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Research Report

Does the duration and frequency of dummy (pacifier) use affect the development of speech?

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Abstract

Background: The current literature suggests a link between dummy (or pacifier) use and a number of both positive and detrimental consequences. Positive consequences include soothing effect and protection from sudden infant death syndrome (SIDS), while negative ones include increased risk of otitis media and dental malformation. However, there is little research surrounding the impact of dummy use on the development of speech sounds.
Aims: To investigate whether duration (in number of months) and frequency per day of dummy use have an individual or combined effect on the development of a child's speech, and if so, in what way.
Methods & Procedures: A total of 100 British-English children aged 24–61 months and growing up in the UK were recruited through nurseries, playgroups and by word of mouth. Their parents were asked to complete a questionnaire about the duration and frequency of dummy use and factors known to influence the development of speech. Following this, the children's speech was assessed using the phonology section of the Diagnostic Evaluation of Articulation and Phonology (DEAP). Analysis of the DEAP was conducted to determine the percentage of consonants correct, number of age-appropriate, delayed and atypical errors. Dummy use and speech outcome measures were then analysed qualitatively and quantitatively using mean and median group comparisons alongside multivariate generalized least squares and generalized negative binomial modelling approaches to test for significant associations.
Outcomes & Results: The results showed that the majority of speech outcomes are not significantly associated with dummy use, however measured, in bivariate or multivariate analyses. However, there is a significant association between increased atypical errors and greater frequency of daytime dummy use. This association is strengthened by restricted sampling within the younger members of the sample, with this association not observable within children older than 38 months, the median sample age.
Conclusions & Implications: The evidence base for any effects of dummy use on speech is very small. Dummy use may increase the number of atypical speech errors a young child makes. However, only the frequency of daytime use seems relevant, not the duration or night-time use, and these errors may resolve over time.

Keywords: dummy use, children, articulation, delay, speech development, typical/atypical development.

What this paper adds

What is already known on this subject

- The use of a dummy with infants in Western countries is comparatively high (between 36-85%). A number of positive and detrimental consequences of dummy use have been documented in the literature; however, research on the effect of dummy use on speech development is significantly lacking. Past studies have included small sample sizes or used single measures of speech outcomes, which may not be specific enough to reveal how speech may be affected. Many speech and language therapists speculate that the use

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of a dummy could be contributing to many of the conditions they treat, yet this claim remains largely unsubstantiated.

Clinical implications of this study

- The study suggests that only prolonged use of a dummy over several hours and during the day may start to show any impact on speech; even then, professionals need to be aware that the evidence base for any speech effects is very small. Clinicians and other professionals who parents consult on dummy use should make sure to provide both the pros and cons of dummy use, in order to enable parents to make an informed decision.

Introduction

A dummy or pacifier is a non-nutritive sucking device typically made of plastic or rubber and which is used by parents to soothe and comfort their children. The use of a dummy with children in Western countries is thought to be high in the first few months of life, varying between 36% and 85% (e.g., Baker *et al.* 2018, Barros *et al.* 1995, Howard *et al.* 1999, Nelson *et al.* 2005, Niemela *et al.* 2000, Victora *et al.* 1997). An extensive literature exists documenting the detrimental outcomes relating to dummy use; these include decreased breastfeeding (cf. Jaafar *et al.* 2011 and O'Connor *et al.* 2009), increased occurrence of ear infections and dental malformations (American Dental Association 2003, Canadian Paediatric Society 2003, Karabulut *et al.* 2009, Van Norman 2001, World Health Organisation 1989). The positive effects of dummy use are also well researched. These include their role in comforting distressed infants (Pansy *et al.* 2008); stimulating and coordinating the suck, swallow, breathe pattern needed to feed in premature infants (Boshart 2001); and their role in preventing sudden infant death syndrome (SIDS) (Hauck *et al.* 2005, Jenik and Vain 2009, Mitchell *et al.* 2006, cf. Sexton and Natale 2009). Despite these vital advantages, media perceptions of dummy use are frequently negative (Whitmarsh 2008a), regularly harshly criticizing celebrities for their use of dummies with their toddlers. Parents and professionals are also split in opinion over whether the use of a dummy should be recommended or discouraged. Some speech and language therapists have even been reported to speculate that the use of a dummy could be a contributing factor to many of the speech and/or language problems they treat on a daily basis (Whitmarsh 2008a). Yet, the current literature surrounding the direct link between dummy usage and speech-sound development leaves this claim largely unsubstantiated (Hanafin and Griffiths 2002, Nelson 2012). Dummy use has at best been identified as a potential risk factor, rather than causing speech delay, and only through joint significance when grouped with bottle and thumb sucking (Fox *et al.* 2002).

Dummy use can be suggested to impact speech-sound development indirectly as a secondary effect of both dental malocclusions and otitis media, known consequences of dummy use. Articulation problems can arise from dental malocclusions, which can lead to distortion of fricatives and alveolar phonemes (Boshart 2001). Given that dummy use and speech production share similar oro-motor mechanisms and control, placement of the dummy in the oral cavity creates reduced opportunities for babbling and production practice, including of early words (Burr *et al.* 2020, Shotts *et al.* 2008). Babbling is an important precursor to the development of speech, allowing the child production practice, which equips them with the motor control necessary for refining and rescaling early vocalizations, supporting them in their journey towards more complex adult-like sound production (Green *et al.* 1997, 2000, Nip *et al.* 2011, Oller *et al.* 1999, Steeve and Moore 2009). Reduced babble may therefore lead to slower emergence of sounds, which over time may result in a phonological delay. Otitis media during the critical period of speech development may also result in reduced or delayed babbling (Shriberg *et al.* 2000) or children receiving inconsistent input and missing certain sounds (Doyle *et al.* 2003); this can lead to reduced consonant inventories (Shriberg *et al.* 2000). The combination of disordered speech arising from distortions, inconsistent input and reduced opportunities for vocalizations with the dummy in place (Van Norman 2001) can lead to the use of more atypical speech errors; these may become engrained in a child's phonology in the case of incorrect motor plans, which lead to a loss of contrast, leading to a phonological disorder (Bauman-Waengler 2015, Boshart 2001, Dodd 2005, Van Norman 2001).

Limited evidence exploring the *direct* relationship between dummy use and speech-sound development is available, however, as evidenced by a recent systematic review in this area (Burr *et al.* 2020). The review explored evidence for links between speech-sound disorder (SSD) and each of feeding and non-nutritive sucking behaviour (to include dummy- and digit-sucking).

