Child: care, health and development

Associations between maternal responsive linguistic input and child language performance at age 4 in a community-based sample of slow-to-talk toddlers

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ABSTRACT

Background: In a community sample of slow-to-talk toddlers, we aimed to (1) quantify how well maternal responsive behaviours at age 2 years predict language ability at age 4, and (2) examine whether maternal responsive behaviours more accurately predict low language status at age 4 than does expressive vocabulary measured at age 2 years.

Design/Methods: Prospective community-based longitudinal study. At child age 18 months, 1138 parents completed a 100-word expressive vocabulary checklist within a population survey; 251 (22.1%) children scored ≤20th percentile and were eligible for the current study. Potential predictors at 2 years were: (1) responsive language behaviours derived from videotaped parent-child free-play samples; and (2) late-talker status. Outcomes were (1) CELF-P2 receptive and expressive language standard score at 4 years and (2) low language status (standard score >1.25 standard deviations below the mean on expressive or receptive language).

Results: 208 (82.9% of 251) participants were retained to age 4. In adjusted linear regression analyses, maternal expansions predicted higher receptive (p<0.001, partial R^2=6.5%) and expressive (p<0.001, partial R^2=7.7%), while labels predicted lower receptive (p=0.01, partial R^2=2.8%) and expressive (p=0.007, partial R^2=3.5%) language scores at 4. The logistic regression model containing only responsive behaviours achieved 'fair' predictive ability of low language status at age 4 (area under curve (AUC) 0.79), slightly better than the model containing only late-talker status (AUC=0.74). This improved to 'good' predictive ability with inclusion of other known risk factors (AUC=0.82).

Conclusion: A combination of short measures of different dimensions, such as parent responsive behaviours, in addition to a child's earlier language skills increases the ability to predict language outcomes at age 4 to a precision that is approaching clinical value. Research to further enhance predictive values should be a priority, enabling health professionals to identify which slow-to-talk toddlers most likely will/will not experience later poorer language.

Key Messages

- Neither traditional risk factors nor early language screening tools accurately predict which toddlers will go on to have language difficulties in the preschool years.
- This population-derived study provides some of the strongest evidence to date for an association between maternal use of expansions and labels at age 2 with higher and lower language outcomes at age 4 respectively.
- A combination of short measures associated with child language (such as maternal responsive behaviours) increases the ability to predict language outcomes at age 4, providing optimism that further research could enhance predictive values to be of clinical value.

INTRODUCTION

Language difficulties affect one in five pre-schoolers (Reilly *et al.* 2010). Long-term ramifications at the population level include deficits in academic performance (Young *et al.* 2002; Law *et al.* 2009), adolescent attention and social difficulties (Snowling *et al.* 2006), reduced employment opportunities (Law *et al.* 2009), and poorer adult mental health (Law *et al.* 2009). Thus, a persistent language difficulty can be of great financial burden to individuals and families, as well as to society as a whole (Sciberras *et al.* 2015).

According to a 2016 *Lancet* Series on early childhood development, there is now a strong economic case for investing in the early years, with a need for preventative interventions to ensure children reach their developmental potential (Lo *et al.* 2017; Black *et al.* 2017). Further, a recent review identified promising preventative interventions for children at risk of persistent language difficulties (Law *et al.* 2017). Although early identification and preventative intervention is therefore highly desirable, it has proven very problematic. High levels of natural resolution and fluctuation mean it remains challenging to accurately target resources at age 2 to those most likely to have later problems, e.g. at age 4 (Reilly *et al.* 2010). Neither traditional risk factors nor early language screening tools accurately predict which toddlers will go on to have language difficulties in the preschool years (Law *et al.* 2012; Reilly *et al.* 2010; Wallace *et al.* 2015). Of particular concern is that sensitivity (i.e. identifying children who go on to develop a language disorder) is typically poor when using a single core language or vocabulary measure in toddlerhood (Law *et al.* 2012). As a result children who might benefit most from intervention slip through the cracks.

