<LRH>Laura J. Conway et al.

<RRH>Language and behaviour in slow-to-talk toddlers

Research Report

Associations between expressive and receptive language and internalizing and externalizing behaviours in a community-based prospective study of slow-to-talk toddlers

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Abstract

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Background: Evidence suggests that language and social, emotional and behavioural (SEB) difficulties are associated in children and adolescents. When these associations emerge and whether they differ by language or SEB difficulty profile is unclear. This knowledge is crucial to guide prevention and intervention programmes for children with language and SEB difficulties.

Aims: To determine whether receptive and expressive language skills are associated with internalizing and externalizing behaviours in slow-to-talk toddlers.

Methods & Procedures: In a community-based prospective study of 200 slow-to-talk children, language was measured at 24 and 36 months using Preschool Language Scale 4th Edition and at 48 months using Clinical Evaluation of Language Fundamentals—Preschool 2nd Edition. Internalizing and externalizing behaviours were measured by parent report at each age. Longitudinal data were analysed using repeated-measures regression, with up to three observations per child. Robust standard errors were used to account for non-independence of measures within participants. The shape of the associations were examined by fitting quadratic and cubic terms. The effects of confounders on the associations were examined.

Outcomes & Results: Receptive language had a negative linear association with internalizing behaviours after adjusting for confounders ($\beta = -0.16$, 95% [CI = $-0.26, -0.07$], $p = .001$); and a negative curved association with externalizing behaviours after adjusting for biological confounders ($\beta_{\text{quadratic}} = 0.08$ [0.01, 0.15], $p = .03$, $\beta_{\text{cubic}} = -0.04$ [$-0.07, -0.02$], $p = .001$), attenuating after adjusting for environmental confounders ($\beta_{\text{quadratic}} = 0.06$ [$-0.01, 0.13$], $p = .09$, $\beta_{\text{cubic}} = -0.03$ [$-0.06, -0.003$], $p = .03$). The curvature suggests that the negative association with externalizing behaviours only existed for children with either very low or very high receptive language scores. After controlling for confounders, there was no evidence that expressive language scores were associated with internalizing ($\beta = -0.08$, 95% [CI = $-0.17, 0.01$], $p = .10$) or externalizing behaviours ($\beta = 0.03$, 95% [CI = $-0.09, 0.18$], $p = .61$). Tests of interaction revealed no evidence of a differential association by age.

Conclusions & Implications: In 24–48-month-old slow-to-talk children, lower receptive language scores were associated with higher internalizing behaviours. The magnitude of the association was small. For children with very poor receptive language scores, lower receptive

language skills were associated with higher externalizing behaviours. Young children with low receptive language abilities may be at risk of internalizing difficulties; those with very low receptive language skills may be at particular risk of externalizing difficulties. This has clinical implications for interventions for young children with receptive language difficulties.

Keywords: language, externalizing behaviour, internalizing behaviour

<A>What this paper adds

What is already known on the subject

Language and SEB difficulties are associated in childhood. When the association emerges, whether it differs by language domain or SEB profile, and whether it exists across the language–skills distribution or only at the extremes is unclear.

What this paper adds to existing knowledge

The association between language and SEB difficulties emerges from 24 months, is stable to 48 months and differs by profiles. Receptive, not expressive, language skills are independently associated with SEB adjustment. Whilst receptive language is negatively associated with internalizing behaviours across its whole distribution of abilities, only receptive language skills at the extremes are associated with externalizing behaviours: very poor receptive language skills may be a risk factor for externalizing difficulties, while very good skills may be protective.

What are the potential or actual clinical implications of this work?

Clinicians need to be aware that children with low receptive language skills between 2 and 4 years of age and a history of being slow to talk may be at risk of SEB difficulties from as young as 2 years. Those with the lowest language skills are of greatest concern for being at risk of externalizing difficulties and should be monitored for externalizing difficulties. However, low language skills should be considered in the context of other biological and environmental risk factors.

<A>Introduction

Language and social, emotional and behavioural (SEB) difficulties affect approximately one in five children (Bayer *et al.* 2012, Reilly *et al.* 2010), restricting their long-term prospects across academic, employment and interpersonal domains. Language and SEB difficulties have high levels of co-morbidity in samples of clinically referred children (e.g., St Clair *et al.* 2011). Clinical studies, however, are not ideal to quantify the language–behaviour association in the community: they typically commence after a child has been diagnosed with the difficulty, may over-represent participants with severe impairment and subsequently may inflate co-morbidity estimates (Plomin *et al.* 2002). Prospective population-based studies that commence in infancy or early childhood have the advantage of starting before difficulties emerge, contain the full spectrum of language difficulties from mild to severe, and often collect concurrent information on co-morbidities and confounders (e.g., Whitehouse *et al.* 2011, Zubrick *et al.* 2007).

There is some evidence that the association between language and SEB difficulties does exist in population samples, evident at school entry and persisting until at least age 11 years (Yew and O’Kearney 2015a). However, the nature of the association, when it emerges, if it holds across the distribution of language and SEB adjustment scores or only at the extremes, and whether it differs by language and SEB adjustment profiles remains unclear. This is critical information if preventative interventions are to be appropriately targeted in terms of content, timing and identification of children at risk.

A number of hypotheses attempt to explain the nature of the association between language and behaviour. For example, language and SEB difficulties may co-occur due to common biological (e.g., low birth weight) or environmental risks (e.g., low socio-economic status) that create broad developmental vulnerabilities. Alternatively, because language is a social behaviour, language difficulties may impede positive interactions and lead to withdrawal, frustration or aggression (Cole *et al.* 2010). Alternatively, behaviour difficulties may interfere with language development (Carpenter and Drabick 2011) by limiting the frequency and quality of interactions, decreasing exposure to rich linguistic input. Finally, the association may be indirect: poor early language development leads to poor academic achievement, which may lead to disengagement with school and subsequent development of

social and mental health problems (Beitchman *et al.* 1996). These hypotheses are not necessarily mutually exclusive, and may differ depending on the language domain or SEB profile. It has been difficult to test these hypotheses within studies to date due to different sample ages, different components of language and SEB adjustment measured, and different confounders examined. Understanding the nature of the association will be helpful for clinicians, parents and teachers in their attempts to help those children effected by both language and SEB difficulties reach their potential.