In the case of the latter, the report concludes that the evidence is questionable and unpredictable. The authors also noted differences in the way SSD was explored, with some studies focusing on articulatory aspects while others on phonological representations, and in whether the measures were obtained indirectly from the parents or the children themselves. Below, we look at the findings from these and other available studies in more detail.

Barbosa *et al.* (2009) explored the effect of dummy use on 128 Patagonian pre-schoolers aged 3.01–5.08 years. Parents completed questionnaires regarding their children's sucking habits and then children were assessed using a standardized speech assessment. A threefold increased risk of speech problems was found for children who used dummies or sucked their fingers for longer than 3 years; however, this relationship was only found to be approaching statistical significance for dummy use. Within work on English, La Prairie *et al.* (2010) investigated the effect of dummy use on the articulation of the alveolar phonemes /s/, /z/, /d/, /t/ and /l/ in 14 English-speaking children from Illinois aged 2–4 years. Children who had used a dummy were found to be at least 10% less accurate at articulating alveolar phonemes than age-matched controls; however, they still scored within the average range and there was no clear relationship identified between articulation and duration of dummy use. Another study conducted by Shotts *et al.* (2008) into the effects of prolonged dummy (defined as beyond 18 months) use on articulation skills focused on 68 English-speaking children from Arkansas, aged 2.00–6.05 years. Using a standardized speech assessment, Shotts *et al.* (2008) found that there was no significant difference between children who had minimal dummy use (less than 1 month), typical dummy use (up to 15 months) and prolonged dummy use (beyond 18 months).

A recent study on dummy use in 199 Australian-speaking children with and without phonological impairment and using the Diagnostic Evaluation of Articulation and Phonology (DEAP) (Dodd *et al.* 2002), the same standardized phonological assessment as the one used in the present study, found no association between history of using a dummy, or indeed thumb sucking, and the presence or severity of phonological impairment (Baker *et al.* 2018). Finally, the most recent study in this area (Barca *et al.* 2020) looked at the potential influence of dummies on language (i.e., aspects of the grammar) rather than speech-sound development by age 8 years and found that school-aged Italian children who used the dummy beyond age 3 years found it harder to define abstract words than children who did not. This was explained as being due to the lack of sensorimotor simulation and inner talk that children typically engage in when learning abstract words. It is worth noting that all children in the study were typically developing and equally accurate at performing the task. Furthermore, dummy use was only retrospectively measured, and no speech outcomes were recorded.

None of the above studies presented stratified information regarding the duration and frequency of dummy use. While duration was taken as the age at which dummy use stopped, the daily frequency of dummy use during that period may matter too, since the longer the dummy is in place during waking hours the fewer the opportunities for oral practice and hitting targets in particular places of articulation. Additionally, three of the studies (Barbosa *et al.* 2009, La Prairie *et al.* 2010, Shotts *et al.* 2008) only used one speech outcome measure: a standard score. While such a score may indicate whether or not a child produces age-appropriate speech, it does not provide information regarding the nature of the errors, and whether they exhibit typical or atypical patterns of realization. These distinctions in error types are crucial for differential diagnosis of SSDs, helping towards the indication of whether a child presents with articulation of phonological difficulties. Baker *et al.* (2018) also considered the severity of phonological impairment, but children who met the criteria for atypical phonological impairment were excluded. Atypical errors may be informative for a study on dummy use, but current evidence comes only from a single case study, which found that speaking with a dummy in place leads to backing of alveolars (Garber and Reynold 1994). In sum, the evidence for a potential effect of dummy use on speech-sound development is weak and inconclusive. Burr *et al.* (2020) point to the dearth of studies in this area and the need to look at the potential effect of frequency as well as duration of non-nutritive sucking; this forms the focus of the current study.

Aims of the current study

This study explores whether there is a direct link between frequency (hours per day) and duration (months from onset to ceasing) of dummy use and speech-sound development through asking the following question: Does the duration and frequency of dummy use affect speech-sound development, and if so, in what way? It was hypothesized that prolonged dummy use will affect the speech-sound development of children, which will be exhibited in the following ways:

- A higher presence of delayed speech errors in comparison with non-dummy users due to reduced opportunities for babbling and production practice, including of early words (Shotts *et al.* 2008).

Table 1. Demographic and language background of non-dummy versus dummy users

	Non-dummy users	Dummy users (includes night-time only users)	Daytime dummy users	Night-time only users
Females	20	27	20	7
Males	22	21	16	5
First-born	24	33	25	8
At least one prior ear infection	6	12	10	2
Family history of speech and language difficulties	6	8	3	5
Bilingual	6	6	4	2
Maternal education				
No qualifications	3	7	6	1
GCSEs	8	9	6	3
A-Levels	16	18	14	4
Undergraduate degree	6	8	5	3
Master's degree	9	6	5	1
Thumb sucker	9	3	3	0
Group *N*	42	48	36	12

- A higher presence of atypical speech errors in comparison with non-dummy users due to distorted and reduced opportunities for vocalizations with the dummy in place (Van Norman 2001).

The focus on the prevalence of delayed speech errors was chosen because it can be informative about the possibility that the slower emergence of sounds might lead to phonological delay. The focus on atypical errors was chosen as it can be informative about the potential of these patterns to develop into phonological disorders.

Methodology

Participants

A total of 100 children growing up in the UK, 52 boys and 48 girls, were recruited from various nurseries and playgroups in Newcastle upon Tyne and London through an advert. Additionally, participants were supplemented through word of mouth and social media posts. Interested parents were sent an information sheet and consent form. Inclusion criteria for the study comprised of the following: children had to be between the ages of 24 and 71 months (actual range = 24–61 months, mean = 38.1, standard deviation = 8.6), parents had to opt in to the study by returning a signed consent form and parents had to complete a questionnaire (see appendix A) in full. Participants were excluded from data analysis if their questionnaire revealed any medical conditions, which were known to affect development of speech. Four participants were excluded for this reason (one had Cowden's syndrome and three had chronic glue ear). Participants were also excluded from data analysis if fewer than half the number of items on the DEAP assessment were elicited (70/141 items). A further two participants were excluded from data analysis because of this reason. Participants for whom it was not possible to determine dummy use due to missing information in the questionnaire, for example, missing average number of hours of dummy use per day, were also excluded. Four further participants were excluded for this reason. This left a total of 90 participants: 43 boys and 47 girls table 1.