An alternative approach to screens that focus on child language is to consider novel predictors of language outcomes (Ellis & Thal 2008) such as maternal responsive behaviours, defined as contingent, appropriate and prompt parent responses to a child's initiations (Bornstein & Tamis-LeMonda 1989). Both empirical and theoretical research support their important role in early child language development. During infancy parent behaviours that are contingent and responsive to a

child's communicative acts, such as babbling or gesturing, promote turn taking and facilitate infant word-referent mapping, supporting vocabulary growth (Tamis-LeMonda *et al.* 2014). Semantically contingent responses to a child's focus of attention are thought to provide an optimal learning environment; decreasing the demands on a child's attention and cognitive functions allows the child to readily process information produced by the parent (Hebert *et al.* 2004; McGillion *et al.* 2013). Such behaviours include maternal use of labels, imitations, expansions and questions. All have been shown to predict the timing of toddlers achieving expressive language milestones (Tamis-LeMonda *et al.* 2001) and child vocabulary and expressive language outcomes (Taumoepeau 2016; Girolametto *et al.* 1999; Tomasello & Farrar 1986). Maternal responsive behaviours at age 2 years are also strongly associated with children's language cross-sectionally and in short-term follow-up at the population level (**removed for blind review*).

The arduous task of recording and coding parent-child interactions has been a major obstacle to measuring maternal behaviours at the population level (Gardner 2000). However, new technology has yielded techniques that are feasible, efficient and reliable at the population level (**removed for blind review*). We report on a population-based study that measured both maternal responsive behaviours and language in slow-to-talk toddlers at age 2 years and their language outcomes at age 4 years. In this paper, we aimed to:

1. Prospectively quantify the degree to which mothers' responsive language at 2 years predicts language outcomes at age 4, and
2. Investigate whether maternal responsive behaviours more accurately predict low language status at age 4 years than parent-report expressive vocabulary measured at age 2 years using the 100-word Sure Start language measure.

METHODS

Study design and participants

This prospective longitudinal study involved mother-child dyads recruited as part of the **removed for blind review* randomised controlled trial. The children are treated here as a single cohort, because the trial had robustly null results with no trend to an intervention effect (adjusted mean difference between intervention and control children at age 3 years: -2.4, CI −6.2 to 1.4, p=0.21 expressive; -0.3, CI −4.2 to 3.7, p=0.90 receptive) (see Wake *et al.* 2011 for intervention details). We selected three local government areas in (**removed for blind review*) to span the full socioeconomic range from disadvantaged to advantaged, with all children born May-December 2006 eligible for enrolment. Parents of infants attending their routine 12 month check were invited by their nurse to participate. Parents provided written informed consent, and the study was approved by the (**removed for blind review*).

At child age 18 months, 1138 of the 1217 (93.5%) parents recruited at child age 12 months completed a 100-word expressive vocabulary checklist (Sure Start Language Measure: Roy, Kersley & Law 2005). 251 (22.1%) children scored ≤20th percentile for expressive vocabulary and were eligible for this study, providing a sample likely to be enriched for both being late talkers at 2 years and having low language at 4. We excluded children with known pre-existing medical conditions, cognitive delay or parents unable to complete questionnaires in English at a Grade 6 (11 year old) reading level.

Procedures

Data required for this study (parent-child interaction data at age 2 and language outcomes at age 4) were available on 204 (81.3%) of the 251 eligible slow-to-talk toddlers. At age 2, trained research assistants visited the home for a 60-minute language assessment (Preschool Language Scale, 4th edition: Zimmerman, Steiner & Pond 2002) with the child, blind to trial arm status. Mother-child dyads were also video recorded during 15 minutes of free-play. The researcher provided two sets of toys (a farm and nurturing set) and the mother was instructed to play with her

child as she normally would. At age 4, a further blinded language assessment was conducted in the home.

Measures

Predictors at age 2: Maternal responsive behaviours and expressive vocabulary

An extensive review of the literature identified six responsive behaviours considered most likely to predict child language outcomes at 2 and 3 years (see **excluded for blind review*), comprising: expansions (Girolametto *et al.* 1999; Lasky & Klopp 1982), imitations (Girolametto *et al.* 1999; Lasky & Klopp 1982) interpretations (Girolametto *et al.* 1999), labels (Girolametto *et al.* 1999; Namy & Nolan 2004), supportive directives (Masur *et al.* 2005) and responsive questions (Tamis-LeMonda *et al.* 2001). Four of these behaviours (expansions, imitations, labels and responsive questions) were retained for the current analyses because our previous findings showed associations with language outcomes (**removed for blind review)*. The other two behaviours (supportive directives and interpretations) were not associated with child language outcomes.

