Infant Regulation: Associations with Child Language Development in a Longitudinal Cohort.

Fallon Cook^{a,c} PhD
Laura Conway^a PhD
Emina Omerovic^a BSc, MClAud
Petrea Cahir^{a,c} BA(Hons)/BSc; MSpPath
Rebecca Giallo^{a,c} PhD
Harriet Hiscock^{a,b,c} PhD
Fiona Mensah^{a,b,c} PhD
Lesley Bretherton^{a,e} PhD
Edith Bavin^{a,e} PhD
Patricia Eadie^f PhD
Stephanie Brown^{a,c,g}, PhD
Sheena Reilly^{a,c,d} PhD

Affiliations

^aMurdoch Children's Research Institute, Melbourne, Australia

^bRoyal Children's Hospital, Melbourne, Australia

^cDepartment of Paediatrics, University of Melbourne, Melbourne, Australia

^dMenzies Health Institute Queensland, Griffith University, Queensland, Australia.

^eLa Trobe University, Melbourne, Australia

^fMelbourne Graduate School of Education, University of Melbourne, Australia

^gDepartment of General Practice, University of Melbourne, Melbourne, Australia.

Corresponding author: Fallon Cook, Murdoch Children's Research Institute, Royal Children's Hospital, Flemington Road, Parkville, Victoria, Australia, 3052. Tel: (+61) 3 9345 5484; Email: fallon.cook@mcri.edu.au

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Objective: To determine whether infants who have regulatory problems (eg, sleeping, crying, and feeding problems) at one year of age are at increased risk of experiencing language difficulties at ages 5 and 11 years, compared with settled infants.

Study design: Parent survey and child assessment data (n=1131) were drawn from a longitudinal community cohort study. Latent Class Analysis identified 5 profiles of infant regulation including those who were *settled* (37%), had *tantrums* (21%), had *sleep problems* (25%), were *moderately unsettled* (13%) and *severely unsettled* (3%) at 12 months of age. Adjusted regression analyses examined associations between infant regulatory profiles and language ability (Clinical Evaluation of Language Fundamentals – fourth edition; CELF-4) at ages 5 and 11 years.

Results: Infants who were moderately unsettled had lower language scores at age 5 (Adjusted Mean Difference (AMD) -3.89, 95% CI -6.92, -.86) and were more likely to have language difficulties (Adjusted Odds Ratio (AOR) 2.71, 95% CI 1.28, 5.75), than infants who were settled. Infants who were severely unsettled at 12 months of age, had lower language scores at ages 5 (AMD -7.71, 95% CI -13.07, -2.36) and 11 (AMD -6.50, 95% CI -11.60, -1.39), than infants who were settled. Severely unsettled infants were 5 times more likely to have language difficulties at age 5 than their settled counterparts (AOR 5.01, 95% CI 1.72, 14.63).

Conclusion: Children at one year of age with multiple regulatory problems are at an increased risk for poorer language skills at ages 5 and 11 years.

Difficulties with infant sleeping, excessive crying/fussiness, and feeding, collectively referred to as regulatory problems, are common (15-30%), often comorbid (~15%) and result in increased costs to the health care service.(1,2) Infant regulatory problems have been associated with parent fatigue and depression, (3,4) stress in the home environment,(5) and less optimal parent-infant interactions.(6)

Infants with regulatory problems during the first postnatal year, experience increased risk for ongoing dysregulated behaviour,(7) internalising and externalising behaviour problems,(8,9) and a range of mental health difficulties (10) during early to middle childhood. There are likely complex intersecting factors that explain these associations, including early life adversity (household stress, poverty, exposure to family violence), parenting efficacy and parent mental health. Exposure to stress in utero or during infancy may also alter the epigenetic regulation of genes involved in the hypothalamic-pituitary-adrenal (HPA) response to stress (11), increasing risk for dysregulated behaviour.

