recordings were shorter. We excluded recordings shorter than 6 hours long. Eleven recordings were excluded due to being too short. Three recordings were excluded due to the child being sick (these recordings were also too short), and six were excluded because of missing or improperly filled out observation sheets.

See Appendix 1 for details regarding length and number of recordings for each participant.

For Daycare Centre recordings, a research assistant from our lab would arrive prior to the typical arrival time for the participant family in order to set up the equipment upon their arrival. This research assistant stayed throughout the day and filled out the observation sheets. The research assistant was instructed to avoid interacting with the children or adults (adults were informed of this ahead of time), or making eye-contact with the child. Observation sheets included marking the start time and stop time of the recording, time of day, naptime, as well as activities, and numbers of adults and children present. The recording device remained active during naptime, but the vest was removed and placed near the child. Daycare Centres received \$50/day[1] of recording as a thank-you for participating, to be used to enhance the children's selection of toys or contribute to costs of activities for the children.

For the Homes and Home Daycares, it was felt that the presence of an observer would more significantly influence the adults' behaviour. Therefore, a parent (usually, but not always, the mother) or the daycare teacher was instructed in the use of the recording equipment and the observation sheets, and no research assistant was present during recording. Research assistants picked up and dropped off recording devices at these settings. Home recording participants were recruited from our lab's existing database of parents interested in participating in research studies, or if the parents of a target child from a daycare setting wished to contribute data from their home. Home Daycares received \$50/day of recording, and Homes were compensated at \$20/day of recording. Daycares received a higher compensation than homes because it was used for the benefit of multiple participating families.

Preparing data for analysis

LENA Pro (version 3.2.2) and LENA's secondary data analysis tool (ADEX) were used to generate spreadsheets containing LENA's estimate of AWC in 5-minute increments by clock time, e.g. from 9:00 to 9:05, then 9:05–9:10 and so on. The predictor variables of interest (taken from the observation sheets) were the raw number of adults (Adult Count) and children (Child Count) in the room, and the ratio of adults to children (Adult:Child ratio) during each 5-minute block. These measures were combined manually with the ADEX spreadsheet in Excel. In some cases in which the observation sheet was unclear, the second author listened to the wav file to confirm the likely number of children and adults present. Naptimes were also included in the spreadsheet manually based on the observation sheets, and supplemented by listening to the audio when the observation sheets were unclear. Naptimes, the first and last half-hour of the recording, and segments shorter than 5 minutes (at the beginning and end of the recording, and if the recorder was paused in the middle of the day, since the 5-minute blocks were based on clock time) were excluded from further analysis. Recording times after 5 p.m. were excluded from analysis across all childcare settings to allow for more comparability across the settings, as these would not be common in the daycare settings.

Statistical analysis

Measurements per 5-minute block are nested within children, implying a lack of statistical independence – each child will have a different average level of exposure to language which depends not only on the environment variables of interest but also on unique, unmeasured factors such as individual caregiver characteristics and the child's own characteristics influencing the caregiver's behaviour. Conventional methods such as ANOVA are therefore inappropriate. To account for the correlation between time blocks within children, the relationship between number of adults, adult:child ratio and AWC was investigated with linear mixed-effects regression models, with the children modelled as the sole random effects. Adult word count was log-transformed to account for its skewed distribution. Various model forms were investigated for adult:child ratio, including linear, quadratic, logarithmic, square root, and combinations thereof, up to second order. This fractional polynomial approach (Royston & Altman, 1994) is useful when the relationship under investigation may be non-linear, more complex than traditional polynomials, and is unknown *a priori*. Competing models were compared based on residual plots and their Bayesian Information Criterion (BIC; Schwarz, 1978). We explored a number of covariance structures, but according to AIC and BIC statistics none was superior to a simple compound symmetry structure, in which all measurements nested within the same subject are equally correlated. This reflects that AWC was a noisy variable. Environments were modelled separately to allow for potential differences in the relationship between predictors and AWC, and because there was little overlap in the distributions of the values of the predictors across environments. This would have made the simultaneous analysis of environment and the predictor difficult to model and interpret. We also excluded time blocks with rare values of the predictor, for example 4 adults per child in the home environment ($n = 6$ time blocks). Analyses were performed with PROC MIXED of SAS version 9.3.