Table 1 provides an overview of the study's coding scheme, as well as the frequency of responsive behaviours for the sample. Maternal responsive behaviours were coded from the middle 10 minutes of each videotaped observation using the Observer® XT software (Noldus Information Technology 2008), with all expressed as rate per minute. Intra- and inter-rater reliability showed very high intra-class correlation coefficients of 0.95 to 0.99 for all four behaviours.

At age 2 years parents completed the 100-word Sure Start language measure (Roy, *et al*. 2005), a parent-reported measure of expressive vocabulary. The Sure Start measure is adapted from the MacArthur-Bates Communicative Development Inventory: UK short form (MCDI-UK short form) (Dale *et al.* 2003), which is a widely used (both nationally and internationally) and accepted parent-reported measure of child productive vocabulary (Fenson, *et al.* 1994).

Child language outcomes at age 4

At age 4 years, the Clinical Evaluation of Language Fundamentals-Preschool Second Edition (CELF-P2) (Semel *et al.* 2006) was administered, providing receptive and expressive language standard scores. The CELF-P2 is widely used, norm-referenced and standardised to a mean of 100 (SD 15).

Potential confounders, selected a priori

Potential confounders were the **removed for blind peer review* trial arm status and several baseline variables, i.e., gender, birth order, age at follow-up, maternal education, and SEIFA (Socio-Economic Indexes for Areas) disadvantage index score (**removed for blind peer review* mean, 1000; SD, 100) for the family's postcode of residence. SEIFA scores are derived from the **removed for blind peer review* Census, with a higher score indicating a less disadvantaged neighbourhood relative to other areas (**removed for blind peer review*).

Analyses

All analyses were conducted using Stata 14 (StataCorp 2015). Linear regression was used to examine the relationship between each of the four responsive behaviours and language outcomes (receptive and expressive language scores) at age 4 years (aim 1). Responsive behaviours were included as predictor variables (continuous) one at a time in separate unadjusted (crude) regression analyses to determine if the responsive behaviours predicted language scores (continuous) over and above the potential confounders.

For aim 2, we first determined the 'optimal' cut-off value of the most highly-predictive maternal responsive behaviours in predicting low language status at age 4. We constructed ROC curves using the 'roctab' command in Stata 14 (StataCorp 2015). The ROC curve is a plot of sensitivity (true positive rate on the *Y* axis) against 1-specificity (false positive rate on the *X* axis) at each possible

cut-off value of the predictor variable; the closer to the upper left corner, the better the predictive ability of the test (Linnet *et al.* 2012). Kirkwood and Sterne (2003) define acceptable levels of sensitivity and specificity to be greater than 70%. In order to maximise sensitivity and specificity, the cut-off value was determined as the cutpoint in the ROC curve closest to (0,1) (i.e., the point with perfect sensitivity and specificity).

Late talker status was defined using the commonly used cut-off of below the 10th percentile on the parent-reported expressive vocabulary measure at age 2. 'Not a late talker' was coded as 0; 'Late talker' was coded as 1. The outcome variable of low language status at age 4 was defined using a score of >1.25 standard deviations below the mean for expressive or receptive language on the CELF-P2 (Reilly *et al.* 2010). 'Not low language status' was coded 0; 'Low language status' was coded as 1.

Next, logistic regression analysis was run to examine how the dichotomised maternal responsive behaviours and late-talker status predicted low language status at age 4. As predictors, the first model included late-talker status, the second model included the two predictive dichotomised maternal responsive behaviours (expansions and labels), and the third model included both late-talker status and the two maternal responsive behaviours. The final model adjusted the combined third model for the predictive risk factors identified in the Early Language in Victoria Study, which quantified the contributions of child, family and environmental factors to child language at age 4 years (Reilly *et al* 2010). Risk factors included child gender, prematurity, birth weight and order, multiple birth, socioeconomic status, maternal education, and age at child's birth, non-English speaking background and family history of language difficulties.