Measures

Dummy-use measures

Dummy-use information was collected through a detailed questionnaire (see appendix A), which included whether or not a dummy had ever been used, what age the child started and stopped, what times of day they used their dummy and for how many hours a day on average. A question regarding thumb and finger sucking was also included. Information was also collected on factors that are typically known to affect the development of speech: order of birth, bilingualism, hearing loss, family history of speech and language difficulties, socioeconomic status (SES; parental education, occupation and income), medical conditions and gender (Fox *et al.* 2002, Harrison and McLeod 2010).

The data from the questionnaire pertaining to dummy use were used to identify dummy users versus non-dummy users. Within the dummy users, duration (months) and frequency (h) of dummy use were established, as well as time of day of dummy use (daytime, during sleep or mixed). Participants were assigned a total daytime 'dummy use' score using the following

Table 2. Duration and frequency of dummy use, within dummy users, separated by age category

	Number of 2–3 year olds (mean)	Number of 3–4 year olds (mean)	Number of 4+ year olds (mean)	Total *N* (mean)
Duration (months)	*22 (23.5)*	*17 (21.9)*	*9 (26.9)*	*48 (23.6)*
0–12	4 (7.5)	5 (3.2)	1 (7.0)	10 (5.3)
13–24	4 (21.0)	5 (18.4)	3 (19.3)	12 (19.5)
25–36	14 (21.4)	3 (35.3)	3 (29.3)	20 (29.9)
36+	0	4 (39.5)	2 (44.5)	6 (41.2)
Frequency (daytime hours)	*15 (2.6)*	*11 (3.0)*	*8 (6.1)*	*36 (3.6)*
1–2	10 (1.4)	8 (1.3)	4 (1.8)	22 (1.6)
3–4	2 (3.5)	1 (4.0)	0	3 (3.7)
5–8	3 (6.0)	4 (5.8)	2 (6.3)	9 (5.9)
9+	0	0	2 (15.0)	2 (15.0)
0 (Sleep only)	7	4	1	12
Age category *N*	22	17	9	48

Note: The number of participants within a category is reported alongside the means for duration/frequency within that category.

formula:

$$\text{Duration of dummy use} \times \text{frequency of dummy use} = \text{estimated total day time dummy use}$$

If a parent gave a range of hours for frequency of dummy use, for example, 2–10 h, the midpoint was taken. If a parent specified that the dummy was only used during sleep a daytime dummy use score of 0 was given, as this was not expected to interfere with speech-related sensorimotor practice. Non-dummy users were also given a dummy use score of 0.

To avoid the inflated margin for error through this multiplication, the estimated total daytime use was converted into a rank within the sample from 1 to 90. Those who never used the dummy were given the lowest rank. Those who used the dummy at night tied for the next lowest rank, as they must have it in for some time prior to sleep and after first waking up. Then those who actively used the dummy during daytime for some period of months were ranked in the remaining places from 55 to 90. Midpoint rankings were used to settle ties meaning that all non-dummy users ranked 21.5 and all night-time only users ranked 48.5. This method was preferred to a centile score due to the skewed variation making fixed sized groups difficult to justify.

The mean duration (age at ceasing minus age of onset) of dummy use was 23.6 months and the mean frequency of dummy use was 3.6 h per day across all dummy users. Within the dummy users, there were a range of durations and frequencies of dummy use, which can be seen by age group in table 2 and figure 1. The most common duration of dummy use for the 2–3-year-olds was 25–36 months, while there were two equally frequent ranges amongst the 3–4 year olds: (0–12 and 13–24 months) and the same for the 4+ year-olds: (13–24 and 25–36 months). The most common frequency of dummy use was 1–2 h across all the age groups. A total of 12 out of the 48 individuals (25%) who had used a dummy only used their dummy during sleep.

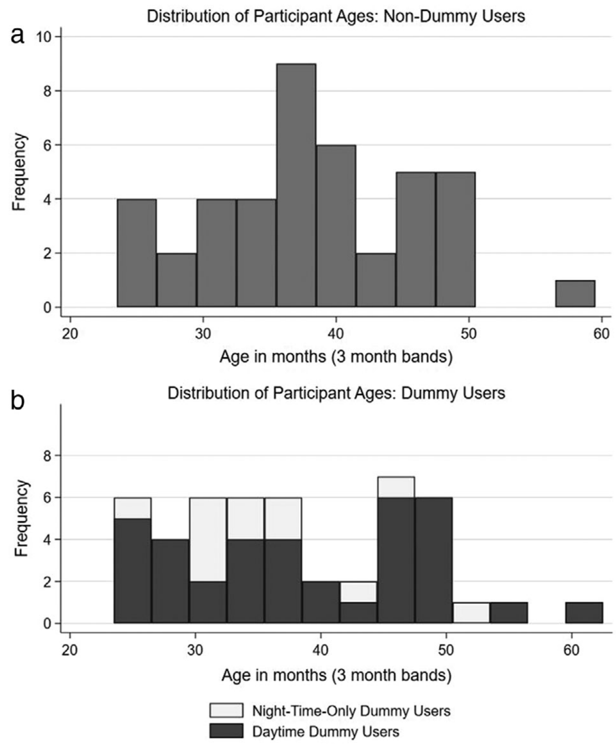

Figure 1. **D**istribution of ages within (a) dummy users and (b) non-dummy users.

Speech outcome measures

The children's speech was assessed by the first author, a final year speech and language therapy student, using the DEAP (Dodd *et al.* 2002). The student had been trained on using the DEAP and was regularly using it as part of their clinical practice. Children were asked to name 50 pictures from the phonology subtest. The phonology subtest was chosen due to its ability to elicit all consonants in most phonetic contexts and all but one vowel over a range of syllable shapes and lengths as well as its ability to allow for individual error pattern analysis. The child's response was transcribed using broad phonetic transcription with the addition of diacritics where further detail was needed for distortions, for example, for dentalization or lateralization. Speech assessments in the nurseries were carried out individually with each child in a quiet room when possible. Assessments for the children recruited at playgroups, via word of mouth and social media took place at the children's homes in a quiet room. All assessment sessions were audio-recorded using a Milaloko Digital Voice recorder. A range of speech outcome measures were collected to allow for the different possible effects of dummy use on speech development to be explored. First, a calculation of percentage consonants correct (PCC), percentage vowels correct (PVC) and percentage phonemes correct (PPC) was made using the guidelines in the DEAP manual (Dodd *et al.* 2002). Then analysis of each child's errors in each word was carried out, classifying these as age-appropriate, delayed or atypical according to the norms in the DEAP (which include expected patterns for ages 2.0–2.11, based on 32 children) and Grunwell (1982). Distortion errors, for example, lateralization and dentalization, were classified as 'other' within the typical/atypical categories depending on whether or not they were errors commonly observed in typically developing children.

