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https://doi.org/10.1016/j.jad.2019.09.027

Lewis, A.J., Sae-Koew, J.H., Toumbourou, J.W. and Rowland, B. (2019) Gender differences in trajectories of depressive symptoms across childhood and adolescence: A multi-group growth mixture model. Journal of Affective Disorders .

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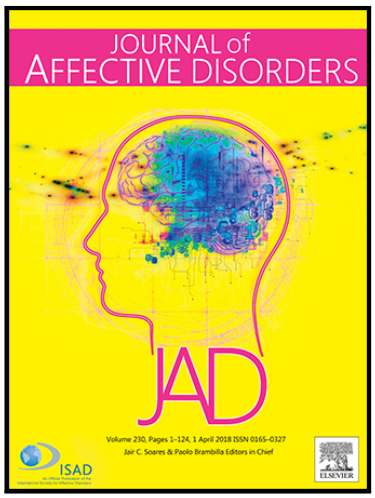

Gender differences in trajectories of depressive symptoms across childhood and adolescence: a multi-group growth mixture model

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PII: S0165-0327(19)30790-6
DOI: https://doi.org/10.1016/j.jad.2019.09.027
Reference: JAD 11130

To appear in: *Journal of Affective Disorders*

Received date: 27 March 2019
Revised date: 1 September 2019
Accepted date: 3 September 2019

Please cite this article as: Andrew J. Lewis , Jonathan H. Sae-Koew , John W. Toumbourou , Bosco Rowland , Gender differences in trajectories of depressive symptoms across childhood and adolescence: a multi-group growth mixture model, *Journal of Affective Disorders* (2019), doi: https://doi.org/10.1016/j.jad.2019.09.027

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Highlights:

- The trajectories of depressive symptoms over childhood and adolescence inform our understanding of the developmental course of depression.
- In a sample of children from large longitudinal study in Australia four such trajectories were found: *low-stable* (75%); *decreasing* (11%); *increasing* (9%); *high and rising* (6%).
- Females were 80% more likely than males to be in a group with increasing depressive symptoms between 4 and 14 years of age.
- Reactive temperament and maternal depression were consistent predictors of being in the increasing group.
- Persistent temperament appears to act as a protective factor for females.

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Title

Gender differences in trajectories of depressive symptoms across childhood and adolescence: a multi-group growth mixture model

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Submitted to:

Journal of Affective Disorders

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Abstract

Background: This study sought to identify depression trajectories across childhood and to model a range of child and family predictors of whether a child may be on an increasing trajectory towards depressive disorder in adolescence.

Methods: Multi-group growth mixture modelling (MGMM) was used on a sample of 4983 children from the Longitudinal Study of Australia Children (LSAC). Depressive symptoms of these children were assessed over 10-years with six time-points, administered every

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second year commencing at 4 years via the parent report version of the Strength and Difficulties Questionnaire. Predictors of class membership were also examined.

Results: Four trajectories were found to be the best fitting model characterising low-stable (75%); decreasing (11%); increasing (9%); high and rising (6%) groups. Females were more likely to be in a trajectory of increasing depressive symptoms between 4 and 14 years of age than males. Reactive temperament and maternal depression at four and six years of age were consistent predictors of increasing and high trajectories while persistent temperament acts as a protective factor for females.

Limitations: The findings should be interpreted in the light of limitations due to common-method variance and the absence of diagnostic indicators of depressive disorder.

Conclusions: We conclude that there are gender differences in patterns of depressive symptoms from childhood to adolescence and meaningful predictors of these early developmental trajectories. Preventative interventions in childhood targeting parents with depression and children with temperamental difficulties may be indicated.

Key words: childhood depression, adolescent depression, person-centred methods, trajectory modelling, latent class growth curve modelling.

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It is widely reported that there is a sharp increase in the incidence of depressive disorders for females in early adolescence (Sawyer et al., 2001; Andrew J Lewis et al., 2017). In this paper we examine patterns of depressive symptoms using a person-oriented approach. We analyse data from a large sample of nationally representative Australian children sampled repeatedly across childhood and adolescence. We are particularly

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interested in the use of trajectory modelling to investigate whether subgroups of depressive and anxiety symptoms can be discerned from preschool into adolescence. Our focus is on the identification and prediction of membership of two patterns in particular: consistently high and increasing trajectories of depressive symptoms.

Notwithstanding early resistance to the idea, pioneering studies by Spitz and Bowlby provided vivid accounts of depressive reactions to separation, loss and deprivation in very early childhood. Even so, in childhood a diagnosis of depressive disorder is quite rare for both genders (estimated to be between 0.5% and 2.5%), but these rates rise markedly in adolescence especially for females (estimates range between 4 to 8%). During adolescence the rate of new female cases increases at approximately double the rate for males (Naninck, Lucassen, & Bakker, 2011). When we shift focus from diagnosed disorders to differences over time of patterns within reported depressive symptoms, it is possible to identify subgroups which show reliable longitudinal patterns of symptoms (Sterba, Egger, & Angold, 2007; L. Shore, Toumbourou, Lewis, & Kremer, 2018). Such an approach makes an important addition to understanding of the premorbid course and development of depressive disorder. Furthermore, given the known gender differences in the rate of onset of depressive disorder, it is important to consider whether such gender differences in the course of symptoms can be identified prior to adolescence.