Excessive infant night waking and infant crying have been associated with reduced maternal emotional availability (12) and less optimal parent-infant interaction.(6) Warm, responsive parent-child interactions that follow the child's lead and interests are associated with a range of desirable child outcomes including enhanced emotional wellbeing, peer relationships and language development.(13–17) A randomised controlled trial found that advice for caregivers to increase 'contingent talk' with their infant (talking about the focus of the infant's attention) improved infant communication at 15 and 18 months of age.(18) Infants with regulatory problems may experience less frequent or optimal parent interactions because more parental resources are dedicated to trying to settle or calm the infant, or because it may be difficult to have rich and stimulating interactions with an infant who is tired, fussing, or crying.(6)

Several factors appear to influence the trajectory of language development including low maternal education, being from a non-English speaking background, low infant birthweight and experiencing greater socio-economic disadvantage.(19,20) Less mature sleep consolidation at 6 to 18-19 months of age, is associated with increased risk for poor language development at ages 3 to 5 years.(21,22) Poor language development is associated with negative long term outcomes, including reduced educational attainment and occupational outcomes, having fewer friends, and poorer ability to respond and adapt to social interactions.(23–27).

If associations exist between infant regulatory problems and language development t, they may identify a group to target for early intervention to prevent poor language development through promoting responsive and reciprocal interactions between parents and infants. In a prospective, longitudinal, community cohort, we aimed to examine the development of language skills at ages 5 and 11 years, in infants with various profiles of regulatory problems at 12 months of age.

Methods

Participants

Data were drawn from the Early Language in Victoria Study (ELVS), a community based cohort study in Victoria, Australia, that aims to examine language development from infancy through to adulthood.(28) Recruitment started in 2003, with invitations to participate offered to all eligible parents of infants attending the 8 month well-child appointment with their Maternal and Child Health Nurse. Parents were excluded from participation if they had insufficient English to complete the written questionnaires (questionnaires did not exceed a grade 6 reading level). Parents of 1910 infants enrolled in the cohort study (82% of those invited). Comprehensive information about the ELVS has been published elsewhere.(28) For

the current study, socioeconomic data were drawn from wave 1 (8-10 months of age, n=1759), infant regulation data were drawn from wave 2 (12 months of age, n=1759), and language assessment data were drawn from waves 6 (5 years of age, n=965), and 10 (11 years of age, n=826). All participants provided written, informed consent and ethical approval was obtained from the Royal Children's Hospital Human Research Ethics Committee (27078/33195) and the La Trobe University Human Ethics Committee (03-32).

Measures

Socio-demographic baseline data were collected at infant age 8-10 months (child age, sex, birth weight, length of gestation (weeks), birth order, admittance to Special Care Nursery (SCN) or Neonatal Intensive Care Unit (NICU), and maternal country of birth, marital status, education and languages spoken). Families were allocated a Socio-Economic Indices for Areas (SEIFA) index of relative disadvantage, based on home postal code (with higher scores indicating less disadvantage) to give a broad indication of disadvantage within the geographical area of each participant's home.(29) When their infant was 12 months old, mothers completed the Kessler-6 (K6), a measure of psychological distress with strong psychometric properties. (30) Scores ≥ 8 indicated the presence of significant psychological distress.

Infant regulation

Mothers completed items relating to their infant's regulation at 12 months of age, including the presence and severity of infant sleep problems, excessive crying, temper tantrums, and mood swings, by scoring each as either 0= none, 1= mild, 2= moderate, or 3= severe.(31) Mothers also rated their infant's temperament: 'Compared to other children, I think my child is: 1= much easier than average, 2= easier than average, 3= average, 4= more difficult than

average, 5= much more difficult than average'.(31) The presence of infant feeding problems was established by collapsing several study designed items into one variable. Parents were asked if their infant coughed/choked or gagged (yes/no) on puree or smooth foods (e.g. yoghurt), mashed foods or solids (e.g. potatoes), or lumpy foods (e.g. peas), and these were scored 1 point each to indicate the number of feeding problems present (0= no feeding problem, 1= 1 feeding problem, 2= 2 feeding problems, 3= 3 feeding problems).

Child language

At both 5 and 11 years, children were administered the Clinical Evaluation of Language Fundamentals fourth edition (CELF 4) (32) by a speech pathologist, psychologist or trained research assistant, either at their school or during a home visit. These time points were chosen because they correspond with the beginning of formal education in Australia (age 5, preparatory year) and the end of the primary school years (age 11, grades 5-6). These ages allow us to consider the potential positive influence language rich environments such as formal schooling, may have on children who began school with poorer language skills. Language development trajectories tend to be less stable at earlier ages.(20,33) Subtests to obtain Core Language composite scores were completed including Concepts and Following Directions, Recalling Sentences, Formulated Sentences (at both ages); Word Structure and Sentence Structure (at 5-years); and Word Classes (at 11-years) and generated standardized scores for core language ability (M=100, SD=15). In accordance with previous epidemiological studies (34,35), participants with a core language score > 1.25 standard deviations below the mean (<81) were considered to have language difficulties. This does not represent a formal diagnosis of developmental language disorder. The CELF 4 has excellent psychometric properties.(36)