Reliability checks

A total of 20% of the sample, a total of 18 children, was randomly selected and transcribed by a final-year speech and language therapy student, also trained in using the DEAP, in order to check inter-transcriber agreement. Both transcribers were blind to the children's level of dummy use. Similarity of transcription was calculated as a percentage of sounds that were transcribed the same. The percentage of agreement between the two transcribers was 87%, which is comparable with acceptable levels of inter-transcriber agreement (e.g., Seifer *et al.* 2020, Shriberg and Lof 1991, Willadsen *et al.* 2020).

Control variable measures

The following control variables were included due to association with dummy use and speech outcomes in the literature: maternal education, birth order, gender and the age of the child.

Maternal education was preferred as a proxy for SES to paternal education, parental occupational status or income. Six factors justify this; best model fit, precedence in the literature (Harrison and McLeod 2010), parsimony to increase the likelihood of model convergence, the 100% response rate to this question and collinearity to the other four potential measures of SES.

Ear infection was not included as control variable because our sample only reported occasional and short-term infections (not more than 2 weeks).

Age (months) squared was added to the model (age^2 in the model specification below), improving our fit and allowing for a non-linear relationship between speech development and age over the range sampled.

Analytical strategy

The model applied for each outcome variable is as follows:

$$\mathbf{Y}_{\mathbf{i}} = \alpha + \beta_{1-5}\gamma_{1-5} + \beta_6\mathbf{X}_{\mathbf{i}} + \hat{\varepsilon}_{\mathbf{i}}$$

where Y_i is the outcome score (4] outcomes) by individual; α is the constant or intercept; X_i is the dummy − use variable; γ is the control variables (maternal education, birth order, gender, age, age^2); β is the coefficient estimates; and $\hat{\varepsilon}_i$is the error term.

Our outcome variables do not follow the normal distribution, as shown in figure 2. For PCC, a slight left skew is observable which is corrected through robust generalized least squares estimation to obtain the parameter estimates from the model above.

The distribution of the count data on the three forms of errors, typical (age appropriate), delayed and atypical, had four potential solutions. The right-hand tail (left skew) could be approached using either a Poisson or a negative binomial approach. The high prevalence of zeros could be modelled using zero inflation if they were significantly more common than low non-zero observations.

Therefore, four model specifications were tested, both with and without zero-inflating, comparing Poisson regression with negative binomial regression. The models were compared using the Akaike information criterion (AIC) and Bayesian information criterion (BIC), as shown in table 3 for the yes/no variable for dummy use. A generalized (not zero-inflated) negative binomial model was selected for these three outcomes due to the statistics presented and the high risk of non-convergence of the zero-inflated negative binomial models for our multiple measures of dummy use. The selected model is appropriate for widely dispersed data with many low non-zero values.

A negative binomial model fits a Poisson model to the data, then a constant-only model to predict the

Table 3. Model fit for delayed and atypical errors

		Poisson	Zero-inflated Poisson	Negative binomial	Zero-inflated negative binomial
Typical age-appropriate errors	AIC	860.6	835.3	622.0	608.6.1
	BIC	878.1	870.2	642.0	645.9
Delayed errors	AIC	654.4	578.2	469.0	451.6 (DNC)
	BIC	671.8	613.0	488.0	488.9 (DNC)
Atypical errors	AIC	532.5	513.9	419.4	411.58 (DNC)
	BIC	549.9	548.8	439.3	448.9 (DNC)

Note: DNC, did not converge.

means and dispersion before combining the two in a maximum likelihood estimation procedure.

To capture the potentially varied effects of dummy use, we use five different variables. First, a yes/no indicator of the child using a dummy; second, a yes/no indicator of whether this is in the daytime; third, the length of time for which the child has used the dummy (duration in months); fourth, the frequency of the number of hours per day (daytime) that the dummy is used by the child on average; and finally, the ranked variable for total hours of use derived from duration and frequency described above.

Results

Bivariate group comparisons

Table 4 presents summary statistics for the DEAP speech outcomes by dummy use group. Group comparisons tests (both *t*-tests and Kruskal–Wallis tests, due to the non-normality of the outcomes, as shown in figure 2) were carried out on each of the speech outcomes. No significant differences ($p > 0.05$) were found for any comparison before or after Bonferroni corrections. This was robust to the inclusion of night-time only dummy users in either group.