Regarding when the association between language and SEB difficulties begins, population-based studies that commence early in life offer the best opportunity to detect emerging relations. The age at which language is first measured and analysed in existing population-based studies varies from infancy to primary-school age. The age at which SEB adjustment is measured also varies, with some studies measuring it concurrently with language skills (Rescorla and Achenbach 2002, Zubrick *et al.* 2007), others measuring it longitudinally (Clegg *et al.* 2015), with a smaller number doing both (Bretherton *et al.* 2014, Whitehouse *et al.* 2011). Whilst some studies report no or limited evidence for an association between language and behaviour (Rescorla and Achenbach 2002, Zubrick *et al.* 2007), many others report a cross-sectional (Bretherton *et al.* 2014, Whitehouse *et al.* 2011) or longitudinal association (Silva *et al.* 1987, Clegg *et al.* 2015). A more precise estimate of the age at which the association emerges, and whether it persists longitudinally, would facilitate the timing of intervention strategies.

Most population-based studies, with a few exceptions (e.g., Clegg *et al.* 2015, Plomin *et al.* 2002), have defined language or behaviour, or both, as categorical rather than dimensional (e.g., Whitehouse *et al.* 2011). This has clinical implications because it reduces our ability to determine whether the association holds across the whole distribution of abilities or whether it exists only at the extremes. This knowledge would support the identification of empirically derived cut-points for defining children ‘at risk’ or in contrast, suggest that a gradient model of risk be adopted, whereby decreasing scores are associated with increasing difficulties.

‘Low’ and ‘typical’ language groups have historically been defined at baseline based on scores from one measure, often expressive vocabulary (e.g., Zubrick *et al.* 2007). SEB

scores or the proportion of participants scoring within the clinical range for SEB difficulties are then typically compared between groups. When groups are predefined in this way, the potential for monitoring associations is reduced. Firstly, grouping based on a single language domain may not accurately represent abilities in other domains. Secondly, since early language skills develop rapidly and fluctuate (Ukoumunne *et al.* 2012), between-group analysis may conceal heterogeneity in skills within the groups over time, reducing the likelihood of identifying emerging associations.

Finally, in order to target interventions appropriately, clinicians need to know which components of language are associated with which aspects of SEB adjustment. A crucial gap in the literature concerns receptive language which may be a stronger predictor of later language skills than expressive language (e.g., Watt *et al.* 2006). Receptive language delays are a clinical indicator for referral (Reilly *et al.* 2015), and may be indicative of broader underlying cognitive difficulties likely to be related to SEB adjustment (Toppelberg and Shapiro 2000). Recent population-study findings support this (Bretherton *et al.* 2014, Clegg *et al.* 2015, Girard *et al.* 2016), but differences in sample ages, design (cross-sectional or longitudinal), language and SEB measures, and how language is conceptualized (categorical versus dimensional) limit conclusions for clinical guidelines being drawn.

Similarly, there is a lack of information about whether internalizing and externalizing behaviours are differentially associated with language. Evidence suggests early internalizing and externalizing behaviour development follow different pathways (Bayer *et al.* 2012). Feasibly, different aspects of language and SEB adjustment may be associated (Beitchman *et al.* 1996), and these associations may change throughout development (St Clair *et al.* 2011). This is difficult to establish since studies differ in how they measure SEB adjustment. Some use summary scores (e.g., Clegg *et al.* 2015), whilst others measure specific behaviours such as conduct problems (e.g., Girard *et al.* 2016).

To address these issues, population-based studies that measure both early receptive and expressive language abilities alongside SEB adjustment at multiple times are needed. This will strengthen the evidence from which to derive clinical recommendations for children with language difficulties.

Aims

This study examines to what extent language skills and SEB adjustment are associated in a population-based prospective study of slow-to-talk toddlers. Specifically, we aim to examine:

1. (a) whether receptive and expressive language and internalizing and externalizing behaviours are associated at 24, 36 and 48 months, and (b) the form of these associations (i.e., linear versus non-linear);
2. whether these associations vary across the different ages; and
3. whether the associations may be explained by biological or environmental confounders.

<A>**Methods**

Study context

[AQ1] Study Name (removed for review) is a cluster randomized-controlled trial (NHMRC #xxxxxx) within a population-based language survey (removed for review, 2011). As there were no outcome differences between intervention and comparison groups, participants are analysed here as a single cohort. Parents of 12-month-olds attending their well-child check-up in three of Melbourne's local government areas were invited to participate. A total of 1217 completed the baseline questionnaire. Exclusion criteria included: known developmental delay, major medical condition, suspected autism spectrum disorder and parents with insufficient English to complete written questionnaires. At 18 months, 93.5% ($n = 1138$) completed a low-expressive vocabulary screen. Children scoring ≤ 20 th percentile based on population norms for the screen (Roy *et al.* 2005) ($n = 301$, 26.4%) were eligible for the trial. At 48 months, participants were recruited into a subsequent trial, [AQ2] Study Name (removed for review) (NHMRC #xxxxxx) (removed for review, 2015). Ethical approval was from the Royal Children's Hospital Human Research Ethics Committee (#xxxxx). A total of 202 families gave informed consent to this study. Four children subsequently diagnosed with autism at 3–4 years were excluded from analysis. The magnitude of language-behaviour associations found in previous population-based studies is small. This sample offers a greater

opportunity to detect an association in children who might be at the lower end of a language ability ‘spectrum’ (Roos and Weismer 2008), and hence be at greater risk of SEB difficulties.