The area under the curve (AUC) was calculated to quantify the ability of each regression model to discriminate between those children with low language at age 4 and those with typical language at age 4. Higher AUC values suggest better discriminatory abilities as follows: 0.61-0.69, poor

validity; 0.70-0.79, fair validity; 0.80-0.89, good validity; and ≥0.9, excellent validity (Kirkwood & Sterne 2003).

RESULTS

Table 2 shows the characteristics of the mothers and children followed up at age 4 compared to those who were not followed up. Of the 251 parent-child dyads that provided video data at age 2 years, 204 (81.3%) provided outcome data at age 4 years. Just under half of the children followed up at age 4 were girls, the average age of mothers was 33 years, mother-child dyads were slightly less disadvantaged than the average Australian family and almost all toddlers lived with both parents (95.2%, 198/208). In this sample of slow-to-talk toddlers, the average number of words reported by parents at age 2 years on the 100 word checklist was 34.8 (SD = 22.5). At 4 years of age, 22.6% (46/204) scored >1.25 SD below the mean on CELF-P2 expressive or receptive subtests (Reilly *et al.* 2010) and were defined as having the outcome of low language at age 4 years.

The unadjusted and adjusted linear regression models of receptive and expressive language outcomes on each maternal responsive behaviour separately are presented in table 3 (aim 1). Associations changed only marginally from the unadjusted to adjusted models. Imitations showed little association and responsive questions showed only weak predictive associations with receptive (coefficient: 3.5; CI: -0.1 to 7.1; p=0.06; partial R^2=1.8%) and expressive (coefficient: 3.5; CI: -0.1 to 7.0; p=0.06; partial R^2=1.9%) language at age 4. However, more expansions strongly predicted higher receptive (coefficient: 6.1; CI: 2.8 to 9.3; p<0.001; partial R^2=6.5%) and expressive (coefficient: 6.5; CI: 3.3 to 9.7; p<0.001; partial R^2=7.7%) scores, while more labels predicted lower receptive (coefficient: -3.4; CI: -6.3 to -0.6; p=0.02; partial R^2=2.8%) and expressive (coefficient: -3.7; CI: -6.6 to -0.9; p=0.01; partial R^2=3.5%) scores.

For aim 2 we included the two maternal behaviours (expansions and labels) that were shown in the results for aim 1 above to predict expressive and receptive language outcomes at age 4, over and

above potential confounding variables. Based on ROC analysis, we dichotomised these variables at their optimal cut off points of 0.4 expansions/minute (equating to sensitivity of 71% and specificity of 64%) and 1.1 labels/minute (equating to sensitivity of 71.1% and specificity of 55.6%); in other words, sensitivity just reached acceptable levels, while specificity fell short (noting that the sample in this study overrepresented children with lower expressive vocabulary). The dichotomised variables were then entered into logistic regression analyses, as was the late-talker status variable.

Table 4 shows results for each of these logistic regression models. The odds of low language at age 4 increased significantly if the child was a late-talker at age 2 (OR: 5.4; 95% CI: 2.6 to 11.4; p<0.001). The second model shows that high use of maternal expansions significantly reduced (OR: 0.26; 95% CI: 0.12 to 0.54; p<0.001), while high use of labels at age 2 increased (OR: 2.6; 95% CI: 1.3 to 5.5; p=0.01) the likelihood of a child having low language at age 4. When including all together in Model 3, both late-talker status (OR: 2.9; 95% CI: 1.2 to 6.9; p=0.02) and expansions (OR: 0.43; 95% CI: 0.18 to 1.04; p=0.06) attenuated; however, use of labels did not attenuate (OR: 2.8; 95% CI: 1.3 to 6.2; p=0.01). After further adjusting for known risk factors (Model 4), late-talker status attenuated to no longer independently predict low language at age 4 (OR: 2.3; 95% CI: 0.82 to 6.3; p=0.1). However, neither of the responsive behaviours attenuated further; use of expansions remained protective (OR: 0.35; 95% CI: 0.13 to 1.0; p=0.05), while high use of labels actually strengthened to greatly increase the odds of low language four-fold at age 4 (OR: 4.5; 95% CI: 1.7 to 11.9; p<0.003).