Table 3. Distribution of number of adults for each childcare environment in 5-minute increments.

	0	1	2	3	4	5+
Home	9	2699	1378	236	83	0
Home Daycare	0	2327	742	182	0	0
Daycare Centre	0	449	1198	946	307	211

Table 4. Distribution of ratio of adults to children in 5–minute increments for each childcare environment.

|	n	Min.	Max.	Lower quart	Upper quart	Median
Home	4396	.333	4.00	1.00	1.50	1.00
Home Daycare	3251	.091	1.50	.200	.400	.250
Daycare Centre	3111	.091	1.50	.286	.500	.375

Table 5. Distribution of one-on-one experiences across childcare settings.

	Home (w/o siblings)	Home (with siblings)	Home Daycare	Daycare Centre
One-on-one	1371	788	86	20
Other	993	1253	3165	3091

Results

Our first research question examined whether there were differences in the number of adults in the children's presence and ratios of adults to children across the childcare settings. Tables 3 and 4 show the distribution of number of adults and ratio of adults to children for each childcare environment, and the mean. There are unsurprisingly striking differences in these distributions for both raw numbers and ratios. Daycare Centres overall had much higher raw numbers of adults present than Homes or Home Daycares. Both Daycare Centres and Home Daycares had very few instances of ratios with more adults than children, while this was common in the home setting. Table 5 shows the distribution of one-on-one (i.e. only one adult and one child present) to other experiences for each environment.

In our first series of analyses, we examined how the quantity of adult speech heard by toddlers changes as a function of the raw *number* of adults present (research questions 2 and 4). The number of adults was treated as a discrete predictor. In the Home environment, there was an increase in average AWC with increasing number of adults present ($p < .001$; see Figure 1, Table 6). However, the distribution of word counts also notably differed as a function of the number of adults. With a single adult present, the counts were highly skewed with many large outliers, whereas the distribution was approximately normal when four
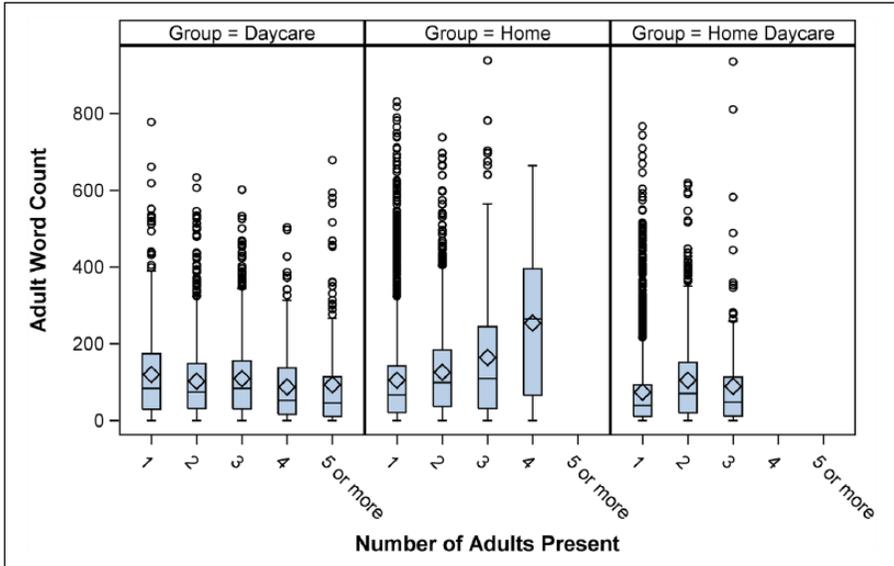
Figure 1. Adult word count distributed by childcare setting and number of adults present. Line represents the median, diamond the mean. Rectangles represent 25th and 75th percentiles, and whiskers represent maximum and minimum excluding outliers (small circles).

Table 6. Distribution of adult word count in 5-minute increments for each childcare environment, and relationship with number of adults.