Measures

Primary language measures were standardized continuous receptive and expressive language scores (mean = 100, SD = 15) from face-to-face home assessments using Preschool Language Scale (PLS-4) (Zimmerman *et al.* 2002) at 24 and 36 months, and Clinical Evaluation of Language Fundamentals Preschool Edition (CELF-P2) (Semel *et al.* 2006) at 48 months. Primary SEB adjustment measures were continuous internalizing and externalizing behaviour raw scores from parent-completed measures: Child Behaviour Checklist/1.5–5 (CBCL) at 24 and 36 months (Achenbach and Rescorla 2000) and Strengths and Difficulties Questionnaire 2–4 years (SDQ) (Goodman 2001) at 48 months. The change in measures occurred when participants joined the subsequent trial, [AQ3] Study Name, when they were 48 months old, primarily to harmonize measures between studies. A second study joining Study Name, New Study Name (ref removed for review), was using the SDQ as its outcome measure at age 48 months. Hence, the decision was made for Study Name to also use the SDQ at 48 months and at subsequent data collection points as part of Study Name.

The CBCL comprises 99 statements which the parent rates on a three-point scale. Summed ratings yield an internalizing behaviour score (possible range = 0–72) and externalizing behaviour score (possible range = 0–48). CBCL raw scores were used rather than *T*-scores because the wide age range of the norming sample (1–5 years) might reduce sensitivity to variation in yearly age bands (Bayer *et al.* 2008).

The SDQ comprises 25 statements which the parent rates on a three-point scale, yielding scores on four problem domains: hyperactivity/inattention, conduct problems, peer problems, and emotional symptoms. The hyperactivity/inattention and conduct problem subscales are summed to give an externalizing behaviour score (possible range 0–20), and the peer problems and emotional symptoms subscales are summed to give an internalizing behaviour score (possible range 0–20). Higher scores indicate more problem behaviours. Unlike the CBCL, there are no *T*-scores for the SDQ. Rather, parent ratings are summed across items to yield domain and summary scores. The summary scores for internalizing and

externalizing behaviours were used in this analyses, modelled as continuous variables. For detailed scoring information, see <http://www.sdqinfo.com>.

Ideally the CBCL would have been used at 48 months because of the larger number of items per composite scale compared with the SDQ. However, because of the harmonization previously mentioned, the SDQ was used. A collateral benefit of this was the shorter length of the SDQ may have reduced the burden on families participating in this longitudinal study which comprised a large battery of measures. Both CBCL and SDQ yield an internalizing and externalizing summary score which are used in the analyses here.

Biological and environmental covariates were collected in the baseline questionnaire, identified a priori as potential confounders of language and/or SEB difficulties based on theoretical argument (e.g., Morgan *et al.* 2015) and previous findings (Clegg *et al.* 2015, Zubrick *et al.* 2007). Biological covariates were: gender, gestational age, birth weight (proxy measure of biological risk) and birth order (first or later born); environmental covariates were: parental education, maternal age at child's birth, household employment (at least one parent employed), non-English-speaking background (NESB), and socio-economic status measured by the Socioeconomic Indices for Area (SEIFA) disadvantage score (Australian Bureau of Statistics (ABS) 2001).

Analyses

To describe the prevalence of language difficulties, low and typical receptive and expressive language groups at 24, 36 and 48 months were defined using the cut-off ≥ 1.25 standard deviations (SD) below the mean for standard scores (Reilly *et al.* 2010). The SDQ borderline cut-point norms were applied to hyperactivity/inattention (6–10), conduct problems (3–10), emotional symptoms (4–10) and peer problems (3–10) subscales.

We applied regression models to explore whether language and SEB scores were associated between 24 and 48 months (aim 1a). As noted above, various theories explain the language–behaviour association. In order to fit regression models, it was necessary to specify an explanatory and an outcome variable. Given our sample was defined by language skill, we defined language scores as the explanatory variables. However, we acknowledge that the

associations described do not imply a directionality whereby language is determining SEB adjustment or vice versa.

Language and SEB scores were examined as continuous variables, standardized to z -scores (mean = 0, SD = 1) to facilitate comparability. Regression coefficients therefore represent effect sizes, Cohen's d , reflecting the standardized difference between two means (Cohen 1992). Longitudinal data were analysed using repeated-measures regression, with up to three repeated observations per participant (one per wave) (Vittinghoff *et al.* 2011). This reduced the number of statistical comparisons and increased the precision of estimates compared with those that would be attained by analysing the data at each wave. We accounted for the within-participant clustering, and subsequent non-independence of the repeated measures within participants, by using robust standard errors. Receptive language and expressive language scores were analysed separately from each other to avoid the collinearity that would be introduced by including them together in a model.

There were a small number of internalizing behaviour values which were high ($n = 3$) and indicative of children experiencing a high level of difficulties, as would be expected within a community sample of children. However, to check that these values were not unduly influencing the associations, the analyses were conducted with and without these cases. When the cases were excluded from the analyses, the magnitude of the association between receptive language and internalizing behaviour scores was largely unchanged (all cases: $\beta = -0.19$ [-0.31, -0.08], $p < .001$; high values excluded: $\beta = -0.15$ [-0.23, -0.06], $p = .001$), as was the association between expressive language and internalizing behaviour scores (all cases: $\beta = -0.11$ [-0.22, -0.01], $p = .034$; high values excluded: $\beta = -0.08$ [-0.17, 0.001], $p = .053$). We concluded that the associations between internalizing difficulties and language abilities were not driven by the small number of extreme values.

To explore the form (shape) of the associations (aim 1b), a range of models were fitted to the data. This was to determine whether the associations uniformly existed across the full range of language scores (in which case evidence of linear effects would be found), or differentially at the extremes (in which case evidence of curvature would be found). First we examined evidence for linear effects of language, such that a one unit higher language score would be associated with an estimated mean change in SEB score of uniform magnitude

across the full range of language scores. Regression models in which language scores were fitted as continuous (assuming a linear effect) were compared with ones where language scores were included as categorical (assuming a non-linear effect) using Wald tests. Non-statistically significant differences between the models were interpreted as there being no evidence supporting a non-linear effect of language on SEB adjustment. Next we examined evidence for specific non-linear effects of language, by fitting quadratic and cubic terms to the regression models alongside the linear term. Statistically significant associations were accepted as evidence for the relevant form of the association (i.e., linear, quadratic or cubic).