The area under the curve for responsive behaviours signified only fair discrimination between children with and without low language status (Model 2, 0.72) – slightly better discrimination than late-talker status alone (Model 1, 0.67). Combining responsive behaviours with late talking status and then further adjusting for risk factors progressively strengthened discrimination, to 0.74 (Model 3) and 0.82 (Model 4) respectively, reaching Kirkwood & Sterne's criterion of 0.80 for 'good' discrimination in the final model.

DISCUSSION

There is growing support for identifying factors that may be measured in the early years, alone or in combination, to identify children who will benefit from early intervention (McKean *et al.* 2016). Maternal responsive behaviours (specifically expansions and labels) measured at age 2 years predicted both expressive and receptive language scores at age 4 years in this sample of slow-to-talk toddlers. Responsive behaviours and late-talker status performed similarly in discriminating between children with low language and normal language scores at age 4 years, providing fair and poor predictive precision respectively. Combining them in the same model provided moderate predictive precision and, when combined with the risk factors, the model improved further to provide good discrimination.

The finding that maternal labels were associated with *poorer* expressive language is in contrast to previous studies, which generally showed either no association or a positive association, i.e., more labels predicted better language outcomes (Tomasello & Todd 1983; Yoder *et al.* 1998). As maternal labels are a response to a child's focus of attention (Yoder *et al.* 1998) and not dependent on a child's preceding verbalisation, these findings may actually be an instance of reverse causation in that by age 2 years they may reflect on the child's low language ability (i.e., the child is producing less language and providing fewer opportunities for the mother to respond). While labels may be positive and promote language at the preverbal and single-word stage of language development in infants and young toddlers (Namy & Nolan 2004; Yoder *et al.* 1998), by age 2 years they may be a sign that the child is behind.

Strengths: This large community-based sample not only confirms but goes beyond previous studies (Girolametto *et al.* 2002; Tamis-LeMonda *et al.* 2001; McDuffie & Yoder 2010; **removed for peer review*) in supporting a positive relationship between the use of expansions with child language outcomes in a sample likely to be more representative. Previous findings for a number of

the responsive behaviours examined (i.e., labels and responsive questions) have not been definitive because studies have included either small samples of typically developing children or samples of children presenting clinically with severe language deficits, as well as including mother-child dyads from relatively homogeneous backgrounds.

Limitations: This study only included children who were slow to start talking at 18 months of age, so caution must be taken when interpreting the results. However, by age 4 years they had a wide range of outcomes (mean (SD), range: 94.0 (14.1), 56 to 130; and 97.3 (14.4), 50 to 138 for receptive and expressive language respectively). This offered a large sample of children with varying language abilities, resulting in the potential to establish the predictive power of responsive behaviours beyond the current evidence-base. Non-English speaking families were excluded from the current study, although families with adequate English but for whom English was not their first language could participate. Therefore, findings may not fully generalise to non-English speaking families. In addition, more socio-economically disadvantaged mother-child dyads were slightly underrepresented. This could threaten generalisability, given the substantial evidence suggesting that the quality and quantity of parent-child interaction mediates the association between socio-economic status and language development. However, there is empirical evidence demonstrating that exposure-outcome associations in longitudinal studies are relatively robust to deviations from representativeness (Nohr *et al.* 2006; Nilsen *et al.* 2009).

Interpretation: Identification of those most at risk of persistent language problems via a one-off measure has thus far not proved helpful (Wake *et al.* 2011; Reilly *et al.* 2010). That lower maternal expansions may in fact be an indirect measure of poorer language production at age 2 years is supported by our finding that, when included with late talker status, the power of both variables to predict low language at age 4 years attenuated. Likewise, maternal use of labels may in fact be a marker for a parent's intuitive recognition that their child is at a much lower stage of language acquisition than would benefit from more 'advanced' responsive inputs, i.e., the child is already on

a poor pathway. Models including all of late talking status, maternal responsive behaviours and known risk factors for low language provided the strongest prediction and good discrimination. The area under the curve was similar to that reported at age 4 in the Early Language in Victoria Study of 0.78-0.84 using known risk factors and late talking status alone in a normally-developing community sample (Reilly *et al.* 2010). This provides optimism that even better predictive models may yet be developed. An important next step could be to examine the added discriminatory power of maternal responsive behaviours to a combined language risk-factor model in a population-based sample including the full range of toddler language ability. Understanding a child's exposure to maternal responsive behaviours may assist practitioners to identify those children most likely to have poorer later language. In addition, findings from the current study support teaching and encouraging primary caregivers to use responsive behaviours, such as expansions, to assist child language development. Such behaviours could be promoted through existing early child health services such as 2 year old child and family health nurse checks.