Longitudinal research on child psychopathology typically presumes a variable-oriented model in which changes over time for each individual are assumed to reflect variation within a generalizable and normative pattern of child development. An alternative approach is to assume the individual is the unit of analysis. This person-centred approach therefore shares some of the assumptions of the ideographic approach in which it is assumed that important individual differences within a population may constitute different sub-populations which should be considered in their unique

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characteristics (Bergman & Magnusson, 1997; von Eye & Bergman, 2003; Sterba & Bauer, 2010).

Person centred models are particularly applicable to mental health research and can be used to test theoretical models based on predictions of class membership (Bauer & J, 2003; von Eye & Bergman, 2003). For instance, a simple hypothesis is that given that mental disorders do not impact on the majority of children it can be predicted within general population data that the most prevalent class will be those with consistently low levels of depressive symptoms and these should be very stable over time (Sterba et al., 2007). However, in the light of the theory of differential susceptibility, trajectories that are consistently high in symptoms from infancy onwards may reflect relatively fixed developmental pathways which arise early in development and are relatively impervious to environmental influence and may reflect genetic or early intrauterine factors thought to influence temperamental dispositions (Belsky, Bakermans-Kranenburg, & van Ijzendoorn, 2007). In other cases, initially high symptoms may decline over time, suggesting the child or the social environment has found a means of resolving or accommodating early setbacks, or that the child's point in development has rendered previous problems less relevant, reflecting the lay notion of 'growing out of it'. Those who show an increasing trajectory may be experiencing an accumulating exposure to psychosocial risk or may be demonstrating an increased sensitivity to environmental risk factors such as parenting and the quality of the family environment.

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Previous studies of the trajectories of depressive symptoms

In our recent meta-analysis of longitudinal studies of child and adolescent depressive symptoms, we identified 20 previous studies including data from 41 236 participants which had reported trajectory models (Lori Shore, Toumbourou, Lewis, & Kremer, 2017). While there was consistent evidence for different subgroups, the specific

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number of trajectories identified varied from 3 to 11, depending on the ages, measures and timing of symptom measurement (Sterba & Bauer, 2010). Our meta-analysis confirmed that 56% of the combined sample showed a pattern of consistently low or no symptoms. Many studies were able to identify more than one trajectory with increasing depression symptoms and a combined analysis showed that 12% of children experience a high depression trajectory.

However, only six of the twenty studies included any measurement prior to 12 years of age. The only previous study to include data from a baseline commencing at 4 years of age was the study by Dekker (2007) examining a Dutch sample of just over 2000 participants. There remains relatively little work examining the early childhood predictors of membership of high risk trajectories for depressive symptoms. This is a major limitation in the literature which we address in this study by using a trajectory modelling approach combined with predictors of group membership to identify modifiable risk factors which predict a high risk developmental pathway (A. J. Lewis, Galbally, Gannon, & Symeonides, 2014).

Predictors of depression trajectories

Gender differences in vulnerability to depression in adolescence have been widely investigated (Ge et al., 2003; Makri-Botsari, 2005; Patton et al., 2008; Andrew J Lewis, Kremer, Douglas, Toumbourou, et al., 2015; Andrew J Lewis et al., 2017). For example, Essau and colleagues (2010) reported adolescent females had a higher incidence of Major Depressive Disorder and a more chronic course than males when followed up at 30 years of age. Importantly, in this study, a younger age of onset was the strongest predictor of severity in the course of depression in females. This suggests that there is a more substantial long term impact of childhood depression in females (Essau et al., 2010). While

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we have substantial information regarding the adolescent onset of depression and the higher vulnerability of females it remains unclear whether this gender difference emerges at some point in childhood for a particular subgroup of females. Furthermore, the gender specific predictors around family environment, temperament and parenting can be used within trajectory models to give a more nuanced understanding of the interaction of timing of symptoms and developmental risk factors.

In this study we combine trajectory analysis with analysis of predictors of trajectory membership and for our predictors we elected to focus on maternal depression, child temperament and parenting factors. Our selection of predictors was based on the definition of temperament as a basic behavioural disposition grounded in a genetic-biological framework (Shiner et al., 2012) and parenting as a more clearly environmental factor. There are well established relationships between maternal depression and child internalising disorders (S. H. Goodman et al., 2011; Galbally & Lewis, 2017). Recently a 22-years longitudinal study on the effects of PND reported independent effects from exposure to maternal depression on stress regulatory outcomes across adolescence and well into adulthood (Barry et al., 2015). In terms of temperament, Compas et al. review consistent findings that difficult child temperaments such as emotional reactivity and a heightened intensity of emotional reactions are associated with depressive disorders in adolescence (Compas & Oppedisano, 2000). Moreover, several studies have already examined temperament as a predictor of increasing or high developmental trajectories of internalising symptoms. In a study of depression trajectories from 11-18 years of age Mezulis *et.al.* found high infant negative affectivity increased the risk of membership in the increasing depression symptoms trajectory by 90%. Notably this study also found that infant negative affectivity predicted membership of a decreasing trajectory (which they called 'early high class') by a fourfold ratio, as compared to their low-stable group

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(Mezulis, Salk, Hyde, Priess-Groben, & Simonson, 2014). In terms of parenting, in a 10 year longitudinal study commencing in early childhood Whalen and colleagues reported that both males and females in the high depression trajectory had experienced significantly more family adversity by age 5 than children in the other trajectories (Whalen et al., 2016).