	Num. adults	Mean	Median	SD	p-value*
Home	1	104.9	67.0	120.5	1 vs 2 < .0001
	2	125.6	99.0	116.5	1 vs 3 < .0001
	3	164.0	109.5	172.8	1 vs 4 < .0001
	4	253.5	265.0	180.1	2 vs 3 = .031
					2 vs 4 < .001
					3 vs 4 = .038
Home	1	73.4	39.0	98.1	Not significant
Daycare	2	104.4	70.5	109.6	
	3	88.6	48.0	126.6	
Daycare	1	119.9	84.0	121.9	1 vs 2 = .041
Centre	2	102.1	74.0	96.3	1 vs 5 or more = .016
	3	108.6	84.0	100.5	2 vs 3 = .002
	4	87.1	53.0	94.3	3 vs 4 = .012
	5 or more	93.4	45.0	123.5	3 vs 5 or more = .003

*Pairwise contrasts. Only showing significant differences in table. P-values were generated from univariate mixed-effects models with log(AWC) as the outcome and number of adults as a discrete predictor.

adults were present. In the Home Daycare analysis, there was no significant relationship between number of adults and AWC ($p = .237$). For the Daycare Centre, the effect of number of adults was significant ($p = .010$), but there was not a straightforward relationship.
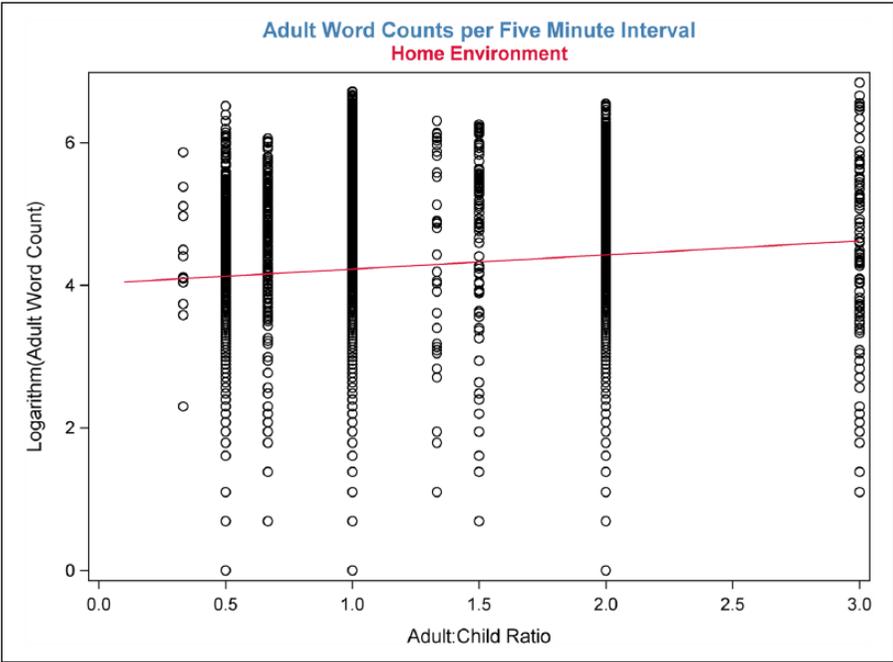
Adult Word Counts per Five Minute Interval
Home Environment

Figure 2. Adult word counts by ratio for the Home setting.

One adult and three adults present were associated with the highest word counts, with two adults significantly lower. Four adults present and five or more were associated with the lowest word counts.

In our second series of analyses (research questions 3 and 4), we examined how the quantity of adult speech heard by toddlers changes as a function of the *ratio* of adults and children present. For the Home environment the best fit model was a linear relationship with log(AWC) (beta = .199, $p < .001$; see Figures 2–4, Table 7). As with the raw numbers analysis, we found no significant relationship in the Home Daycare setting (beta = .148, $p = .336$ for linear relationship; non-linear terms did not improve model fit). In the Daycare Centre, the best fit model was a logarithmic relationship of ratio with log(AWC), in which the rate of increase in AWC gradually diminishes as the ratio increases (beta = .446, $p < .001$). However, although the adult:child ratio was significantly related to AWC in both the home and daycare environments, the variance around the predicted means remains quite large. For example, the estimated model R^2 in the home environment, holding the random effects constant, was less than 1%. Therefore the adult:child ratio was only able to explain a small amount of the variation in AWC. This reflects the noisy behaviour of the adult word counts.