Statistical Analyses

Latent Class Analysis was carried out to identify unique profiles of infant regulation at 12 months of age, with all items pertaining to infant sleep, excessive crying, temper tantrums, mood swings, temperament, and feeding problems included as indicators in the model. This procedure and the characteristics of each profile have been described in detail elsewhere.⁽¹⁰⁾ In sum, five profiles were identified, ranging from the most settled infants who had very few or no regulatory problems (the *settled* profile; 36.8%, n= 647; this group formed the reference group), those with mild tantrums and few other regulatory problems (the *tantrums* profile; 21.3%, n= 375), those with mild to moderate sleep problems and few other regulatory problems (the *sleep problems* profile; 25.4%, n= 446), those with multiple moderate regulatory problems (the *moderately unsettled* profile; 13.2%, n= 232), and those with multiple, severe regulatory problems (the *severely unsettled* profile; 3.4%, n= 59). The descriptive names given to each of the 5 regulatory profiles were unavoidably brief and merely reflect the predominant regulatory feature/s reported by each profile. Model fit statistics can be seen in Table 1 (available at www.jpeds.com).

Linear and logistic regression analyses were carried out to compare each regulatory profile to the settled profile on socio-demographic characteristics. Linear regression was carried out to compare each of the regulatory profiles to the settled profile, on core language scores at 5 (n=965) and 11 (n=826) years of age. Multinomial logistic regression was carried out to examine the proportion of children in each regulatory profile, compared with the settled profile, who had language difficulties at 5 and 11 years of age. Model 1 is the crude unadjusted model. Model two was adjusted for potential confounding variables identified a priori in the extant literature (10,19,20,37–39), including maternal characteristics (maternal age, marital status, country of birth, non-English speaking background, secondary school

completion, socioeconomic disadvantage and maternal distress (K-6 ≥ 8)), and child characteristics (age, sex, birth weight, gestation, NICU/SCN admittance, birth order).

Complete case analysis was carried out and missing data was not imputed. To impute large amounts of missing outcome data may have introduced artefact – making our models more predictive than they truly are. This replicates the approach we used when we examined mental health outcomes in these children.(10)

Results

Baseline socio-demographic characteristics of the sample who provided data on infant regulation (n=1759), compared with the analytic sample described in this paper (those who provided data on infant regulation *and* language data at 5 and/or 11 years of age; n= 1131, 64%), are reported in Table II. The analytic sample (n=1131) comprised 59% of the entire ELVS cohort (n=1910).(28) Regarding characteristics of the analytic sample, infants allocated to the severely unsettled profile in comparison with those in the settled profile, were more likely to have been admitted to NICU or SCN, and their mothers were less likely to complete secondary school and more likely to report psychological distress at 12 months postpartum. Infants allocated to the moderately unsettled profile, in comparison with the settled profile, were more likely to be firstborn, have a mother of non-English speaking background, live in an area of slightly more socio-economic disadvantage (although still above national average), and their mothers were more likely to experience psychological distress at 12 months postpartum. Infants allocated to the tantrum profile compared with the settled profile, were more likely to be firstborn and infants allocated to the sleep problems profile compared with the settled profile, were less likely to have mothers of non-English speaking background.

Language outcomes

Infants allocated to the sleep problem or tantrum profiles had similar language scores at age 5 and 11 years to infants who were settled (Table 3 and Figure). The moderately unsettled profile reported significantly lower language scores than the settled profile at age 5, and were also more than twice as likely to have language difficulties (Table 4). The severely unsettled profile reported significantly lower language scores than the settled profile at age 5 and 11 years. The mean language scores for the moderately and severely unsettled profiles, although lower than the settled profile, still fell in the typical range. Infants in the severely unsettled profile were 5 times more likely to have language difficulties at 5 years of age, than the settled profile but this was not the case at age 11 years (Table 4). The difference in mean language scores for each regulatory profile in comparison with the settled profile, was consistently largest for the severely unsettled profile, followed by the moderately unsettled profile, at both 5 and 11 years of age (Table 3).