To investigate whether the associations between language and SEB adjustment scores varied between 24 and 48 months (aim 2), tests of interaction were conducted. An indicator variable for wave of data collection (1 = 24 months, 2 = 36 months, 3 = 48 months) multiplied by the language explanatory variable was entered to specify the interaction terms. Wald tests compared the regression models containing the interaction terms to models without these terms. Non-statistically significant differences between the models were interpreted as there being no evidence for differences in the associations by wave.

Regarding aim 3, confounders were grouped into biological and environmental exposures. The biological group was added to the best fitting models identified in aim 1, followed by the environmental group to determine whether the associations existed independently of these exposures. A change in beta coefficient, confidence interval, and R^2 was interpreted as evidence of some of the variation in SEB adjustment being explained by the confounders.

Given the multiple comparisons considered, all models were interpreted with caution and by looking for consistent patterns. Analyses were conducted with Stata 13.0 (StataCorp LP, 2013).

<A>Results

Participant characteristics

Sample demographics are presented in table 1. The mean SEIFA score (mean = 1026) indicates the sample was marginally more advantaged than the average Australian population (mean = 1000).

<tab 1>

Language and SEB adjustment scores are presented in table 2. At 24 months, 14.7% and 32.8% had low expressive and receptive language respectively, compared with 8.9% and 12.5% at 36 months and 14.4% and 17.4% at 48 months. Histograms revealed that although the sample was selected as being slow to talk at 18 months, by 36 and 48 months the spread of language scores included a diversity of abilities expected in a typical population sample, where the mean is 100, SD = 15 (figure 1).

<fig 1>

It was not possible to determine the number of participants at 24 and 36 months scoring within the borderline/clinical range for SEB difficulties due to the lack of age-specific cut-points in the CBCL. However, the mean internalizing (normal range = 0–72; 24 months mean = 5.4, SD = 4.6; 36 months mean = 6.3, SD = 4.9) and externalizing scores (normal range = 0–48; 24 months mean = 12.2, SD = 7.6; 36 months mean = 11.1, SD = 7.3) were at the lower end of the possible range, indicating very few problem behaviours. It was also not possible to determine the number of participants scoring above the cut-points for internalizing and externalizing problems at 48 months old because those cut points were not available for the SDQ (2–4). However, to provide descriptive data regarding the nature of SEB functioning in the sample for the reader, we applied the cut-offs for the SDQ domains at 48 months: 13.0% and 24.6% scored within the borderline/clinical range for hyperactivity/inattention and conduct problems respectively, and 23.7% and 17.2% scored within the borderline/clinical range for emotional symptoms and peer problems. The mean scores for three domains were within the normal range = emotional symptoms (normal range = 0–3; mean = 1.6, SD = 1.6), hyperactivity/inattention (normal range = 0–5; mean = 3.2, SD = 2.2), peer problems (normal range = 0–2; mean = 1.2, SD = 1.4). The mean score for conduct problems was slightly elevated (normal range = 0–2; mean = 2.3, SD = 1.8).

<tab 2>

Correlations amongst language and SEB measures are presented in table 3. Receptive language measures were positively correlated over time ($r = .59-.71$) as were expressive language measures ($r = .40-.75$). Cross-time correlations between internalizing behaviour measures ($r = .27-.68$) and externalizing behaviours ($r = .42-.70$) were also positively

correlated. Receptive and expressive language measures were correlated ($r = .40-.62$), supporting our decision to separate our analyses of receptive and expressive language.

<tab 3>

Associations between language domains and SEB adjustment

Aim 1 examined whether receptive and expressive language and internalizing and externalizing behaviours were associated. In the unadjusted models there was evidence that higher language scores, meaning better skills, were associated with lower SEB adjustment scores, meaning better SEB adjustment with the exception of expressive language skills and externalizing behaviour scores (table 4, model 1). For example, for each SD higher expressive language score, there was an estimated 0.11 SDs lower internalizing behaviour score; this means better expressive language skills were associated with lower internalizing problems (mean difference, $\beta = -0.11$, 95% CI $[-0.22, -0.01]$, $p = .03$). A similar finding occurred between receptive language and internalizing behaviours ($\beta = -0.19$ $[-0.31, -0.08]$, $p = .001$), and between receptive language and externalizing behaviours ($\beta_{\text{quadratic}} = 0.07$ $[0.002, 0.14]$, $p = .04$, $\beta_{\text{cubic}} = -0.04$ $[-0.07, -0.02]$, $p = .002$). No evidence was found for an association between expressive language and externalizing behaviour ($\beta = -0.02$ $[-0.14, 0.10]$, $p = .74$).

Shape of the associations between language domains and SEB adjustment

Regarding the form of the associations (aim 1b), Wald tests revealed no evidence of non-linearity when language scores were modelled as categorical in addition to the continuous linear term for any of the associations (e.g., receptive language: internalizing behaviours, $F(3, 199) = 0.07$, $p = .98$, and externalizing behaviours, $F(3, 199) = 1.75$, $p = .16$). However, examination of the shape of the associations through fitting cubic and quadratic terms of the language variables in addition to the linear term revealed more nuanced findings. Figure 2 illustrates the form and strength of the best fitting model of each combination of the language-behaviour associations.

The model of receptive language and externalizing behaviours supported the use of both a quadratic ($\beta_{\text{linear}} = -0.13$ $[-0.24, -0.02]$, $p = .02$, $\beta_{\text{quadratic}} = 0.09$ $[0.01, 0.17]$, $p = .03$, R^2

= .035) and a cubic term ($\beta_{\text{linear}} = -0.01 [-0.16, 0.14]$, $p = .90$, $\beta_{\text{cubic}} = -0.05 [-0.09, -0.01]$, $p = .02$, $R^2 = .033$) (see supplementary table 4). The final best-fitting (unadjusted) model supported the quadratic and cubic terms together ($\beta_{\text{quadratic}} = 0.07 [0.002, 0.14]$, $p = .04$, $\beta_{\text{cubic}} = -0.04 [-0.07, -0.02]$, $p = .002$, $R^2 = .042$). The linear term did not contribute independently to this model. Figure 2 illustrates the reverse ‘S’ shape of this association, showing evidence that the strength of the association between receptive language and externalizing behaviours varied across receptive language ability. After adjusting for biological confounders this association remained evident ($\beta_{\text{quadratic}} = 0.08 [0.01, 0.15]$, $p = .03$, $\beta_{\text{cubic}} = -0.04 [-0.07, -0.02]$, $p = .001$), whilst controlling for environmental confounders lead to an attenuation of the quadratic term ($\beta_{\text{quadratic}} = 0.06 [-0.01, 0.13]$, $p = .09$, $\beta_{\text{cubic}} = -0.03 [-0.06, -0.003]$, $p = .03$) (table 4, models 2 and 3).