Discussion

In this study, we examined how the daytime experiences of children across childcare settings varied with respect to the number and ratio of adults present. Beyond these raw
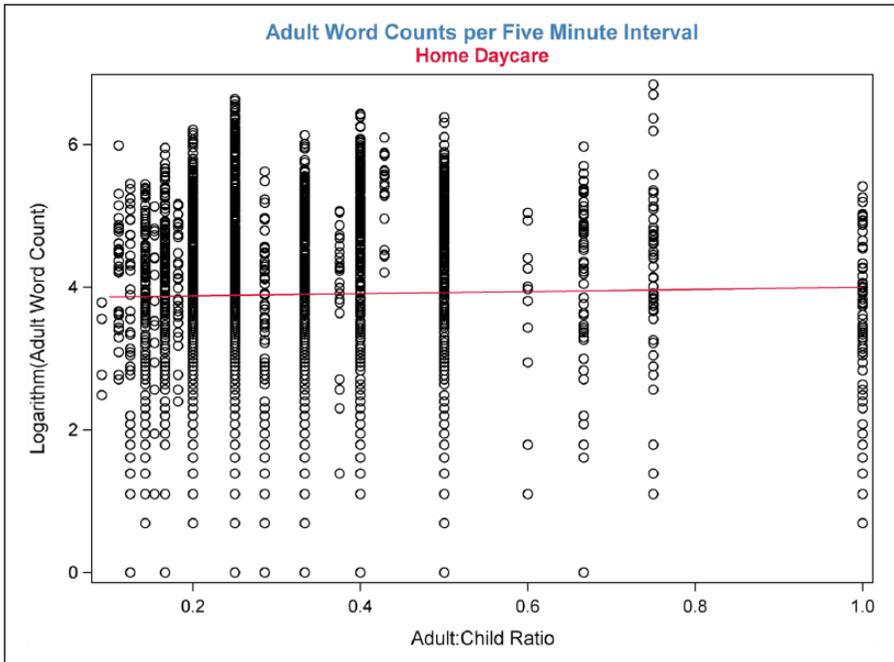
Figure 3. Adult word counts by ratio for the Home Daycare setting.

quantitative differences in the number/ratio of adults, children in these different child-care circumstances experience differences in the way that number and ratio of adults are related to the quantity of speech heard by the child. Because we explored natural variation in real-world experiences rather than systematically manipulating those experiences, our dataset did not permit us to directly compare the childcare settings with respect to the relationship between number/ratio of adults and quantity of speech. However, separate analyses revealed differences in the nature of those relationships.

In the Home environment, with respect to research question 1, well over half of the child's daytime experiences were with a single adult. Second most common was with two adults present, and relatively few time points included more than two adults. Ratio data indicate that these experiences were largely 1:1 experiences. Despite the relatively small variation in number of adults and ratio of adults to children, increasing number and ratio were associated with increases in the adult word count, consistent with our predictions for research question 2. However, the relatively variable word count associated with the one-adult context at home likely reflects the fact that this 1:1 context includes considerable variation in the caregiver's activity, and in whether this activity is communicative with the child or not.