Discussion

Complex and severe infant regulatory problems were associated with lower language scores during childhood. Severely unsettled infants, who had multiple severe regulatory problems at 12 months of age, had poorer language development during early to middle childhood, than their settled counterparts. Specifically, severely unsettled infants had 5 times higher likelihood of exceeding the cut point for language difficulties at age 5, compared with settled infants (24% vs 6.4%, respectively). By age 11 a significant difference in language scores was still observed between the severely unsettled and settled groups. However, severely unsettled infants were no longer more likely to meet criteria for language difficulties at age 11, indicating that the gap in language skills between severely unsettled and settled infants, was beginning to close. The language rich environment at school may have helped these

children ‘catch up’ to their peers. Moderately unsettled infants also had poorer language scores than their settled peers at age 5, and had almost 3 times greater likelihood of exceeding the cut point for language difficulties.

Prior research suggests an association between less mature sleep consolidation from 6-18 months and increased risk for poorer language development at ages 3 and 5.(21,22) The current findings support and expand on this prior research, showing that deficits in language ability for dysregulated infants may extend in to late childhood. In our sample, infants with mild to moderate sleep problems and few other regulatory problems (the ‘sleep problems’ profile), had similar language ability to settled infants. This suggests that sleep problems alone may not predict poorer language development, but rather, it is the presence of multiple severe regulatory problems that places an infant at increased risk for poorer language ability during childhood. This finding should reassure the ~25% of parents who report infant sleep difficulties in the absence of other regulatory problems.

We previously reported similar outcomes for these same participants when examining mental health difficulties.(10) Infants with sleep problems and few other regulatory problems had no increased risk for mental health difficulties (Strengths and Difficulties Questionnaire, (40)) at age 11, yet infants in the severely unsettled profile experienced over 10 times the odds of meeting criteria for a mental disorder. Therefore, it appears that multiple severe regulatory problems at 12 months of age, may mark the beginning of a poorer developmental trajectory for some children. Mental health and language skills may influence each other. Poorer language abilities may limit a child’s social functioning, increasing risk for mental health difficulties.(41–43) Conversely, child mental health difficulties may interfere with the quality and quantity of parent-child interactions that support language development.(44)

The transactional model of parenting suggests that both parent and child contribute to creating an environment that supports language learning.(45) Severely dysregulated infant behavior is likely to interfere with parent attempts to engage in responsive parent-child interactions that are known to bolster early language development.(15–17) Parents may be discouraged by the lack of infant feedback, or spend time and energy trying to calm their dysregulated infant, with fewer opportunities to attempt these interactions. Parents who are depressed may find responsive interactions particularly difficult and are more likely to be less attentive and show less sensitivity toward their infant.(46) Due to their unsettled behavior, dysregulated infants may have fewer opportunities to practice communication skills. In the current study, the high rate of maternal distress (27%), compounded with the severity of the infant's unsettled behavior, may have combined to cause major disruption to responsive and reciprocal interactions that support early language development.

There may also be a common biological or genetic factor that is associated with both dysregulated infant behavior and language development. For example, children with neurodevelopmental disorders such as autism often present with both sleep difficulties during infancy (47) and difficulties with language development.(48) Further research is required in order to identify potential intersecting biological, environmental and social factors that may influence infant behavior, mental health and language development during childhood.(49)

The strengths of the current study include the prospective, longitudinal design, large sample size, and use of a 'gold standard' language measure administered by trained staff who were blinded to regulatory profile allocation. However, there are other factors that may influence the development of language skills in the intervening years between measurement points that were not measured in the current research, including: parent-child interactions, parenting behaviors, early learning environment, early life adversities such as exposure to inter parental conflict and violence, and other biological, environmental and social factors.(49) Our

measure of infant regulation relied on subjective maternal ratings and has not been validated against objective behavioral measures. Maternal report of infant regulatory behaviors may differ from objectively measured behavioral observations. For example, we do not know if mothers who reported a baby sleep problem in the current study were reporting that their baby had difficulty falling asleep, had problems with frequent night waking, and/or were not getting enough sleep. It is also noted that due to participant attrition, only 29 severely dysregulated infants (the most at-risk infants) provided language data at age 11.