There was no evidence that quadratic or cubic terms were supported by the regression models for the other associations. See supplementary tables 1–4 for details of all forms tested.

<fig 2>

Variability in the language and SEB associations by child age

There was no evidence that the associations between language and SEB adjustment varied across the age range 24–48 months (aim 2), evidenced by the statistically non-significant terms for interaction by age that were found for both internalizing and externalizing behaviours, with receptive and expressive language (see supplementary table 5). This supports the presentation of constant estimates of associations across the ages 24, 36 and 48 months. For example, there was no significant difference between the associations estimated for mean internalizing behaviours and receptive language at wave 3 compared with those at wave 2, or for those at wave 4 compared with those at wave 2 ($F(2, 199) = 0.19$, $p = .83$).

Contribution of biological and environmental exposures to the associations

Our third aim examined whether the associations between language and SEB adjustment may be explained by biological or environmental confounders (table 4, models 2 and 3).

Regarding expressive language and internalizing behaviours, the addition of biological exposures to the model (child age, sex, gestation, birth weight, birth order)

increased the variance explained from 1.2% to 6.4%, whilst leaving the beta-coefficient confidence intervals largely unchanged ($\beta_{\text{unadjusted}} = -0.11 [-0.22, -0.01]$, $p = .03$, $R^2 = 1.2$; $\beta_{\text{model2}} = -0.12 [-0.22, -0.02]$, $p = .02$, $R^2 = 6.4$). Addition of the environmental exposures (treatment group, SEIFA, NESB, parental education, maternal age, parental employment) resulted in the variance explained increasing to 9.2%, and the evidence for the contribution of language scores to the model diminishing ($\beta_{\text{model3}} = -0.08 [-0.17, 0.01]$, $p = .10$, $R^2 = 9.2$). This suggests that once environmental confounders were added, expressive language explained little variation in internalizing behaviour scores.

In contrast, evidence of the association between receptive language and internalizing behaviours remained even after biological ($\beta_{\text{model2}} = -0.21 [-0.33, -0.10]$, $p < .001$, $R^2 = 9.0$) and environmental exposures ($\beta_{\text{model3}} = -0.16 [-0.26, -0.07]$, $p = .001$, $R^2 = 11.0$) were included in the models. The variance explained in internalizing behaviour scores increased from 3.6% in the unadjusted model, to 9.0% in model 2, and 11.0% in model 3.

Finally, evidence for the association between receptive language and externalizing behaviours remained after controlling for biological exposures ($\beta_{\text{model2_quadratic}} = 0.08 [-0.01, 0.13]$, $p = .03$, $\beta_{\text{model2_cubic}} = -0.04 [-0.07, -0.02]$, $p = .001$, $R^2 = 5.7$). The associations attenuated slightly after the environmental exposures were also included, although the cubic term remained statistically significant ($\beta_{\text{model3_quadratic}} = 0.06 [-0.01, 0.13]$, $p = .09$, $\beta_{\text{model3_cubic}} = -0.03 [-0.06, -0.003]$, $p = .03$, $R^2 = 8.8$). The variance in externalizing behaviour scores explained by receptive language scores was 4.2%, increasing to 5.7% in model 2, and 8.8% in model 3.

<A>Discussion

This paper describes the range of associations between early receptive and expressive language and internalizing and externalizing behaviours in a prospective population-based sample of slow-to-talk children. Children's receptive language abilities across the distribution were negatively associated with their internalizing behaviour scores, meaning poorer receptive language skills were associated with poorer internalizing behaviours. On the contrary, receptive language and externalizing behaviours were negatively associated only in children with either very good or very poor receptive language scores. However, consistent

with previous reports in this area, a very modest amount of variability in internalizing and externalizing difficulties could be attributed to variability in young children's receptive language abilities. There was no evidence that children's expressive skills were related to their externalizing behaviours, nor to internalizing behaviours once biological and environmental confounders were considered (aim 1). These patterns were evident from 24 months, and were stable up to 48 months (aim 2).

Our findings suggest that receptive language skills may be integral to the emerging language-behaviour association in the early years in slow-to-talk children. The curved association with externalizing behaviours is interesting and, to our knowledge, this is the first study to report the non-linear nature of the association at this age. A negative association with externalizing behaviour only existed for children with either very low or very high receptive language scores. Compared with children with mid-range receptive language skills for whom there was little evidence of an association with externalizing behaviours, children with the poorest receptive language skills experienced the poorest externalizing behaviours and children with the highest receptive language skills seemed to be protected from externalizing difficulties.

Very good receptive language skills may protect a child from experiencing the frustration, isolation and confusion related to misunderstanding interactions, whereas very poor receptive language skills may place the child at risk of these experiences. Children with mid-range comprehension may display age-appropriate externalizing behaviours. On the graph there appears to be an inflection around 1.5 SDs below the mean. We postulate this might approximate to a 'comprehension threshold' below which interactions are increasingly problematic for children, leading to problems understanding and predicting their world and triggering externalizing behaviours. Alternatively, children scoring below this threshold may be unable to use language for 'self-talk' or to be verbally scaffolded by their parents to regulate their behaviour (Vallotton and Ayoub 2011). A final interpretation is that assessing receptive language skills in very young children is difficult, and those with externalizing behaviour problems may be particularly challenging to assess. Hence it is not possible to rule out the possibility that the low receptive language scores may reflect measurement difficulty rather than poor receptive language skills per se. The linear association with internalizing

difficulties warrants a different interpretation. There may be no comprehension threshold below which internalizing problems become apparent. Instead, there is a steady worsening of internalizing behaviours as receptive language skills decline.