In the current study we examine maternal depression, early temperament and exposure to parenting within multivariate models to see which is the stronger predictor of trajectories of increasing symptoms over time. It was first hypothesised that repeated measures of parent reports of childhood internalizing symptoms could be used to successfully model subgroups of children with different developmental patterns of such symptoms. We hypothesised that the majority would belong to a low- stable group but that both increasing and decreasing groups would be evident representing around 10-20% of the sample. Our second hypothesis was that trajectories involving increasing levels of internalising behaviour would be different for males and females with females over represented in increasing trajectories. Finally we predicted that risk factors such as maternal depression, reactive child temperament and angry parenting variables would be positively associated with high or increasing trajectories, while sociable and persistent temperament as well as warm parenting would act as protective factors and therefore be negatively associated with high or increasing trajectories. Such relationships should hold good after controlling for the effects of confounders within multivariate analyses.

2. Methods

Study Design and Sample

Data was drawn from six waves of The Longitudinal Study of Australian Children (LSAC). LSAC is a nationally representative study initiated by the Australian Government Department of Families, Housing, Community Services and Indigenous Affairs to examine

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the growth and development of children in Australia. The sampling design and method have been described in Soloff, Lawrence, and Johstone (2005). LSAC used a two-stage cluster sampling design with Australian postcodes (stratified by state of residence and urban versus rural status) as the primary sampling units. Sampling units were infants born between March 2003 and February 2004 selected from the Australian Medicare database. Random selection of children within each postcode produced a cohort aged between 4 and 5 years of age, with all birth months represented. Of those selected for contact, 5107 parents elected to participate in the first wave of LSAC in 2004 (64.2% response rate). Wave two data was collected in 2006, wave three in 2008, wave four in 2010, wave five in 2012, and wave six in 2014.

Procedures

Data was collected from the child's primary caregiver via face-to-face interview with a trained researcher. 98.6% of primary caregivers were the child's mother (Soloff et al. 2005). After each interview, both primary and secondary caregivers completed a self-report questionnaire. The study was approved by the Australian Institute of Family Studies Ethics Committee and parents provided written informed consent.

Measures

Demographic data

Parents were asked to report on their child's gender and age in months as well as their own age in years, country of birth (Australia/New Zealand vs other), marital status (married vs other), main language spoken at home (English vs other), combined parental income brackets, and high school completion. Social and Economic disadvantage was measured using Socio-Economic Indexes for Areas (SEIFA) which is based on Australian census data (Australian Bureau of Statistics, 2001). The index of relative socioeconomic

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disadvantage uses postcode of residence to determine neighbourhood economic status and has been standardized to a mean of 1000 (SD 100), with higher values indicting a greater advantage.

Depressive Symptoms

Depressive symptoms were measured by parent report using the emotional symptoms subscale of the Strengths and Difficulties Questionnaire (SDQ)(R. Goodman, 1997). The SDQ is a 25-item measure of behavioural and emotional problems for children aged 4 to 16 years which is widely used and has sound psychometric properties. The emotional symptoms scale has five items which are rated 0 = not true; 1 = somewhat true; 2 = certainly true. The mean of the 5 items is used as a summary score. Items assess symptoms of somatic complaints, worried, unhappy or tearful, nervous or lacking confidence and fearful. The SDQ has been shown to have good convergent and discriminant validity for clinical disorders in a low risk sample in the U.K (A. Goodman, Lamping, & Ploubidis, 2010). Moderate to strong internal reliability was exhibited across all SDQ subscales in an Australian population study (Hawes & Dadds, 2004) in both pencil and paper and online formats (Seward, Bayliss, Stallman, & Ohan, 2018). Previous studies have established that with an Australian population sample the clinical cut point on the SDQ emotional symptoms subscale is best considered to be scores greater than or equal to 4 which represents those children in the highest 10% of scores (Hayes, 2007).

Temperament

LSAC used a shortened version of the Australian revision of the Toddler Temperament Scale (TTS). This is a frequently used questionnaire which is a psychometrically sound measure of early childhood behaviour (Fullard, McDevitt, & Carey, 1984). The TTS is a 97-item measure which was first implemented in the Australian Temperament Project in

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1983. Items in the TTS are typically grouped into six temperament styles which have moderate to high internal consistency (alphas = 0.53 - 0.76) and good test-retest reliability (Prior, Sanson, & Oberklaid, 1989). The shortened TTS used in LSAC includes 4 items each for sociable, persistence and reactivity scales rated on a six-point scale (alphas = 0.98-0.99). The scale of the TTS are: *Approach- Sociability* which refers to the degree of comfort a child has in novel situations or with unfamiliar peers or adults and can be contrasted to avoidance. Example items include 'pleasant (smiles, laughs) when first arriving in unfamiliar places' and 'smiles when an unfamiliar adult plays with him/her'; *Reactivity* refers to the child's degree of emotional intensity and volatility and items included 'responds to frustration intensely (screams, yells)' and 'reacts strongly (cries, screams) when unable to complete a play activity'; *Persistence* refers to the child's capacity to see tasks through to completion and example items include 'plays continuously for more than 10 minutes at a time with a favourite toy' and 'stops to examine objects thoroughly (5 minutes or more)'. High scores indicate dispositions towards sociability, reactivity and persistence respectively. Each temperament scale was assessed by four items, in which parents rated the frequency of the behaviour on a 6 point scale of "almost never", "not often", "variable – usually does not", "variable – usually does", "frequently" and "almost always. Since there are numerous models of temperament, in order to locate the current study in other current temperament models, we note the similarity in temperament concepts to Rothbart's categories wherein the Approach-Sociability scale would be analogous to Rothbart's category of Surgency, Reactivity to the dimension of Negative Affectivity, and the conceptual similarity between Persistence and Regulatory Capacity which in older children is conceptualised as Effortful Control (Shiner et al., 2012).