The Home Daycare experience looked somewhat similar to the Home experience with respect to numbers of adults present, with a majority of experience being with a single adult. However, less time was spent with a second adult present, and as expected for research question 1, ratio data provide a very different picture from the Home
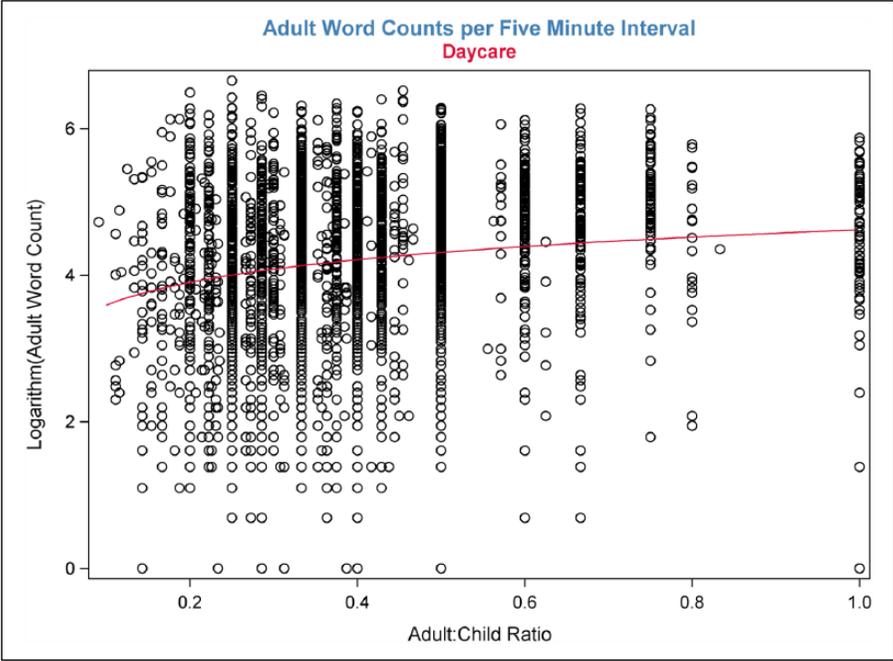
Figure 4. Adult word counts by ratio for the Daycare Centre setting.

Table 7. Relationship between adult:child ratio and adult word count in 5-minute increments for each childcare environment.

Environment	Predictor	Regression coefficient	*p*-value	95% Confidence interval
Home	a:c ratio	.199	< .0001	.129, .269
Home Daycare	a:c ratio	.148	.336	−.153, .449
Daycare Centre	Log(a:c ratio)	.446	< .0001	.329, .563

Estimates were generated from univariate mixed-effects models with log(AWC) as the outcome and continuous functions of adult:child ratio as the predictor.

environment – these experiences are in a group setting with multiple children. In these circumstances, there was no relationship found between number of adults or ratio of adults to children and the AWC (research questions 2 and 3).

The Daycare Centre environment provided much higher numbers of adults than either the Home or Home Daycare environment (as predicted for research question 1), and, somewhat surprisingly, higher ratios of adults to children than Home Daycares. Under these conditions, a significant relationship with number of adults was found, but this was not a straightforward relationship, with one and three adults generating the highest AWC (presumably, high AWC with only one adult present has a high probability of being child-directed). Notably, because of the much more variable number of adults in the

Daycare Centres, the ratios represent much more varied total numbers of individuals (a ratio of .5 could be 1 adult and 2 children, or 2 adults and 5 children, etc.) than in the Home and Home Daycare settings. In the Daycare Centre ratio analysis, there was an increase in word count with increasing ratio, but this effect diminished as ratio increased.

Overall, therefore, the relationship between quantity of speech heard by the child and both number and ratio of adults present appeared more stable in the home environment than elsewhere (research question 4). In addition, there is a striking difference in the number of one-on-one caregiver–child experiences between the home and daycare environments, even for homes with siblings in the family. While unsurprising, it is important to quantify this distinction, particularly given recent findings that one-on-one experiences are better predictors of language development than group experiences (Ramírez-Esparza et al., 2014, 2017).