It is important to note that only a small amount of variability in SEB scores was explained by the participants' receptive language abilities in our regression models. An issue we did not consider but which warrants investigation is whether the associations represent a direct contribution of receptive language difficulties to the development of SEB difficulties, or whether, as some have recently speculated (Conti-Ramsden and Durkin 2015, Yew and O'Kearney 2015b), they represent an indirect contribution. Yew and O'Kearney (2015b) have argued that language difficulties interact with the predictors of SEB difficulties during development, intensifying the influence of certain risk factors (e.g., hostile parenting, low SES) and neutralizing the influence of some protective factors (e.g., child sociability). In this way, language difficulties might *indirectly* contribute to the development of SEB difficulties. This hypothesis may help explain the small amount of variability in SEB outcomes in the current study. The socially and educationally advantaged nature of our sample means that more vulnerable families were under-represented. The absence of vulnerable families, and risk factors associated with SEB difficulties (e.g., low SES, hostile parenting), may have restricted our ability to observe indirect contributions of language difficulties to SEB difficulties. It is equally feasible that the advantaged sample benefited from protective factors that offset the risk posed by language difficulties.

In seeking to understand the nature of the language-behaviour association, we investigated the associations with and without inclusion of biological and environmental confounders to determine whether they might be explained by common risk factors or whether they exist independently (aim 3). Receptive and expressive language skills explained a small amount of variation in SEB scores in the unadjusted models (between 1.2% and 4.2%). They continued to make a unique contribution after controlling for biological confounders (i.e., gender, birth weight, parity). However, once environmental confounders (e.g., SEIFA, parental education and employment) were controlled for, there was no longer evidence that *expressive* language independently predicted internalizing behaviours. This suggests the association was explained by environmental factors that present a risk for both

poor expressive language and poor internalizing behaviours. Children with a history of being slow to talk who present clinically with low expressive language between 24 and 48 months may be at risk of internalizing difficulties only in the presence of environmental risks. Future research examining whether expressive language difficulties may interact with these biological and environmental risk factors to contribute to the development of SEB difficulties is necessary.

In contrast, receptive language contributed to internalizing and externalizing behaviours independent of environmental factors, suggesting a more direct association than is the case for expressive language. Nevertheless, the small amount of variation explained supports conclusions from other studies suggesting that a range of biological and environmental factors contribute to SEB difficulties beyond poor language skills (Clegg *et al.* 2015, Morgan *et al.* 2015). It may be more appropriate to consider poor language skills at 24–48 months as one of many factors which increase the risk of SEB difficulties, rather than a standalone risk. The possibility that there are complex interactions between language difficulties and risk and protective factors for SEB difficulties is a particularly promising area for future research (Conti-Ramsden and Durkin 2015, Yew and O’Kearney 2015b). From a clinical perspective this supports the importance of taking histories that capture a range of biological (e.g., birth weight, parity) and environmental risk and protective factors (e.g., maternal age at birth, parental education and employment).

The different patterns between receptive and expressive language scores and internalizing and externalizing behaviour scores suggest there may be multiple pathways to the associations between language and behaviour. It also highlights the importance of investigating different components of language and behaviour, as they are differentially associated, as previous researchers have hypothesized (e.g., Beitchman *et al.* 1996, Tomblin *et al.* 2000). An association between receptive language and behaviour was apparent from 24 months old, much earlier than the school-age association which some have hypothesized is mediated through poor academic achievement (Beitchman *et al.* 1996). Future research should examine whether emerging literacy changes this association. The early association between expressive language and internalizing difficulties identified in the unadjusted but not adjusted model may exist at this age by virtue of common environmental risks. Perhaps low

expressive language becomes increasingly problematic as children's environments broaden to include meaningful interactions outside the family. Children's difficulties expressing themselves to peers and teachers may lead to greater frustration, anger and aggression. Or, the association may be more intricate than this, with language difficulties contributing indirectly to SEB difficulties by modifying the effect of risk or protective factors on the development of internalizing or externalizing behaviour problems. So, whilst we found a stable pattern of associations between 24 and 48 months, the associations may change after starting school, and follow different trajectories. Future research should follow pre-schoolers into their school years to investigate these trajectories, and consider both direct and indirect contributions of language difficulties to SEB difficulties.

This study is not without limitations. The sample only comprised children who were slow to talk, defined by their expressive vocabulary scores at 18 months of age. This means that children who scored above the expressive vocabulary cut-point but who may have had other language difficulties, for example, with receptive language, or who developed language difficulties later, and those who had expressive vocabulary skills within normal limits were not included. It would be valuable to compare our findings to those from a sample of children from a typical population not screened for delayed expressive vocabulary. This would also enable examination of the language profiles of children who did not meet the 18 months low expressive vocabulary criteria. Potentially the associations we found in our sample that was representative of 24-month-olds who were slow to talk at 18 months may be different in a sample of 24-month-olds representative of all language abilities at 18 months. For example, the association between receptive language and SEB adjustment might be greater than we found since children who had receptive but not expressive difficulties at 18 months were not included in our sample. Furthermore, the associations may differ in children with later emerging language difficulties.

However, it is reassuring that only 17.4% and 14.4% of our slow-to-talk sample had low receptive and expressive language respectively at 48 months, similar to the proportion of 48-month-old children in the general population with low language (Reilly *et al.* 2010). This resolution of early difficulties also echoes a previous study that found nearly 70% of children categorized as 'late talkers' at 24 months had typical language skills by 48 months (Reilly *et*

al. 2010). The spread of our sample's language scores at follow-up suggests the 18-month delays had levelled out, and by 48 months included a diversity that allowed analysis across the entire distribution of abilities expected in a general population of pre-schoolers. Categorizing children based on delayed language emergence in the absence of other developmental delays may well be arbitrary. Likewise, the proportion of children meeting borderline/clinical levels on the SDQ subscales at 48 months were similar to what would be expected in a general population (i.e., 80% within normal limits, 10% borderline, 10% clinical).