Maternal Warmth

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The LSAC maternal warmth scale was used to measure this variable. The scale consists of 6 items scored on a 5-point scale where 1 = never/almost Never, 2 = rarely, 3 = sometimes, 4 = often, and 5 = always/almost always. Parents were asked: How often do you express affection by hugging, kissing and holding this child? How often do you hug or hold this child for no particular reason? How often do you tell this child how happy he/she makes you? How often do you have warm, close times together with this child? How often do you enjoy doing things with this child? How often do you feel close to this child both when he/she is happy and when he/she is upset? Measures of scale reliability were cited as being excellent and ranged between the values of 0.92 to 0.96 (Zubrick et al., 2014).

Maternal Anger

The LSAC Maternal anger scale was used to measure this variable. The scale consists of 4 items scored on a 5-point scale where 1 = never/almost Never, 2 = rarely, 3 = sometimes, 4 = often, and 5 = always/almost always. Parents were asked: Of all the times you talk to this child about his/her behaviour, how often is this praise? (reversed); Of all the times you talk to this child about his/her behaviour, how often is this disapproval?; How often are you angry when you punish this child?; How often do you feel you are having problems managing this child in general? Measures of scale reliability (H coefficients), ranged from 0.72 to 0.81 across waves 1 to 4 (Zubrick et al., 2014).

Missing data treatment

It is typical in longitudinal studies for some participants to have missing data over time. The missing data relating to this study were due to attrition or participants not responding to items in the questionnaire. Therefore, the missing data are assumed to be Missing at Random (MAR) and Full Information Maximum Likelihood (FIML) procedures

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were utilised to address missing data in all analyses. The FIML approach does this by making use of all the information available in the dataset and maximising the likelihood of the model given the observed data. FIML is more effective and less biased than LISTWISE deletion, PAIRWISE deletion, or mean imputation methods in cases of MAR (Wang & Wang, 2012).

Statistical analysis

Growth Mixture Modelling (GMM) was used to analyse the data using Mplus 8 (L. K. Muthén & Muthén, 1998-2017). GMM is an extension of latent growth modelling (LGM) which assesses whether a given population under investigation is comprised of multiple subpopulations based on growth trajectories. For the analysis, the observed variables were depression scores for six time-points, with two years between each wave. Depression scores for these six time-points were used to identify depression growth trajectories (classes). The analysis in this paper utilised the standard three step method by saving the most likely number of class trajectories and analysing data separately. When conducting analysis of all models, we specified 100 random sets of starting values to be generated with 20 final stage optimizations. In all analyses, the best log likelihood was replicated. The reporting style of this analysis was conformed to the checklist presented by the Guidelines for Reporting on Latent Trajectory Studies (GRoLTS; Van De Schoot, Sijbrandij, Winter, Depaoli, and Vermunt (2017). Refer to online supplementary material for the GRoLTS paper and checklist.

Latent Growth Trajectories

The first step in the analysis was to determine the number of distinct trajectories that would ideally describe the data. To achieve this, an unconditional model where successive analyses are conducted by adding a trajectory class with each analysis and

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comparing the model-fit indices across analyses. B. Muthén and Muthén (2000) have recommended several parsimony criteria that can be used when selecting the ideal number of class trajectories. These include the lowest scores on Bayesian Information Criteria (BIC) and Aikake Information Criteria (AIC) given the higher Log Likelihood statistic, significance on the Lo-Mendell-Rubin Adjusted Likelihood Ratio Test (LMR-LRT), and the quality of classification across models represented by a higher Entropy statistic. When estimating different class structures, we first considered trajectories fitted with a linear function. However, due to the six waves of data, and the expected shape of the trajectories we predicted that a quadratic function would fit the data better.

Multi-Groups Approach

After the most parsimonious model was identified, invariance testing was undertaken to identify whether the growth model differed significantly for males and females. This was a two-stage procedure. Firstly, we compared the model where the intercept and slope were free to vary between males and females against the model where the intercept and slope for each class were constrained to be equal for males and females. Secondly, we conducted a log-likelihood ratio test to determine whether the models were significantly different. The log-likelihood ratio test can produce a chi-square statistic which can be used to determine significance. The log-likelihood ratio test involves computing a chi-square difference test using log likelihood values and scaling correction factors obtained when using the Maximum Likelihood estimator. If the models were found to be significantly different, then a multi-group approach could be adopted.

Predictors and Covariates of Trajectory Class Membership

The classes were then analysed using Structural Equation Modelling with a focus on distinguishing the predictors on the increasing vs decreasing or low/flat trajectories.

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The purpose of this part of the analysis was to investigate how particular parenting and temperament variables influence the patterns (latent class membership) of growth trajectories over time on boys and girls. To this end, a multivariate model was specified where covariates were added simultaneously to predict the latent class membership, thereby controlling for the effect of each other in the model and calculating adjustment p values. The covariates entered includes socio-demographic characteristics, temperament and parenting variables. This was applied to males and females separately using a multi-groups approach.

Results

Demographics

Demographic and descriptive statistics of key variables are presented in Table 1. The sample used in the analysis consisted of 4983 children; 83% of respondents were four years old and 17% were five years old at wave one and 51% of the sample were male. The range of the SEIFA indices for the area where each child resided at baseline was between 790 and 1230. The average SEIFA index was 1005.72 (*SD*=78.32). The average age of mothers was 35 years and the average age for fathers was 38 years at baseline. Average depression scores for both females and males, for each wave are presented in Table 2. Except for wave one, raw scores for internalising symptoms were higher for females than males.