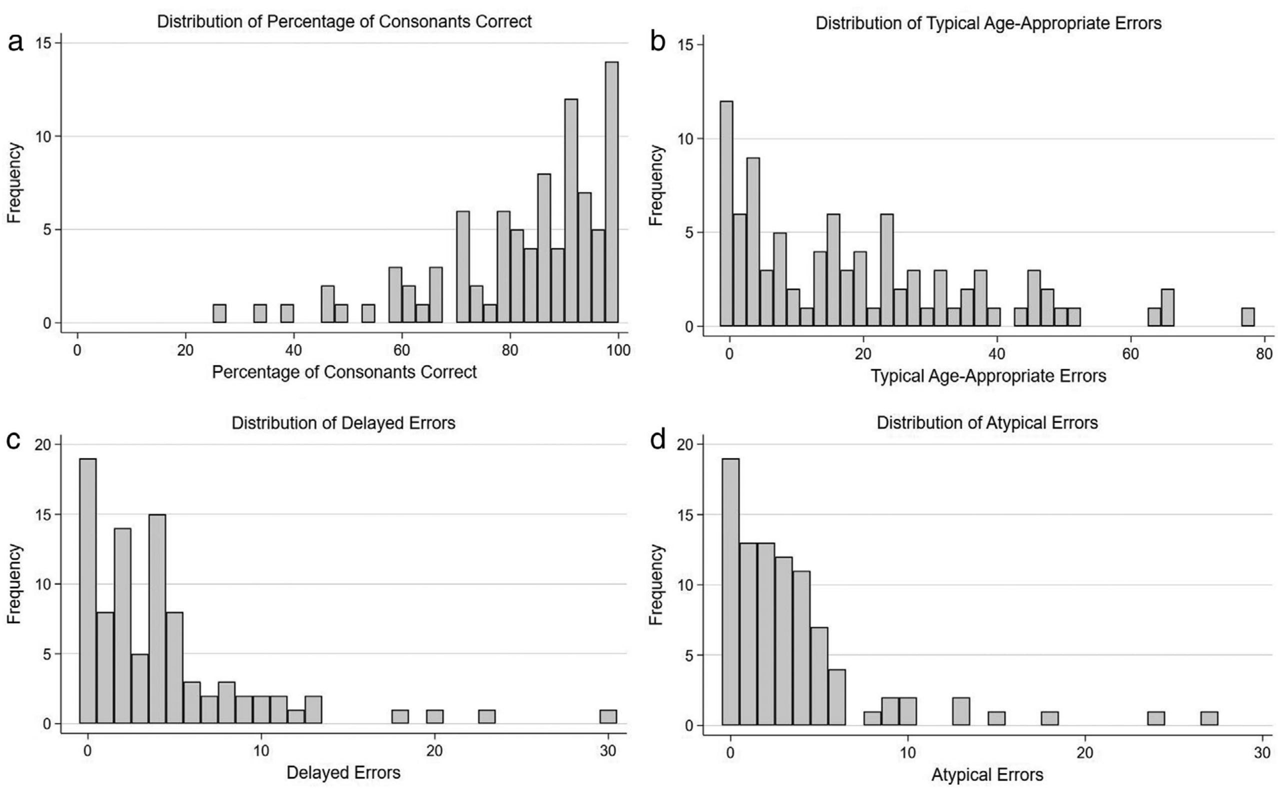

Figure 2. Histogram distributions of the four speech outcomes.
Note: (a) represents a positively coded outcome, whereas (b–d) report errors.

Table 4. Speech outcomes by dummy use

	Non-dummy users	Dummy users (includes night-time only users)	Daytime dummy users	Night-time only users
Percentage of consonants correct	82.50 (14.63)	81.27 (17.73)	81.53 (18.77)	80.50 (14.87)
Typical age-appropriate errors	19.57 (17.95)	18.60 (18.44)	17.36 (19.09)	22.33 (16.52)
Delayed errors	4.31 (4.30)	4.48 (5.99)	4.92 (6.67)	3.17 (3.01)
Atypical errors	3.40 (4.52)	3.98 (5.05)	4.61 (5.57)	2.08 (2.27)
Group *N*	42	48	36	12

Note: Values are mean (SD) by group.

Table 5. Full multivariate regression results for each speech outcome and dummy use measurement

	Dummy use	Daytime dummy use	Duration (months)	Frequency (hours per day)	Total time (duration*frequency) ranked 1–90)
Percentage of consonants correct	1.14	0.45	0.02	–0.03	0.01
	(2.50)	(2.57)	(0.07)	(0.50)	(0.07)
Typical age-appropriate errors	–0.26*	–0.17	–0.01*	–0.06**	–0.01**
	(0.14)	(0.16)	(0.00)	(0.03)	(0.00)
Delayed errors	–0.22	0.02	0.00	0.01	0.00
	(0.24)	(0.23)	(0.01)	(0.05)	(0.01)
Atypical errors	–0.06	0.32	0.01	0.11**	0.01*
	(0.24)	(0.22)	(0.01)	(0.04)	(0.01)

Notes: Robust standard errors in shown parentheses.
Each model controls for maternal education, gender, birth order, age and age^2.
*$p < 0.1$; **$p < 0.05$; and ***$p < 0.01$ (without Bonferroni corrections). All results are insignificant if we control for the number of regressions.

Multivariate regression results

Multivariate regression results (table 5) show that most of our speech outcomes are unrelated to most of our measures of dummy use. However, there are a few exceptions to this rule.

The point estimate betas represent the change in the expected logged number of errors when increasing the dummy use variable by 1. At larger values, this is often simplistically interpreted as a percentage change in the outcome variable. For example, a child who did not use a dummy, with given control characteristics, was predicted to make 10 typical processing errors in our fitted model. If they were to have been recorded as a dummy user, our model would predict approximately 7.7 predicted errors made, or 26% fewer typical errors as a rough estimation. Alternatively, looking at frequency and atypical errors, the same theoretical child not using a dummy who was predicted to have made 10 atypical errors would be expected to have made approximately 11 atypical errors if they had used a dummy for one extra hour per day, close to a 10% increase. Bonferroni corrections (multiplying the *p*-value observed by the number of regressions ran to account for increased risk of a false-positive result, or Type 2 error) would render each of the above results insignificant. This shows the relative weakness of the observed correlations and the limitations of our interpretation.

Further analysis of this association with atypical errors revealed some interesting results visible graphically in figure 3. The line of best fit between age and atypical errors was far steeper within the dummy using group, with a suggestion that the group differences were stronger within the younger sample. Within the older children, there are no visible differences between dummy users and non-dummy users. As shown explicitly in table 6, the older children do not show any association between frequent dummy use and atypical errors. This may be in part due to restricted sample size of frequent dummy users in the group of children over 38 months old. Still, there is still a possibility that the correlation observed within the younger sample ($p = 0.016$) may be a self-correcting transient phenomenon, or even a spurious one.

Tables 7 and 8 present qualitative results for the type of typical and atypical errors that were made by the children, stratified into age groups and dummy use. Note, however, that the apparent difference between the number of occurrences of errors in each group of users need to be considered with caution, as there were 42 non-dummy users and 48 dummy users. While some typical errors such as voicing, final consonant deletion and lenition show higher prevalence amongst dummy users, others such as fronting and cluster reduction are more frequent in the speech of non-dummy users. Atypical errors, on the other hand, were generally