There are of course a number of limitations and considerations that must be made explicit in interpreting these findings. First, this analysis was performed over a daytime-only dataset in order to appropriately compare the home recordings with those in a daycare setting, which is typically during daytime-only hours. The raw numbers therefore should be considered representative only of the children's *daytime* experiences. We expect that patterns in the evening at home (during dinner, bedtime routines, etc.) will be very different from those described here. Second, our sample is small and not diverse. We are therefore cautious about the extent to which these findings may be representative of the broader North American population. Nonetheless, they provide an important first snapshot of how young children's experiences may differ across childcare settings with respect to these characteristics. Lastly with respect to limitations, we are cognizant that due to the nature of the analysis, there are sources of error in our dataset that are difficult to quantify. In the Daycare Centres, the number of adults/children present was carefully coded by a research assistant. We have a high degree of confidence in these reports, but there is no reasonable way to formally calculate their accuracy/validity. By contrast, the reports from the Homes and Home Daycares were more variable in their quality. In some cases, it was necessary to review the audio files to clarify numbers – this likely introduced some degree of error (as individuals may have entered or left without indication on the audio), which is again difficult to quantify.

There are two additional and related considerations that are important to consider in interpreting our findings. First, our quantitative measure of speech input to the child was LENA's 'Adult Word Count' (AWC). It is therefore important to consider what this does, and does not, represent. LENA's AWC is designed to measure all speech produced by an adult that is 'near and clear' to the child wearing the device. The AWC excludes speech that is distant from the child/too quiet, or not a good exemplar of the 'adult speech' category. In addition, LENA excludes from AWC any speech that is overlapping with other speech or noise. Importantly, LENA does not distinguish between 'child-directed' and 'adult-directed' speech, meaning that, for example, speech produced to another adult while sitting in close proximity to the child would be included in the AWC.

This latter is important given that recent evidence tying quantity of speech input to child language development has been largely limited to child-directed speech, whereas adult-directed/overheard speech produced in the child's presence has not been found to correlate with development (Ramírez-Esparza et al., 2014, 2017; Shneidman et al., 2013; Shneidman

& Goldin-Meadow, 2012; Weisleder & Fernald, 2013). However, other studies have suggested that children may well learn at least some kinds of language from overheard speech (e.g. Akhtar, Jipson, & Callanan, 2001; Oshima-Takane, Goodz, & Derevensky, 1996). These various studies have characterized 'adult-directed' and 'child-directed' speech in different ways. For example, in the Weisleder study, 5-minute samples were classified by whether they contained primarily child-directed or overheard speech, whereas the Shneidman study used number of word types as their predictive measure. The Ramírez-Esparza study by contrast differentiated one-on-one interactions from group interactions and separately categorized 'child-directed speech' based on acoustic-linguistic features, and sub-sampled from high speech periods. Additionally, they examined proportion, rather than raw quantity, of child-directed speech. This lack of consistency in the literature makes direct comparisons difficult. However, across the findings, an important question emerges for consideration – how does the number of adults present predict changes in child-directed and overheard speech when considered separately? Our dataset in its current form does not allow us to address this question, but we hope to examine it in the near future.

In addition to differentiating child-directed and overheard speech, this study opens the door for a number of new research questions. Other work from our lab on a smaller, more preliminary version of this dataset found differences across childcare settings in the influence of different kinds of activities on the amount of speech heard by children (Soderstrom & Wittebolle, 2013) – to what extent are these findings tapping into the same underlying relationships between context and quantity of speech? Our findings also suggest that one-on-one interactions form a significant portion of the daily experiences of children at home, but not children in daycares. Given Ramírez-Esparza and colleagues' findings (2014, 2017) suggesting that these one-on-one experiences may be particularly important in early language development, it is crucial to explore the implications of this further. Does this mean that children in daycares experience lower quality linguistic experience than those who stay at home? If so, why are they not found to be disadvantaged in language development (National Institute of Child Health and Human Development Early Child Care Research Network, 2000)? Are there other language experiences in the daycare setting that 'stand in' for one-on-one experiences, and are more important for children with significant childcare experience outside of the home? How do the findings reported here compare with children across different (Western and non-Western) language communities? Overall, our findings suggest that the relationship between quantitative measures of the adults present in the child's environment and their speech exposure may vary considerably by context.

Note

1. The first two daycares received $100/day.

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Appendix 1. Recording information.