An additional sample limitation is that families with low SES, who reportedly have a higher incidence of language and SEB difficulties (Kiernan and Mensah 2009), were under-represented. This means our findings might underestimate the figures that would be seen in a sample that fully represents families experiencing socio-economic disadvantage.

A further limitation is that we did not control for non-verbal IQ in our analyses. Non-verbal IQ has been shown to be associated with SEB difficulties (e.g., Bretherton *et al.* 2014) and language development (e.g., Botting 2005). Non-verbal IQ was only measured during the 48-month-old assessment, using the matrices subtest of the Kaufman Brief Intelligence Test (Kaufman and Kaufman 2004). Participants' mean score was 103.2 (SD = 13.0). However, we did not include the 48-month-old KBIT scores in our long-form analyses because we felt it was not appropriate to infer that these scores reflected the participants' non-verbal abilities at 24 and 36 months.

However, we were able to examine whether their 48-month-old non-verbal IQ scores contributed to the cross-sectional associations between receptive language and SEB scores. Adjusting for non-verbal IQ made almost no difference to the association between receptive language and externalizing behaviour scores ($\beta_{\text{unadjusted}} = -0.48 [-0.98, 0.01]$, $p = .053$; compared with $\beta_{\text{adjusted}} = -0.52 [-1.05, -0.16]$, $p = .057$). It did however attenuate the findings between receptive language and internalizing behaviours ($\beta_{\text{unadjusted}} = -0.40 [-0.76, -0.05]$, $p = .027$; $\beta_{\text{adjusted}} = -0.27 [-0.67, 0.10]$, $p = .142$). This indicates that at 48 months old, non-verbal abilities may contribute to internalizing behaviour problems over and above the contribution made by receptive language skills. Whilst it is not possible to generalize these findings to the earlier ages, they do highlight the need for future research to investigate the

role played by non-verbal IQ in the emergence of the association between language and SEB difficulties.

At 48 months the language and behaviour measures changed. This was because participants from the original study, [AQ4] Study Name, were invited into a subsequent study when they were 48 months old, Study Name, which used different measures. Whilst the tools purport to measure the same constructs, we acknowledge the potential for non-equivalence. Changing measure is not without precedent in longitudinal studies (e.g., Clegg *et al.* 2015, St Clair *et al.* 2011), particularly when following a cohort from a young age. The cross-time correlations between language measures and between behaviour measures did vary, perhaps as a consequence of instability in the constructs themselves, or due to the equivalence of the measures administered, or perhaps because some problem behaviours, e.g., emotional symptoms, may be more difficult to observe in toddlers than in pre-schoolers.

Despite these limitations, our results provide novel insights into the varied but stable nature of the associations between different language domains and SEB profiles from 24 to 48 months old in children with a history of being slow to talk. The particular language and behaviour profiles measured in studies matter. This is important to guide comparisons of existing studies, to inform the design of future studies, and to inform the clinicians and educators who care for children at risk of these difficulties.

This cohort offers the opportunity to monitor whether the associations change as the participants attend school. Future research must monitor the developmental trajectory of the association between receptive language and SEB adjustment into later childhood and adolescence, as well as monitor whether an independent association between expressive language and SEB adjustment emerges. Furthermore, research should model language as one risk factor among many and examine its direct and indirect contribution to SEB difficulties, to inform clinical referral pathways. In addition, understanding whether the associations differ between children whose language difficulties persist and those whose resolve is important for clinical decisions. Finally, it is important to determine whether our findings can be generalized beyond the slow-to-talk population by using a sample representative of the general population.

<A>Summary and conclusions

Our findings show that young children with very low receptive language scores are at risk of experiencing SEB difficulties, and this risk becomes apparent from as early as 24 months old. Although the direct clinical implications of these findings relate to children whose expressive language was slow to develop at 18 months old, they should be interpreted cautiously in relation to children in general until replication within a sample representative of the general population is possible. The findings are perhaps most critical for children whose receptive language abilities fall below a certain threshold, beyond which the risk of externalizing behaviour difficulties is greatest. For these children it is important that clinicians are aware of the possible need for input from psychologists to address their SEB adjustment.

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<<t/s Set names in caps and scaps as per usual style>>

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Table 1. Sample demographics

	<i>n</i>	<i>n</i> (%) or mean (SD)	
Gender, male	200	104 (52.0)	
First-born child	200	74 (37.0)	
Full-term gestation (≥ 37 weeks)	200	179 (89.5)	
Birth weight (g)	193	3381.5 (616.9)	
SEIFA index score of disadvantage ^a	200	1026.0 (53.9)	
Maternal age at child age 12 months	200	34.3 (4.5)	
NESB 10 h/week at 12 months	200	19 (9.5)	
In intervention arm of the trial	200	102 (51.0)	
At least one parent in paid work	192	190 (99.0)	
Parent education (<i>n</i> = 199): did not complete high school		40 (20.1)	
Completed high school		65 (32.7)	
Completed diploma/tertiary qualification/postgraduate		94 (47.2)	

[AQ13] Note: NESB, non-English-speaking background (child exposed to non-English language more than 10 h/week); SEIFA, Socioeconomic Indices for Area: mean = 1000, SD = 100, higher scores indicate less disadvantage.

Table 2. Child language and SEB adjustment scores

	<i>n</i>	Mean (SD)	Low language, <i>n</i> (%)
Child language scores ^a			
Receptive language: 24 months	198	90.4 (14.0)	65 (32.8)
36 months	193	98.5 (15.1)	24 (12.5)
48 months	196	94.6 (13.9)	34 (17.4)
Expressive language: 24 months	198	91.5 (12.0)	29 (14.7)
36 months	192	100.9 (14.5)	17 (8.9)
48 months	195	97.5 (14.3)	28 (14.4)
<i>SEB adjustment</i>			
Externalizing behaviours: ^b 24 months	191	12.2 (7.6)	
36 months	192	11.1 (7.3)	
48 months	190	5.5 (3.5)	
Internalizing behaviours: ^c 24 months	191	5.4 (4.6)	
36 months	192	6.3 (4.9)	
48 months	192	2.8 (2.5)	
			Borderline <i>n</i> (%) ^d
SDQ subscales:	193	3.2 (2.2)	25 (13.0)
Hyperactivity/Inattention			
Conduct problems	191	2.3 (1.8)	47 (24.6)
Peer problems	192	1.2 (1.4)	33 (17.2)
Emotional symptoms	194	1.6 (1.6)	46 (23.7)

Notes: SEB, social, emotional and behavioural adjustment score; SDQ, = strengths and difficulties questionnaire.