Some elements of infant dysregulation, including sleep, can be improved with intervention (50) and future research should examine whether combining sleep interventions with strategies that promote early language skills might optimize language development for these children. Clinicians managing infants with severe, multiple regulatory problems should monitor language development over time.

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Table 2. Socio-demographic characteristics of the initial sample, analytic sample, and for each regulatory profile.

	Regulatory profiles						
	Initial sample	Analytic sample	Settled (reference group)	Tantrums	Sleep problems	Moderately unsettled	Severely unsettled
Child	n=1759	n=1131	n=438 (38.7%)	n=239 (21.1%)	n= 290 (25.6%)	n=130 (11.5%)	n=34 (3.0%)
Age (months), M (SD)	12.1 (0.4)	12.1 (.3)	12.1 (.3)	12.1 (.4)	12.1 (.3)	12.1 (.3)	12.1 (.5)
Male (assigned at birth), n (%)	886 (50.4)	546 (48.3)	209 (47.7)	107 (44.8)	151 (52.1)	62 (47.7)	17 (50.0)
Birth weight (kg), M (SD)	3.4 (.5)	3.5 (.5)	3.5 (.5)	3.5 (.5)	3.4 (.5)	3.5 (.5)	3.5 (.5)
Gestation (weeks), M (SD)	39.3 (1.8)	39.3 (1.8)	39.3 (1.7)	39.4 (1.6)	39.3 (1.9)	39.5 (1.8)	39.1 (2.0)
Admitted to NICU/SCN, n (%)	280 (15.9)	186 (16.5)	64 (14.6)	42 (17.6)	47 (16.2)	23 (17.7)	10 (29.4)*
1 st born, n (%)	876 (50.0)	569 (50.4)	197 (45.0)	144 (60.5)***	140 (48.3)	73 (56.2)*	15 (44.1)
Mother							
Age (years), M (SD)	32.0 (4.5)	32.4 (4.2)	32.4 (4.0)	31.8 (4.3)	33.1 (4.3)	32.1 (4.5)	31.8 (4.2)
Partnered, n (%)	1697 (96.6)	1101 (97.5)	423 (97.0)	235 (98.3)	287 (99.0)	123 (94.6)	33 (97.1)
Born in Australia, n (%)	1492 (84.9)	979 (86.6)	374 (85.4)	214 (89.5)	252 (86.9)	111 (85.4)	28 (82.4)
NESB, n (%)	103 (5.9)	41 (3.6)	19 (4.3)	5 (2.1)	4 (1.4)*	12 (9.2)*	1 (2.9)
Secondary school complete, n (%)	1353 (77.1)	909 (80.5)	350 (79.9)	201 (84.1)	238 (82.4)	99 (76.7)	21 (61.8)*
SEIFA disadvantage, M (SD)	1037.8 (59.7)	1042.7 (54.4)	1042.2 (51.4)	1048.8 (54.6)	1043.2 (53.7)	1031.1 (64.3)*	1044.7 (49.6)
Psych. distress (K6 ≥8), n (%)	144 (8.2)	85 (7.5)	20 (4.6)	17 (7.1)	19 (6.6)	20 (15.4)***	9 (26.5)***

Note: 'Initial sample' includes all cases who were allocated a regulatory profile; 'Analytic sample' includes all cases who were allocated a regulatory profile and also provided language data at 5 and/or 11 years of age; comparisons were made with the settled (reference) group; *= $p < .05$, **= $p < .01$, ***= $p < .001$; M= Mean, SD=Standard Deviation, NICU= Neonatal Intensive Care Unit, SCN= Special Care Nursery, NESB=non English speaking background, SEIFA= Socio-economic Indices for Areas.

Table 3. Core language scores at 5 and 11 years of age, for each profile in comparison to the settled profile.