Patterns of Trajectories

Twelve latent growth trajectory models were fitted and fit indices for these models are reported in Table 3. We first compared the fit of the growth curves with a linear specification (models 1-6) and then with a quadratic function. The quadratic models showed superior fit statistics suggesting that the trajectories are not linear. Then an

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examination of the model fit indices within the quadratic models (model 7-12) suggested that, while a larger number of classes did improve model fit on AIC and aBIC, the four-class quadratic function was the best fitting model. This determination was made on the basis of the decrease in the LMR-LRT statistic which indicates that as the number of classes increased to four classes, each model became a significantly better fit than the previous model. A significant LMR test, that is the log-likelihood value, was the largest value given the size of the entropy statistics and the significance of the LMR test. On this criterion, the five-class model was no longer an improvement on the four-class model. Similarly the entropy statistic peaks at 0.81 with the four class solution as compared to the 3 and 5 class solution. Admittedly, there is very little to differentiate a 4 class from a 6 class quadratic model on fit statistics alone so we selected the 4 class solution on the basis of parsimony.

The slope, intercept and quadratic slope for each trajectory for the four-class quadratic model are presented in Table 4. These data are presented for the total sample. A graphical representation of the growth trajectories for the four classes is presented in Figure 2. A visual examination of the trajectories suggests that the four trajectories could be labelled: "low and stable"; "increasing"; "decreasing", and "high & rising". As predicted, the "low and stable" trajectory comprises the majority of the population (74.89%) and remains the most stable over time. Children in the "decreasing" trajectory (10.67%) had emotional symptom scores that were initially high and above clinical levels at age 4/5 (greater than or equal to 4), and decreased to below clinical levels by ages 6/7. At the age of 4/5, children in the "increasing" trajectory had emotional symptoms that initially began below clinical levels. However, by age 13/14 the level of these emotional symptoms had increased to above clinical levels. Lastly, the intercept of the "high & rising" trajectory (5.57%) began below clinical level symptoms but by age 6/7, increased above clinical levels until the age of 14/15 by which time it had moved below clinical levels again.

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Gender differences across class trajectories

A multi-group growth mixture model was run comparing males and female's trajectories freely varying, compared this against a model which constrained each class trajectory between genders to equality. This indicated that there was a significant difference in chi-square values between the two nested models (χ^2 = 1688.271, *df* = 20, p<.001). This confirmed our second hypothesis indicating that there were statistically significant differences in the progressions of the trajectories between males and females. Therefore, the analysis was continued using a multi-group growth mixture model that was split by gender.

The slopes, intercepts and quadratic function for each of the trajectory classes split by gender are presented in Table 5. The likelihood of belonging to a "low and stable" trajectory was significantly greater for males (77.23%) than for females (71.79%) (OR = 1.19, 95% CI 1.09-1.29, p<.001). Children in the "decreasing" trajectory were more likely to be females (11.12%) than males (10.18%) but this was only marginally significant (OR= 0.94, 95% CI 0.79-1.13, p =.05). Children in the "increasing" trajectory, as predicted in our second hypothesis, were statistically significantly more likely to be females (11.15%) than male (6.07%) (OR= 0.55, 95% CI 95 0.45-0.67, p<.001). Lastly, there was no significant difference in gender within the "high & rising" trajectory were comprised of more males (6.51%) than females (5.93%) (OR =1.13, 95% CI 0.91-1.43, p = 0.27).

Predictors of Male and Female trajectories

The next stage of the analysis used a multivariate model to examine the prediction of class membership by Child Temperament (Sociable, Persistent, Reactive), Parenting

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(Maternal Warmth, Maternal Anger) and Maternal Depression, split by gender and after controlling for Socio-Economic Index for Areas (SEIFA) and country of birth (Birth). We compare each of the three groups, increasing, decreasing and high-stable to the Low and Stable as a reference group. In Table 6 the findings for males showed that for the increasing vs. low and stable trajectory, only reactive temperament at age six was found to significantly increase the likelihood of belonging to an increasing trajectory than a low and stable trajectory (OR = 1.76, p =.012). For the decreasing vs. low and stable trajectory, maternal depression at age six resulted in a higher likelihood of belonging to a decreasing trajectory than a low and stable trajectory (OR = 1.88, p =.020). Lastly, for the high and unstable vs. low and stable trajectories, both maternal depression (OR = 1.84, p =.005) and having a reactive temperament (OR = 1.51, p =.054) at age four increased the likelihood of males belonging to a high and unstable trajectory than a low and stable trajectory. Conversely, having a sociable temperament (OR = 0.64, p =.051) decreased the likelihood of belonging to a high and unstable trajectory.

For females, as presented in Table 7, reactive temperament at age six was found to be the common covariate for females that significantly predicted an increased likelihood of belonging to an increasing (OR = 1.64 p =.004) and decreasing (OR = 1.35, p =.014) trajectory as compared to low and stable trajectories. For the increasing vs. low and stable comparison, it was found that maternal depression at age four significantly increased the likelihood of a child belonging to an increasing trajectory (OR = 2.01, p =.001). Moreover, having a persistent temperament was reported as having an opposite effect, where this covariate decreased the likelihood of belonging to an increasing trajectory than a low and stable trajectory (OR = 1.64, p =.004). Females who experienced angry parenting were more likely to belong to the decreasing trajectory than the low-stable trajectory (OR = 1.81, p =.001). Lastly, the only covariate that increased the likelihood of belonging to a

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high and unstable compared to a low-stable trajectory was having a reactive temperament at age six (OR = 1.75, p =.038).