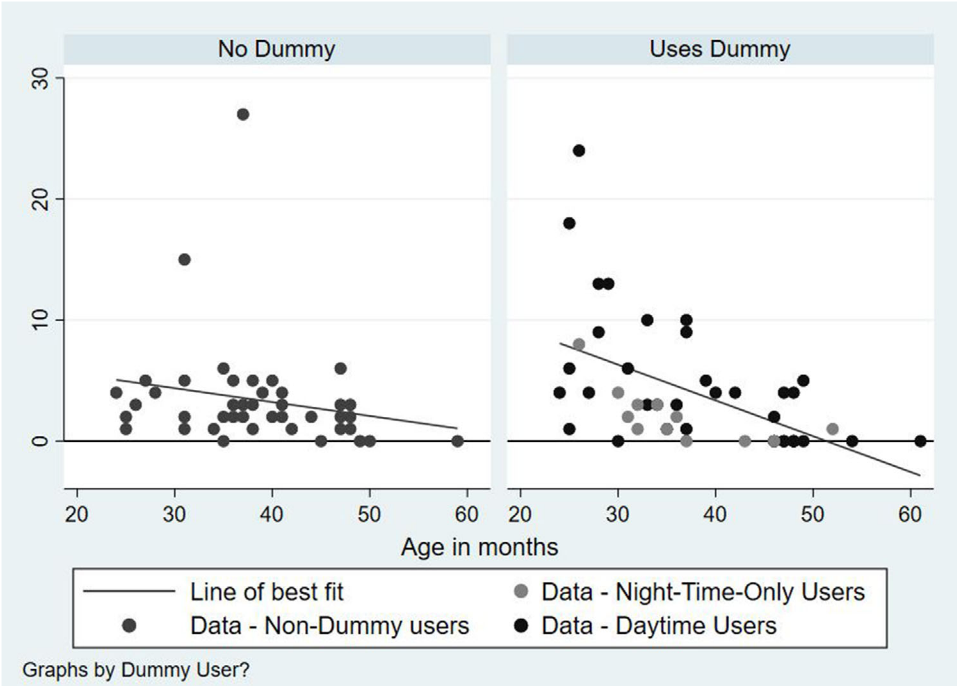

Figure 3. Atypical errors plotted against age by dummy use. [Colour figure can be viewed at wileyonlinelibrary.com]

Table 6. Full regression model with all five controls for restricted sampling either side of the mean age of our sample

	Hours per day of dummy use		
	Full sample	Age ≤ 38 months	Age > 39 months
Atypical errors	0.11**(0.04)	0.16**(0.06)	0.07(0.07)

Notes: Robust standard errors in shown parentheses.
*$p < 0.1$; **$p < 0.05$; and ***$p < 0.01$ (without Bonferroni corrections). All results are insignificant if we control for the number of regressions.

more evident in dummy users, especially with regards to backing, initial consonant deletion and intrusive consonants.

To summarize, typical speech errors made by the child are associated with a lack of dummy use. Dummy use, particularly daily frequency, correlates with a lower number of these typical speech errors. The number of atypical errors made by the participants is positively correlated with dummy use, particularly frequency of daily use. This is a relatively larger effect size and is strengthened by the exclusion of night-time-only dummy users from the dummy using group, which supports the relevant a priori hypothesis. The relationship between age, dummy use and atypical errors certainly justifies further research.

Speech outcomes and control variables

As expected, age and age^2 (months) were commonly the most powerful predictors in each regression except for delayed errors. Each regression ran in table 5 was jointly significant (*F*-test or Wald Chi-squared test) at the 5% level, although this was close for delayed errors due to only maternal education being individually significant.

Higher maternal education predicted improved speech outcomes in all areas, although this association was not significant in predicting atypical errors after accounting for duration, frequency or total time spent with a dummy. Korlahalli *et al.* (2014) show an association between maternal education and dummy use which was not observed in our sample, potentially due to the sampling procedure not being intended to represent the national population. Further research would be necessary to provide clarity on which elements of speech development are most correlated with maternal education.

Both gender and birth order were insignificantly associated with every speech outcome in every model. This was interesting given evidence in the literature for a gender imbalance regarding speech-sound development (Eadie *et al.* 2015, Wren *et al.* 2016).

Table 7. Typical errors found in dummy and non-dummy users by age (years; months) and number of occurrences

Error	Number of errors at age 2.00–2.11		Number of errors at age 3.0–3.11		Number of errors at age 4.0–5.0		Total number of errors across all age groups	
	Dummy users	Non-dummy users	Dummy users	Non-dummy users	Dummy users	Non-dummy users	Dummy users	Non-dummy users
Reduplication	3 (3)	1 (1)	0	0	0	0	3 (3)	1 (1)
Consonant harmony	19 (13)	13 (8)	4 (4)	13 (13)	1 (1)	2 (2)	24 (18)	28 (23)
Weak syllable deletion	43 (16)	19 (9)	8 (6)	27 (15)	2 (1)	0	53 (23)	46 (24)
Voicing errors (initial voicing, final devoicing)	84 (21)	44 (12)	44 (14)	45 (17)	8 (2)	3 (2)	136 (37)	92 (31)
Final consonant deletion	66 (12)	29 (10)	23 (6)	37 (11)	4 (4)	1 (1)	93 (22)	67 (22)
Fronting	152 (20)	117 (13)	49 (15)	124 (19)	20 (5)	5 (2)	221 (40)	246 (34)
Stopping	80 (20)	68 (10)	45 (15)	48 (20)	8 (4)	8 (4)	133 (39)	124 (37)
Cluster reduction	53 (20)	127 (10)	57 (9)	96 (18)	6 (2)	2 (2)	116 (31)	225 (30)
Gliding	38 (16)	18 (7)	19 (6)	25 (10	1 (1)	6 (2)	58 (23)	49 (19)
Deaffrication	46 (19)	36 (12)	17 (8)	34 (14)	9 (4)	5 (2)	72 (31)	75 (28)
Frication	13 (8)	7 (6)	8 (3)	12 (5)	0	0	21 (11)	19 (11)
Approximation	0	1 (1)	0	0	0	0	0	1 (1)
Labialization	0	1 (1)	0	0	0	0	0	1 (1)
Lenition	21 (11)	6 (6)	0	2 (2)	1 (1)	0	22 (12)	8 (8)
Other	18 (10)	7 (6)	2 (1)	9 (7)	2	0	22 (12)	16 (13)

Note: The number of children who produced these errors is indicated in parentheses.

Table 8. Atypical errors found in dummy and non-dummy users by age (years; months), and number of occurrences

Error	Number of errors at age 2.00–2.11		Number of errors at age 3.0–3.11		Number of errors at age 4.0–5.0		Total number across all age groups	
	Dummy users	Non-dummy users	Dummy users	Non-dummy users	Dummy users	Non-dummy users	Dummy users	Non-dummy users
Backing	86 (19)	28 (11)	21 (9)	41 (16)	5 (2)	4 (2)	112 (35)	73 (29)
Affrication	8 (3)	6 (4)	7 (2)	7 (6)	2 (1)	1 (1)	17 (6)	14 (11)
Initial consonant deletion	11 (7)	5 (4)	7 (6)	4 (3)	0	0	18 (13)	9 (7)
Medial consonant deletion	5 (5)	2 (2)	1 (1)	3 (3)	0	0	6 (6)	5 (5)
Intrusive consonant	10 (6)	5 (5)	4 (3)	4 (3)	2 (1)	0	16 (10)	9 (8)
Nasalization	4 (4)	1 (1)	2 (1)	0	0	0	6 (0)	1 (1)
Word medial devoicing	5 (5)	0	2 (1)	5 (4)	1 (1)	0	8 (7)	6 (5)
Other	8 (5)	3 (3)	0	25[a] (4)	0	0	8 (5)	28 (7)

Notes: The number of children who produced these errors is indicated in parentheses.
[a]A total of 22 came from one participant (lateralization).