Conclusions: A combination of short measures of different dimensions, such as parent responsive behaviours, in addition to a child's earlier language skills increases the ability to predict language outcomes at age 4 to a precision that is approaching clinical value. Research to further enhance predictive values should be a priority, enabling health professionals to identify which slow-to-talk toddlers most likely will/will not experience poor language later.

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Table 1 Maternal responsive behaviours coding scheme

Maternal Responsive Behaviour	Definition	Example of coding		Rate per minute (N = 251)	
		Child	Parent	Mean (SD)	Range
Expansions	Mother repeats one or all of the child's preceding words and adds to the child's preceding verbalisation (Girolametto *et al.* 1999; Lasky & Klopp 1982)	"Ball"	"It's a red ball"	0.6 (0.6)	0 to 3.2
Imitations	Mother repeats the child's preceding vocalisation or verbalisation exactly or with a reduction of words (Girolametto *et al.* 1999; Lasky & Klopp 1982)	"Ball"	"Ball"	0.5 (0.5)	0 to 3.3
Labels	Mother labels an object or action, which is the focus of the child, with the label in the final position of the carrier phrase (Girolametto *et al.* 1999; Namy & Nolan 2004)	*Playing with a toy horse*	"That's a horse"	1.2 (0.7)	0 to 4.2
Responsive Questions	Mother asks a 'wh' question (e.g., 'what', 'when', 'who') that is immediate and dependent on the child's preceding act (Tamis-LeMonda *et al.* 2001)	*Child is holding a horse*	"What's that?"	0.7 (0.5)	0 to 2.7

Table 2 Characteristics of participants followed up and not followed up at 4 years

Variables	Followed up at 4 years (N=208) [a]	Not followed up at 4 years (N=43) [b]
Child		
Female child, n (%)	98 (47.1)	23 (53.5)
Twin birth, n (%)	12 (5.8)	0 (0)
Preterm birth (<37 weeks), n (%)	21 (10.1)	6 (14.0)
Birth weight(grams) mean (SD)	3378.1 (618.6)	3489.9 (638.2)
Birth order, n (%)		
First	75 (36.1)	21 (48.8)
Second	91 (43.8)	15 (34.9)
Third or more	29 (13.9)	4 (9.3)
Fourth	11 (5.3)	2 (4.7)
Fifth or more	2 (0.9)	1 (2.3)
Age at 2 year assessment, mean (SD)	24.6 (1.2)	24.9 (1.4)
Normally lives with, n (%)		
Both parents	198 (95.2)	36 (85.7)
One parent	8 (3.8)	4 (9.5)
Other	2 (1.0)	2 (4.8)
Hears non-English language >10 hrs/week, n (%)	18 (8.7)	10 (23.3)
Family history of language difficulties	49 (23.6)	13 (30.2)
SSLM vocabulary raw score at 18 months, mean (SD)	5.3 (3.0)	5.6 (3.2)
SSLM vocabulary raw score at 24 months, mean (SD)	34.8 (22.5)	27.9 (20.9)
CELF-P2 Exp language standard score at 4 yrs, mean (SD)	97.3 (14.4)	-
CELF-P2 Rec language standard score at 4yrs, mean (SD)	94.0 (14.1)	-
Mother		
Mother's age at birth of child, mean (SD)	33.3 (4.3)	31.8 (5.3)
SEIFA, mean (SD)	1025.2 (53.0)	1028.1 (52.2)
Mother's highest level of schooling, n (%)		
Did not complete high school	39 (18.9)	16 (37.2)
Completed high school	72 (35.0)	12 (27.9)
Tertiary degree/postgraduate	95 (46.1)	15 (34.9)
Responsive behaviours rate/minute, mean (SD)		
Expansions	0.6 (0.6)	0.5 (0.7)
Imitations	0.5 (0.5)	0.4 (0.4)
Interpretations	0.6 (0.4)	0.5 (0.4)
Labels	1.2 (0.7)	1.2 (0.7)