Discussion

This study aimed to extend the existing literature by using a person-centred approach to examine the developmental course of depression from childhood and into adolescence. As hypothesised repeated measures of childhood and adolescent depressive symptoms show meaningful subgroups of children with different trajectories of depressive symptoms over time. The hypothesis that the majority of participants would belong to trajectories that were low and stable was supported. Our initial estimates of the proportions in the high or increasing trajectories were slightly over estimated but broadly consistent proportions to other trajectory modelling studies. Our prediction that females would be over represented within increasing trajectories was also supported. Our final hypothesis was only partially supported and our most consistent finding was that reactive child temperament and maternal depression are important early risk factors for both male and female children and that maternal depression appears to impact girls and predicts their belonging to an increasing developmental trajectory for internalising symptoms.

Specifically, in terms of the description of the trajectories themselves, the majority of children (74%) indicated a low and steady level of depressive symptoms. Analyses indicated three additional distinct subgroups: an increasing (9%), decreasing (11%) and high & unstable pattern (6%) of depressive symptoms over childhood and into adolescence. Importantly, the increasing trajectory enters a range of clinically elevated symptoms at the beginning of the adolescent period and this is consistent with previous studies (Brendgen et al., 2005; Mazza et al., 2010; Sterba, Prinstein, & Cox, 2007). Additional findings are also consistent with the literature which suggests that there are a

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'decreasing' and 'consistently high' trajectory. In our study we found a trajectory which is initially high but tapers off and this is likely to be due to our use of non-linear modelling via a quadratic model. These findings are in alignment with the study conducted by Brendgen and colleagues (2005), which identified four trajectories, of consistently low, moderate, increasing and consistently high.

These findings on the trajectories themselves add to the literature which suggests that there are distinct developmental patterns for depressive symptoms in children. Given our data stretches across childhood and into adolescence, it is apparent that the 9% of children who are in an increasing symptom group appear to be on a developmental pathway leading to the adolescent onset of depressive disorder. Specifically the findings add to the extensive literature which shows that generally females have higher rates of depression than males during adolescence (Andrew J Lewis, Kremer, Douglas, Toumborou, et al., 2015; Andrew J Lewis et al., 2017).

In terms of the significance of these findings for our understanding of gender differences in vulnerability to depression, the proportional split for gender in our four trajectories is revealing. In the increasing group, it is apparent that there are almost double the number of females in (11.15%) compared to than males (6.07%). While at 14 years, for this increasing group, the level of depression is the same, the female group has a sharper increase from even as young as ages 8-9 years indicating that the larger number of females in this group also have a sharper level of increase in symptoms. This finding should be considered in the light of the high but decreasing group. In this group females decrease at a slower rate than males as from about 10-11 years. So the net result of combining both the increasing and decreasing groups is that females are both higher and increase (or fail to decrease) at a greater rate than males. This particular analysis shows very well the more subtle understanding of the developmental course of the depression

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which can be derived from such longitudinal trajectory modelling. This finding suggests that there may be two different pathways which contribute to previous findings of higher rates of depression in females than male adolescents. In other words, one group of females increases sharply in symptoms somewhat later in development, while another group of females has higher early symptoms and does not decrease at the same rate as males.

Our findings in terms of predictors of trajectory membership were more mixed. We found that increasing depressive trajectories were predicted by both temperament and parent variables. One of the main risk factors associated with belonging to an increasing trajectory was having a reactive temperament during age four to six. This was found to be consistent across both males and females. This finding is supported by previous literature such as Mezulis *et.al* that suggests that reactive temperament can act as a risk factor for the development of depressive problems in childhood (Andrew J Lewis & Olsson, 2011). We also found that early exposure to maternal depression is another significant predictor of being in the increasing trajectory. This finding was initially found to be significant across both genders. However, when a multi-groups approach was utilised, it was notable that maternal depression was only a significant predictor of our female's class membership of an increasing trajectory.

This finding is both interesting and consistent with various literature which suggests that maternal depression can act as a risk factor for the development of child internalising and externalising problems (S. H. Goodman et al., 2011) but adds important information that the timing of exposure to maternal depression in early development is a particularly important factor for girls. There are already a number of findings suggesting that female children are more susceptible to exposure to maternal depression (Fergusson, Horwood, & Lynskey, 1995; Davies & Windle, 1997). In addition, Forster et al (2008) found that for girls, exposure to longer maternal depressive episodes predicted higher

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levels of internalizing problems but, for boys, the same exposure to maternal depression was more likely to result in externalizing problems. The mechanisms through which this gendered difference in child mental health outcomes occurs required further study. Our findings are consistent with several studies that have identified gender differences using trajectory modelling and particularly for the increasing pattern of internalising symptoms. Toumbourou et al (2011) found that low parent and peer attachment and poor emotional control were precursors of late adolescent depression for females, while for males, depression was predicted only by low emotional control. Such findings are consistent with theories proposing that interpersonal stress, parent–child relationship difficulties, and poor peer relationships are more predictive of the development of depression in females than males (Cyranowski, Frank, Young, & Shear, 2000). A related finding in this study was that persistent temperament acts as a protective factor for females only and that girls rated as having a persistent temperament in the early years of childhood were at decreased likelihood of belonging to an increasing trajectory.

Strengths and limitations of current findings

One of the strengths of the study is the examination of internalising symptoms prospectively over a broader age span from early childhood to preadolescence. The current study has a larger sample size than the two previous studies exploring child internalising trajectories over a similar age range and our sample is based on a nationally representative sample with a well define sampling frame. The study also uses multiple waves of data spanning the age period from 4/5 years through to 14/15 years. Another strength of the current study is that we the internalising symptom measure was administered across both childhood and during the pubertal adolescent period.