Discussion

Effect of duration and frequency of dummy use on speech

This study found no significant association between duration (in months) of dummy use and any of the speech outcome measures except for typical errors, which are not considered a concern for a child's speech development (Dodd 2005, Dodd et al 2002). The study also observes no significant association between frequency (in daily hours) of dummy use and PCC, or delayed errors exhibited by the children on the DEAP phonological assessment.

There was, however, a significant relationship between the number of atypical and typical errors and frequency of daily daytime hours of dummy use, and the estimated total number of hours, duration*frequency, of dummy use by extension. Each additional hour of daily dummy use correlated to an approximate 7–15% increase in atypical errors, and an approximate 3–9% decrease in typical errors. The contradictory directions of these associations add to the mixed literature surrounding dummy use and potential advice. Below, we look at some of the mechanisms that may lie behind the relationship between each of these speech outcomes and dummy use.

Dummy use and atypical errors

Our results suggest that high frequencies of dummy use may result in more frequent atypical speech patterns, while the dummy is in place. The obstruction caused by the dummy may lead to articulations no longer being made in their usual places. Indeed, in the qualitative analysis of the atypical processes used by the children who had used a dummy, backing (producing speech sounds that should be made at the front of the mouth at the back of the mouth instead) was the most common (table 8).

The presence of a dummy in the oral cavity makes productions of phonemes that occur in the region where the dummy sits more difficult, for example, bilabial, alveolar and post-alveolar sounds, which may also explain why these children exhibited fewer typical errors. This makes it more likely the child will produce sounds behind the dummy, in the velar/uvular region, therefore causing these sounds to be 'backed', as has been reported before (e.g., Garber and Reynolds' 1994 case study). Note, however, that the backed articulations were induced in Garber and Reynolds' (1994) study while the dummy was placed in their participant's mouth, while the present study found that backing occurred without the presence of a dummy in the child's mouth. While backing may initially occur as a result of an articulation difficulty, due to the obstruction of the dummy, it may later become engrained in the dummy users' phonology through practice (Steeve *et al.* 2008) and/or compensatory articulation. As we did not test whether backed sounds are stimulable by the children we tested, the precise nature of these errors cannot be specified. Future studies would benefit from further exploration of the distinction between articulation and phonological errors. However, it is important to note that the number of atypical errors was lower for older dummy users, suggesting that these errors may be short lived. Importantly, both dummy and non-dummy users produced more typical than atypical errors.

Backing also occurred in the children who had never used a dummy, but at a lower rate. This suggests that dummy use is not the only factor that can influence the occurrence of atypical errors. A dummy user makes approximately 35% more backing errors than a non-dummy user, on average. This suggests that using a dummy increases the likelihood of backing occurring, either through an articulation or phonological difficulty or through alternative secondary effects such as an increased risk of otitis media (Doyle *et al.* 2003, Rovers *et al.* 2008, World Health Organisation 1989). Otitis media typically leads to children receiving inconsistent speech input and missing high frequency sounds such as fricatives and stops due to decreased hearing thresholds (Doyle *et al.* 2003, Flexer 1999). This could lead to backing high frequency energy like alveolars sounds to lower frequency velars. The rate of ear infections in the dummy users in this study was 25%, compared with 14% in non-dummy users, a 1.8-fold increased risk in dummy users. However, we did not test for this effect in this study as our participants had only occasional and short histories of ear infections.

Dummy use during sleep was not found to be a significant predictor of atypical processes. This could be because using a dummy whilst sleeping does not interfere with speaking, and therefore does not impact on speech-sound productions. This suggests that it is not the dummy use in itself that may influence the development of speech, but rather the use of the dummy whilst or instead of talking (LaPrairie *et al.* 2010). This also downplays the potential role of dental malformations and resulting changes in the shape of the oral cavity as a result of dummy use (Boshart 2001).

Dummy use and typical error processes

Frequency of dummy use was associated with a lower number of age-appropriate errors. This may partly be because some age-appropriate errors such as fronting involve articulations that would actually be more difficult with a dummy in place. Most other errors such as cluster reduction and weak syllable deletion exhibited similar patterns across dummy users and non-dummy users alike. It is also possible that dummy and non-dummy users commit similar numbers of overall errors at a young age but that the type of error made may be substituted according to the time spent with a dummy in their mouth. This could help explain the later convergence in total errors made between the two groups.

Furthermore, delayed errors showed no significant differences between the two groups. Shotts *et al.* (2008) suggested that the use of a dummy could cause speech delay through reduced opportunities for babbling and production practice; however, in this study we noted no differences in the frequency of delayed errors between dummy users and non-users at any age. Both groups of children also had comparable PCC scores.

Implications and future considerations

The present study has built on the small body of literature in the area of dummy use and speech development and presented two main methodological improvements: rather than only examining the duration of dummy use, data was also collected from parental reports on the amount of time children used their dummy on a day-to-day basis; and rather than judging speech ability based on a single score, a range of speech outcome measures were examined (age-appropriate errors, delayed errors and atypical errors). Collecting this extra information enabled analysis of a more precise measure of actual dummy use and the thorough testing of multiple hypotheses established in the literature. This more precise measure is more useful for comparing children's experiences than a strict binary measure and has more statistical power for observing potential effects.

While past studies have suggested that the use of a dummy in excess of 3 years may be detrimental for speech (e.g., Barbosa *et al.* 2009), the present results suggest that more weight needs to be given to daily frequency of dummy use. While a sustained daily frequency over time is expected to exhibit a cumulative effect, the effect of the total hours of dummy use (duration*frequency) appears relatively weak. Older children tend to make fewer atypical errors, potentially counteracting any cumulative impacts. And although there were still group differences between dummy and non-dummy users in the older group, they were far smaller. This has significant health service planning implications around which age to target interventions and what specific errors to look out for in a child. It suggests that any misarticulations correlated with dummy use may be self-reducing before age 4 years, so treatment would perhaps be warranted only if these misarticulations are still present by then.