	Settled (reference group)	Regulatory profiles											
		Tantrums			Sleep problems			Moderately unsettled			Severely unsettled		
Language score	M (SD)	M (SD)	MD/ AMD (95% CI)	p	M (SD)	MD/ AMD (95% CI)	p	M (SD)	MD/ AMD (95% CI)	p	M (SD)	MD/ AMD (95% CI)	p
5 years	n= 373	n= 197			n=253			n= 113			n= 29		
Model 1	100.99 (13.28)	102.22 (13.14)	1.2 (-1.15, 3.60)	.31	101.79 (14.57)	.80 (-1.40, 3.00)	.48	97.82 (13.91)	-3.17 (-6.07, -.28)	.03	93.38 (15.46)	-7.62 (-12.82, -2.42)	.004
Model 2			1.06 (-1.38, 3.50)	.40		.42 (-1.82, 2.66)	.72		-3.89 (-6.92, -.86)	.01		-7.71 (-13.07, -2.36)	.005
11 years	n= 331	n= 170			n= 207			n= 91			n= 27		
Model 1	100.98 (12.56)	102.6 (11.71)	1.66 (-.70, 4.02)	.17	100.05 (14.06)	-.94 (-3.15, 1.28)	.41	100.38 (12.44)	.60 (-3.56, 2.36)	.69	94.04 (11.07)	-6.95 (-11.95, -1.94)	.007
Model 2			1.44 (-1.02, 3.90)	.25		-.94 (-3.24, 1.36)	.42		-1.49 (-4.48, 1.60)	.35		-6.50 (-11.60, -1.39)	.013

Note: The settled group served as the reference group; Model 1 is the crude model and model 2 is adjusted for maternal characteristics (maternal age, marital status, born in Australia, non-English speaking background, maternal education, socioeconomic disadvantage and maternal distress (K6 ≥8)) and child characteristics (child age, gender, birth weight, weeks of gestation, NICU/SCN admittance, birth order); MD= Mean Difference; AMD= Adjusted Mean Difference.

Table 4. Proportion with language difficulties at 5 and 11 years of age, for each profile in comparison to the settled profile.

	Regulatory profiles												
	Settled (reference group)	Tantrums			Sleep problems			Moderately unsettled			Severely unsettled		
Proportion with language difficulties	n (%)	n (%)	OR/ AOR (95% CI)	p	n (%)	OR/ AOR (95% CI)	p	n (%)	OR/ AOR (95% CI)	p	n (%)	OR/ AOR (95% CI)	p
5 years	n= 373	n= 197			n= 253			n= 113			n= 29		
Model 1	24 (6.43)	13 (6.60)	1.03 (.51, 2.07)	.94	19 (7.51)	1.18 (.63, 2.20)	.60	16 (14.16)	2.40 (1.23, 4.69)	.01	7 (24.14)	4.63 (1.80, 11.91)	.002
Model 2			.85 (.37, 1.96)	.70		1.20 (.59, 2.43)	.61		2.71 (1.28, 5.75)	.01		5.01 (1.72, 14.63)	.003
11 years	n= 331	n= 170			n= 207			n= 91			n= 27		
Model 1	18 (5.44)	6 (3.53)	.64 (.25, 1.63)	.35	14 (6.76)	1.26 (.61, 2.59)	.53	6 (6.59)	1.23 (.47, 3.19)	.67	2 (7.41)	1.39 (.31, 6.34)	.67
Model 2			.42 (.11, 1.54)	.19		1.04 (.42, 2.60)	.93		1.89 (.65, 5.52)	.24		.95 (.16, 5.63)	.96

Note: The settled group served as the reference group; Model 1 is the crude model and model 2 is adjusted for maternal characteristics (maternal age, marital status, born in Australia, non-English speaking background, maternal education, socioeconomic disadvantage and maternal distress (K6 ≥8)) and child characteristics (child age, gender, birth weight, weeks of gestation, NICU/SCN admittance, birth order); OR= Odds Ratio; AOR= Adjusted Odds Ratio; LD= language difficulties, reflecting a core language score ≤81; higher language scores indicate better language.

Figure 1. Language scores for each regulatory profile at 5 and 11 years of age.

Table 1 (online). Model fit information for the Latent Class Analysis to establish profiles of infant regulation.

Number of profiles	L ²	AIC	BIC	Entropy	VL
1	-	-	-	-	-
2	-8196.25	16470.49	16683.82	.74	.00
3	-8109.86	16337.73	16660.60	.70	.00
4	-8062.85	16283.71	16716.04	.71	.03
5	-8028.31	16254.61	16796.39	.74	.03
6	-8015.22	16268.45	16919.68	.71	.58

Note: The bolded line represents the model selected for further analysis of the association between infant regulation and childhood language, L²= Likelihood ratio statistic, AIC= Akaike Information Criterion, BIC= Bayesian Information Criterion, VL= Vuong-Lo-Mendall-Rubin likelihood ratio.