However, one of the common limitations of population based studies is the absences of diagnostics measures and instead reliance on symptom counts using parent or

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self-report. We need to be clear in interpreting these findings that symptoms levels are not equivalent to diagnosed disorders. However, both high depressive symptoms and diagnosed depressive disorders are associated with distress, functional impairment and developmental concern and therefore both should be investigated (Compas & Oppedisano, 2000). Another possible limitation of the current study is the use of the emotional symptoms scale of the SDQ. At face value these items appear to indicate anxiety features more than depressive symptoms. The recommended name of this subscale - "emotional subscale" - captures the fact that both anxious and depressive symptoms co-occur frequently in childhood and the SDQ does not strongly distinguish between them. However, there is some evidence such as the 2000 paper by Goodman which presents psychometrics of the SDQ with respect to a structured diagnostic measure of child psychiatric disorder and found that the sensitivity to the diagnosis of depression was 74.5% as compared to that of any anxiety disorder as 50.5%. As such there is some evidence to suggest that the scale in question does indeed refer to depressive symptoms in childhood, while equally the significance of these findings for anxiety symptoms may also be very relevant. Future studies would do well to make use of measures able to makes a clearer differentiation. Another limitation of the study was the use of predictors and symptom counts completed both by maternal report and this suffers from potential problems due to shared method variance.

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We conclude that there are discernibly distinct trajectories of depressive symptoms from childhood to adolescence and these trajectories are distinct for males and females. Our study is broadly consistent with earlier findings in terms of the proportion of the population assigned to stable and increasing trajectories and this is based on a representative sample from a large population study. There are also meaningful predictors of these early developmental trajectories such as risk due to maternal depression and reactive temperament and the protective factor of persistent temperament. Further

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development and evaluation of preventative interventions that target children in early childhood exposed to maternal depression and children with temperamental difficulties would appear to be indicated.

Conflict of interest

The authors have no conflict of interest in presenting the current paper for publication.

Author Statement:

All authors contributed to the production of this paper and met criteria for authorship. AJL deigned the study, gain permissions and access to the study data and conducted preliminary data analysis and wrote the MS. JSK undertook data analysis and focussed on presenting results and the tables and figures. JT and BR assisted AJL in the development of the ideas for the paper and revised drafts, and offered statistical advice and assistance to undertake the analysis. All authors have reviewed and approved a final draft of the paper prior to submission.

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Acknowledgements:

This article makes use of unit record data from Growing Up in Australia, the Longitudinal Study of Australian Children. The study has been conducted in partnership between the Australian Government Department of Families, Housing, Community Services and

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Indigenous Affairs (FaHCSIA), the Australian Institute of Family Studies (AIFS) and the Australian Bureau of Statistics (ABS). The findings and views reported in the current paper are those of the authors and cannot be attributed to FaHCSIA, AIFS or the ABS. LSAC study design and data collection were funded by FaHCSIA. The authors would like to thank Lynne Millar at Deakin University for assistance and advice in LSAC data management.

Role of Funding:

The current study was not supported by any specific source of funding.

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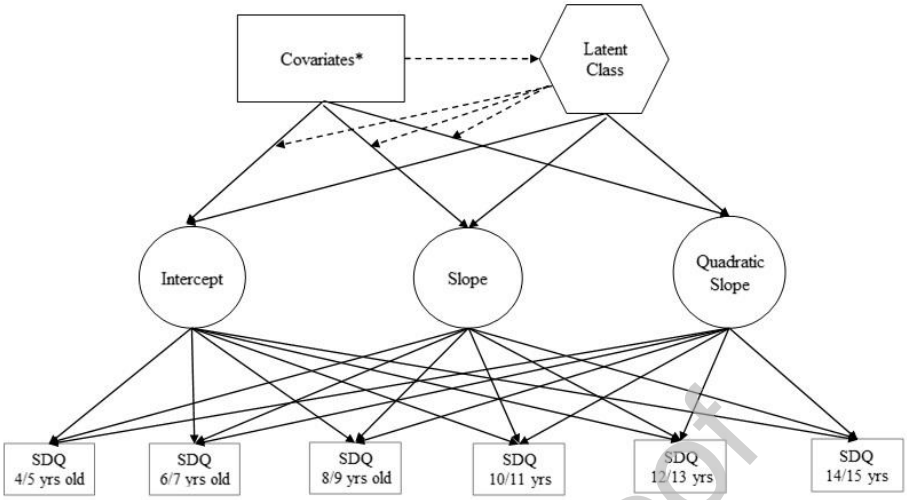
Figure 1: Conceptual Model of Covariate Influence on Latent Class Trajectories



**Covariates: Socio-Economic Index for Areas (SEIFA), Temperament (Sociable, Persistent, Reactive), Parental Warmth, Parental Anger, and Maternal Depression*