Given the largely similar PCC results and error patterns across the two groups, there is no strong speech-related basis on which SLTs and health professionals can advise parents against dummy use. Due to the extensive benefits as well as cons of dummy use outlined in the wider literature outside speech development, it is instead suggested that parents are given information regarding both the pros and cons of dummy use in order to enable them to make an informed decision. Parents may also be advised regarding their dummy use practice should they decide to use a dummy with their child, for example, mainly using the dummy during sleep time or for short periods of time during the day. Furthermore, different advice may be indicated at different time points in the child's life. In the first year of life, for example, advice advocating the use of a dummy may be beneficial due to its effect on preventing SIDS and soothing the infant (Hauck *et al.* 2005, Mitchell *et al.* 2006, Pansy *et al.* 2008). As speech begins to develop it may be useful to encourage parents to start to think about discouraging its use over long periods of time due to its effects on otitis media (World Health Organisation 1989) and dentition. Bruton (2011) found that 55% of parents would turn to a professional for advice when making decisions about whether or not to use a dummy with their child. It would therefore be useful to share this research with general practitioners and health visitors.

Further research should continue to investigate the exact combinations of duration and frequency of dummy use that may affect speech so that this information can be provided to parents to aid them in their decision-making as well as in their dummy use practice. Further research on which articulatory and/or phonological errors are more likely to be present in dummy users (by carrying out the DEAP articulation test alongside the phonology section) and whether these self-correct is necessary to best inform SLTs as well as parents.

Since all of the participants in the study were healthy, full-term children who were recruited through a self-selecting sample (parents who volunteered), the majority were typically developing children; it would be important to include participants with identified speech difficulties in order to explore the potential cumulative effect of duration and frequency on speech development (though we note that Baker *et al.* 2018 found no association between dummy use and phonological impairment). Moreover, the children sampled in the study had a mean frequency of dummy use of 3.6 daily hours; it is difficult to judge whether this figure is relatively low since comparative data are not available. Future studies could replicate this methodology with larger samples and explore whether children who use their dummies at higher frequencies show poorer speech development. The inclusion of other non-nutritive sucking behaviour (digit-, toy- or blanket-sucking) would also be important, as would feeding habits (Hall 2001).

One limitation of the study was that it depended on parental recall of dummy use, which may not have been accurate. Parents may have exhibited social desirability bias regarding under-reporting their child's dummy use, especially as there is such a stigma surrounding dummy use. Mothers in one study conducted by Whitmarsh (2008b) commented that they felt guilt surrounding dummy use because they believed it was not 'good mothering' practice. Evidence of parental awareness of the stigmatization surrounding dummy use was demonstrated in some of the questionnaire responses where parents specified comments such as 'only to sleep though!' or 'never in the day' in parts of the questionnaire which did not required them to specify whether the use was in sleep or awake.

A further limitation was that speech outcome measures were only measured at single word level, not in connected speech due to time limitations. It may be that dummy use has more of an effect on connected speech where articulation errors are more likely to occur (LaPrairie *et al.* 2010). This can be seen in the study conducted by Garber and Reynolds (1994) who found a 20% higher rate of backing in the dummy user in connected speech compared with single words. This might suggest that the effect of dummy use on atypical errors might be more evident in connected speech. Future research should aim to sample speech both at single word and connected speech level.

Finally, there was a larger number of children from a high compared with a low SES background, as judged by parents' education, profession and income. This could also have affected the results as individuals from a high socioeconomic class are less likely to use dummies, which are associated with deprived SES (Fleming *et al.* 1999, North Stone *et al.* 2000). Future studies should seek to recruit an equal number of children from a range of SES backgrounds.

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Conflict of interest

The authors declare no conflict of interest.

Data availability statement

The audio recordings used in this study cannot be made publicly available due to personal information that would make it possible to identify the children in the study. Ethical approval for the study was granted on the condition that no identifiable personal data will be published or shared with any other organization.

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Appendix A: Questionnaire

Parental questionnaire

Date questionnaire is being completed: ____________________________

Child's name: ____________________________

Child's date of birth: _____/_____/______

Child's age in years and months:______ years ______ months

What is your relationship to the child:____________________________

Child's gender: Male Female

1. Were there any pregnancy and/or birth complications? Yes/No
– If Yes, please give details ____
____
2. Were they a full term baby? Yes/No
– If No, how premature or late were they _________________________________
3. What was their birth weight?_________________
4. Please list the names and ages of any siblings: _________________________________
____
5. Has your child had a history of ear infections? Yes/No
– If Yes, how many episodes? ________________________
– And at what age(s)?________________________
– And for how long? ________________________
6. Do you have any concerns about your child's hearing now? Yes/No
– If Yes, please give details__________________________________
7. Is there a family history of any speech and/or language problems? Yes/No
– If Yes, please give details? ____
____
8. Do you speak any other languages at home? Yes/No
– If Yes, which language(s)? ____
9. Has your child sucked their thumb/fingers in the past? Yes/No
– If Yes, do they continue to now? Yes/No
– If No, at what age did your child stop (years and months)
____
– How old were they when they started? (years and months) ________________
10. Has your child ever used a dummy? Yes/No
If yes please complete the remainder of the questionnaire, if no please skip to question 15.
11. At what age did your child start using a dummy (years and months) _________________
12. What time(s) of day did/does your child use their dummy (circle all that apply)
Morning Afternoon Evening Before Bed During Sleep Other
– If other, please give details ____
____
13. For how many hours a day on average did/does your child use their dummy
____
14. Does your child still use a dummy now? Yes/No
– If no, at what age did they stop (years and months)_____________________
15. Does your child have any medical conditions? Yes/No
– If yes, please specify ____

The following questions are about yourself and your child's other parent – the information gathered from these questions will be really useful to us in our data analysis however if you do not feel comfortable answering them please do not feel obliged to.

16. What is the highest level of education you have completed (please tick)
Primary school
GCSE's
A Levels
Undergraduate Bachelor's degree
Master's degree
Doctorate, professional
None of the above, please specify other: ______________________
17. What is the highest level of education your child's other parent has completed
Primary school
GCSE's
A Levels
Undergraduate Bachelor's degree
Master's degree
Doctorate, professional

None of the above, please specify other: ____________________

18. What is your occupation, or if no longer working what was your occupation previously?

____

19. What is your child's other parent's occupation ____________________________

20. Which of these categories best describes your total combined family income for the past 12 months? This should include income from all sources before taxes (please tick)

£0–£10,000

£10,000–£20, 000

£20, 000–£30, 000

£30,000–£40,000

£50,000+

Thank you for completing the questionnaire please return it to your child's class teacher. Following your return of this questionnaire your child's speech will be assessed by the researcher. If you would like a copy of the results of this speech assessment please email c.strutt1@newcastle.ac.uk to request this.