Supportive directives	0.6 (0.5)	0.6 (0.5)
Responsive questions	0.7 (0.5)	0.5 (0.4)

SSLM, sure start language measure; SEIFA, socio-economic indexes for areas disadvantage index score; CELF-P2, Clinical Evaluation of Language Fundamentals – Preschool 2nd edition.
[a] Sample size ranges from 204 to 208 [b] Sample size ranges from 42 to 43

Table 3 Linear regressions of CELF-P2 receptive and expressive language outcomes at 4 years by maternal behaviours at 2 years

Variable	Unadjusted models			Models adjusted for potential confounders[a]			
(rate/minute)	Coefficient	95% CI	*P*	Coefficient	95% CI	*P*	Partial R^2 (%)
Receptive Language							
Expansions	7.2	4.1 to 10.2	<0.001	6.1	2.8 to 9.3	<0.001	6.5
Imitations	4.2	0.2 to 8.2	0.04	3.4	-0.6 to 7.3	0.1	1.4
Labels	-3.2	-6.3 to -0.5	0.02	-3.4	-6.3 to -0.6	0.02	2.8
Responsive Questions	3.5	-0.1 to 7.1	0.06	3.4	-0.2 to 6.9	0.06	1.8
Expressive Language							
Expansions	8.1	5.0 to 11.2	<0.001	6.5	3.3 to 9.7	<0.001	7.7
Imitations	4.4	0.3 to 8.5	0.04	3.3	-0.7 to 7.2	0.1	1.4
Labels	-4.0	-7.0 to -1.1	0.007	-3.7	-6.6 to -0.9	0.01	3.5
Responsive Questions	3.8	0.1 to 7.5	0.04	3.5	-0.1 to 7.0	0.06	1.9

[a]Models adjusted for potential confounder variables including: trial treatment status, gender, age at 4 year follow up, maternal education, SEIFA and birth order (*N* ranges from 200 to 204)

Table 4 Logistic regression analyses for associations of low language status at age 4 with late-talker status and maternal behaviours

Predictor	Model 1 (N=197)		Model 2 (N=205)		Model 3 (N=196)		Model 4 (N=194)	
	OR (95% CI)	*p*	OR (95% CI)	*p*	OR (95% CI)	*P*	OR (95% CI)	*P*
Late-talker status	5.4 (2.6 to 11.4)	<0.001			2.9 (1.2 to 6.9)	0.02	2.3 (0.82 to 6.3)	0.1
High use of expansions (≥0.4/min)			0.26 (0.12 to 0.54)	<0.001	0.43 (0.18 to 1.04)	0.06	0.35 (0.13 to 1.0)	0.05
High use of labels (≥1.1/min)			2.6 (1.3 to 5.5)	0.01	2.8 (1.3 to 6.2)	0.01	4.5 (1.7 to 11.9)	0.003
Female							1.1 (0.45 to 2.7)	0.8
Preterm birth (<36 weeks)							1.0 (0.2 to 5.1)	1.0
Birth weight							0.60 (0.26 to 1.4)	0.2
Birth order (ref: First child)								0.03
Second child							4.1 (1.4 to 12.0)	
Third child or more							3.5 (0.98 to 12.6)	
Twin birth							1.9 (0.32 to 11.6)	0.5
SEIFA disadvantage score							1.0 (0.99 to 1.0)	0.2
Mat education level (ref: <Yr 12)								0.2
Completed high school							0.95 (0.29 to 3.1)	
Tertiary degree/postgraduate							0.41 (0.12 to 1.4)	
Age at birth of child							0.91 (0.82 to 1.0)	0.09
NESB							1.8 (0.38 to 8.16)	0.5
Family history of difficulties							0.64 (0.23 to 1.75)	0.4

Note: Model 1 AUC (area under the curve)=0.67; Model 2 AUC=0.72; Model 3 AUC=0.74; Model 4 AUC=0.82; 'low language status' defined as a score of >1.25 standard deviations below the mean for expressive or receptive language on the CELF-P2.
OR, Odds ratio; CI, confidence interval; SEIFA, socio-economic indexes for areas disadvantage index score; NESB, Non-English Speaking Background.