^aPLS-4 at 24–36 months, CELF-P2 at 48 months.

^bCBCL at 24–36 months: externalizing = aggressive behaviours and attention problem; SDQ at 48 months: externalizing = hyperactivity and conduct problems.

^cCBCL internalizing = withdrawn, anxious/depressed, somatic complaints, emotionally reactive subscales; SDQ internalizing = peer problems and emotional symptoms

^dCut-points for normal and borderline/clinical are: hyperactivity–inattention 0–5, 6–10; conduct problems 0–2, 3–10; peer problems 0–2, 3–10; and emotional symptoms 0–3, 4–10.

Table 3. Correlation matrix of language and SEB measures

Measure	1	2	3	4	5	6	7	8	9	10	11
Correlation											
<i>p</i> -value											
1. 24m Receptive											
2. 24m Expressive	.62										
	<.001										
3. 36m Receptive	.67	.51									
	<.001	<.001									
4. 36m Expressive	.62	.55	.79								

	< .001	< .001	< .001								
5. 48m Receptive	.59	.41	.71	.68							
	< .001	< .001	< .001	< .001							
6. 48m Expressive	.50	.40	.66	.75	.74						
	< .001	< .001	< .001	< .001	< .001						
7. 24m Internalizing	-.19	-.10	-.22	-.14	-.17	– .17					
	.01	.17	.003	.06	.02	.02					
8. 24m Externalizing	-.09	.05	-.13	-.01	-.08	– .06	.65				
	.20	.46	.08	.85	.27	.41	< .001				
9. 36m Internalizing	-.11	-.08	-.22	-.13	-.18	– .13	.68	.49			
	.12	.26	.002	.09	.02	.08	< .001	< .001			
10. 36m Externalizing	-.15	-.06	-.20	-.07	-.13	– .04	.45	.70	.56		
	.03	.42	.01	.36	.08	.58	< .001	< .001	< .001		
11. 48m Internalizing	-.13	-.07	-.14	-.13	-.16	– .11	.27	.15	.48	.21	
	.08	.34	.06	.08	.03	.15	< .001	.04	< .001	.004	

12. 48m Externalizing	-.23	-.11	-.26	-.16	-.14	–	.17	.42	.23	.55	.31
	.001	.14	< .001	.03	.06	.46	.02	< .001	.002	< .001	< .001

Note: 1: 24m Receptive language standard score (SS) (PLS-4); 2: 24m Expressive language SS (PLS-4); 3: 36m Receptive language SS (PLS-4); 4: 36m Expressive language SS (PLS-4); 5: 48m Receptive language SS (CELF-P2); 6: 48m Expressive language SS (CELF-P2); 7: 24m Internalizing behaviour score (CBCL); 8: 24m Externalizing behaviour score (CBCL); 9: 36m Internalizing behaviour score (CBCL); 10: 36m Externalizing behaviour score (CBCL); 11: 48m Internalizing behaviour score (SDQ); 12: 48m Externalizing behaviour score (SDQ).

Table 4. Associations between receptive and expressive language and internalizing and externalizing behaviours

Language domain ^a	SEB adjustment ^b	Model 1: Unadjusted				Model 2: Adjusted ^c			Model 3: Adjusted ^d		
		β [95% CI] ^e	<i>p</i>	<i>R</i> ²	Inter- <i>p</i>	β [95% CI]	<i>p</i>	<i>R</i> ²	β [95% CI]	<i>p</i>	<i>R</i> ²
Expressive	Internalizing	–0.11 [–0.22, –0.01]	.03	1.2	.92	–0.12 [–0.22, –0.02]	.02	6.4	–0.08 [–0.17, 0.01]	.10	9.2

Expressive	Externalizing	−0.02 [−0.14, 0.10]	.74	0.00	.26	−0.03 [−0.15, 0.10]	.69	1.3	0.03 [−0.09, 0.18]	.61	7.1
Receptive	Internalizing	−0.19 [−0.31, −0.08]	.001	3.6	.83	−0.21 [−0.33, −0.10]	<.001	9.0	−0.16 [−0.26, −0.07]	.001	11.0
Receptive	Externalizing Quadratic	0.07 [0.002, 0.14]	.04	4.2	.45	0.08 [0.01, 0.15]	.03	5.7	0.06 [−0.01, 0.13]	.09	8.8
	Cubic	−0.04 [−0.07, −0.02]	.002	4.2		−0.04 [−0.07, −0.02]	.001		−0.03 [−0.06, −0.003]	.03	

Notes: CI, confidence interval; SEB, social, emotional and behavioural adjustment score; R^2 = percentage; Inter- p = p -value for the test for interaction by age.

^aPLS-4 at 24–36 months, CELF-P2 at 48 months.

^bCBCL at 24–36 months, SDQ at 48 months.

^cAdjusted for biological exposures: child age, gender, gestation, birth weight, birth order.

^dAdjusted for biological and environmental exposures: child age, sex, gestation, birth weight, birth order, treatment group, SEIFA, NESB, parental education, maternal age, parental employment.

^eInterpret coefficients as effect sizes with the exception of the coefficients for the curved association between receptive language and externalizing behaviour.

Figure 1. Distribution of receptive and expressive language standard scores at 36 and 48 months in a sample of slow-to-talk toddlers, $n = 193$ – 196 . Note: PLS-4 at 24–36 months, CELF-P2 at 48 months; typical population mean for PLS-4 and CELF-P2 is 100, $SD = 15$.

Figure 2. Associations between receptive and expressive language (z -scores) and internalizing and externalizing behaviours (z -scores) between 24 and 48 months in a sample of slow-to-talk toddlers. Note: PLS-4 and CBCL at 24–36 months, CELF-P2 and SDQ at 48 months.

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