Participant	Recordings	Age at recording (in months)	Length of recording (hh:mm)
Home			
C003	3	23, 24, 25	11:50, 11:36, 11:49
C004	3	12, 13, 13	13:57, 11:53, 11:38
C005	3	21, 21, 21	10:04, 08:36, 10:00
C006	3	20, 22, 22	07:08, 10:17, 10:21
C007	3	22, 22, 22	11:40, 11:00, 10:49
C023	4	20, 20, 20, 21	09:27, 06:33, 07:05, 08:54
C031	3	29, 29, 30	08:11, 08:01, 08:03
C036	5	16, 16, 16, 18	12:10, 11:59, 12:05, 11:00
C042	5	17, 17, 17, 17, 17	09:14, 08:59, 08:21, 08:04, 08:10
C043	5	12, 12, 13, 13, 13	08:24, 08:42, 09:27, 08:24, 09:32
C056	5	22, 22, 22, 23, 24	11:21, 09:16, 08:36, 09:13, 09:03
C057	3	22, 22, 25	11:10, 11:40, 09:54
C074	5	21, 21, 22, 23, 23	11:31, 12:59, 08:32, 08:32, 09:28
C085	5	22, 22, 22, 22, 22	08:04, 08:16, 08:13, 08:09, 08:20
C113	5	24, 24, 24, 25, 25	08:00, 08:13, 08:02, 08:14, 08:03
C116	5	22, 23, 23, 23, 23	08:05, 08:02, 08:59, 09:25, 08:21
C122	5	18, 21, 22, 23	08:04, 08:09, 08:12, 08:18
C161	1	12	07:15
Daycare Centre			
C001a	3	18, 18	08:20, 07:45
C001b	4	29, 29, 29	07:23, 06:57, 07:07
C002	3	29, 30, 30	07:41, 07:31, 07:48
C021	3	14, 14, 14	08:06, 08:37, 08:34
C022	3	19, 19, 19	08:53, 08:12, 08:03
C024	3	26, 26, 26	08:10, 07:18, 08:01
C035	6	15, 15, 15, 15, 16	08:22, 08:57, 08:28, 09:01, 09:01
C045	5	18, 18, 19, 19, 19	07:44, 08:02, 08:01, 08:01, 08:01
C046	3	20, 21, 21	08:00, 08:20, 06:25
C048	2	21, 21	07:46, 08:24
C049	5	24, 24, 24, 24, 25	06:27, 07:20, 07:26, 07:59, 07:43
C051	5	25, 25, 25, 26, 26	07:45, 07:04, 07:26, 07:52, 07:49
C053	4	23, 23, 24	08:01, 07:53, 07:22
C054	5	22, 22, 22, 23, 23	07:23, 07:05, 07:02, 06:52, 07:03
C115	5	36, 37, 38, 38, 39	08:49, 08:01, 07:57, 07:26, 07:25
C123	3	21, 21	08:04, 08:03
Home Daycare			
C026	3	27, 27, 27	08:36, 09:13, 08:19
C033	6	18, 19, 19, 19, 19	08:00, 09:28, 09:08, 04:35, 08:30
C034	4	21, 21, 21	07:42, 07:30, 07:32
C038	5	30, 30, 30, 30, 30	08:51, 09:01, 09:29, 10:02, 09:08
C041	5	29, 29, 30, 30, 30	07:57, 06:51, 08:04, 06:48, 06:59

Appendix 1. (Continued)

Participant	Recordings	Age at recording (in months)	Length of recording (hh:mm)
C044	5	14, 14, 14, 14, 14	07:51, 07:55, 07:54, 08:00, 07:57
C055	3	29, 30, 32	8:00, 8:02, 8:02
C117	4	24, 24, 25	07:22, 06:05, 06:08
C118	5	21, 21, 21, 22, 22	08:00, 07:52, 07:49, 06:59, 07:13
C119	5	29, 29, 29, 29, 30	08:21, 08:14, 08:01, 08:02, 08:06
C120	5	15, 15, 16, 16, 16	07:28, 08:10, 07:41, 07:27, 07:33
C160	4	15, 16, 16	06:40, 07:27, 06:12
C163	5	29, 30, 30, 30	06:19, 06:25, 06:01, 06:11
C164	4	19	07:24, 06:21, 06:41, 07:52