Figure 2: Four Class Quadratic Latent Trajectory Classes Categorized by Gender

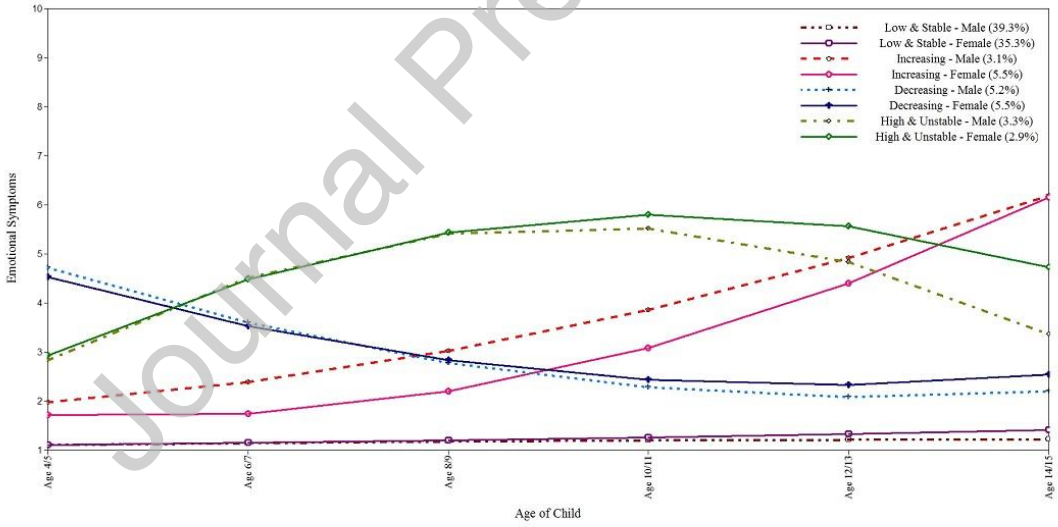


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Table 1

Demographic Characteristics of Parents and Children

Children	*(%)*	*N*
4 years	82.62	4,177
5 years	17.38	866
Male	50.91	2,537
Female	49.09	2,446
	M (SD)	*N*
Reactive	2.82 (0.98)	4,200
Persistent	4.04 (1.00)	4,199
Social	3.96 (1.27)	4,201
Parent	*M (SD)*	*N*
Parenting warmth	4.52 (0.55)	4894
Parenting anger	2.32 (0.64)	4890
Parent depression (C)	1.75 (0.73)	4198
Mother's age (baseline)	34.75 (5.48)	4981
Father's age (baseline)	37.51 (6.14)	4322
SIEFA	1005.72 (78.32)	4983
	(%)	*N*
Married (at time 1)	76.39	3,801

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Aus/New Zealand born	77.91	3,770
English as main language at home	84.4%	4206
Combined parental income less than $800 per week	29.20%	1359
Combined parental income $800-1499 per week	37.30%	1735
Combined parental income $1500 or more per week	33.60%	1563
Mother completed year 12	58.60%	2898
Father completed year 12	52.70%	2239

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Table 2.

Distribution of Emotional Symptoms on SDQ for Six Waves by Gender.

Emotional Symptoms	Total	Males	Females	
	M (SD)	M (SD)	M (SD)	N
Wave 1 (4/5yrs)	1.70 (1.67)	1.71 (1.69)	1.69 (1.00)	4968 (*m*= 2449; *f* = 2375)
Wave 2 (6/7yrs)	1.63 (1.69)	1.58 (1.71)	1.66 (0.93)	4341 (*m*= 2155; *f* = 2069)
Wave 3 (8/9yrs)	1.63 (1.77)	1.62 (1.79)	1.63 (0.88)	3802 (*m*= 1882; *f* = 1821)
Wave 4 (10/11yrs)	1.94 (1.96)	1.86 (1.96)	2.01 (0.91)	4116 (*m*= 2045; *f* = 1961)
Wave 5 (12/13yrs)	1.99 (1.97)	1.92 (1.97)	2.03 (0.88)	3853 (*m*= 1918; *f* = 1832)
Wave 6 (14/15yrs)	1.97 (2.00)	1.68 (1.78)	2.25 (0.82)	3369 (*m*= 1663; *f* =1616)

Note: *m* = male; *f* = female

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Table 3.

Model Fit for linear and quadratic models for child emotional symptoms

	ll	AIC	aBIC	Entropy	Lo	*p*	Model description
Model 1	-45421.79	90865.59	90902.27	-	-	-	1 Class Linear
Model 2	-44946.87	89921.74	89968.43	0.800	914.06	0.000	2 Class Linear
Model 3	-44697.18	89428.37	89485.07	0.817	480.55	0.000	3 Class Linear
Model 4	-44551.10	89142.21	89208.92	0.792	281.15	0.030	4 Class Linear
Model 5	-44471.88	88989.76	89066.47	0.773	152.48	0.129	5 Class Linear
Model 6	-44401.52	88855.04	88941.76	0.774	135.42	0.088	6 Class Linear
Model 7	-45296.09	90622.17	90672.20	-	-	-	1 Class Quadratic
Model 8	-44814.68	89667.37	89730.74	0.789	935.34	0.000	2 Class Quadratic
Model 9	-44510.85	89067.70	89144.41	0.799	590.33	0.000	3 Class Quadratic
Model 10	**-44298.74**	**88651.49**	**88741.54**	**0.812**	**412.11**	**0.026**	**4 Class Quadratic**
Model 11	-44176.60	88415.19	88518.59	0.808	237.33	0.226	5 Class Quadratic
Model 12	-44087.71	88245.43	88362.16	0.813	172.70	0.055	6 Class Quadratic

ll= Loglikelihood, aBIC= Sample-Size Adjusted Bayesian Information Criteria, AIC= Akaike Information Criteria

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Lo= Lo-Mendell-Rubin Adjusted LRT Test, p= significance value for Lo, **Bold**= selected model.

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Table 4: *Intercepts, Slopes and Proportions for Four Class Quadratic Trajectory Model (n = 4977)*

Classes	Intercept	Slope	Quadratic Function	n (%) in class
Class 1: Low & Stable	1.13	0.05	-0.001	3728 (74.89)
Class 2: Decreasing	4.62	-1.27	0.16	531 (10.67)
Class 3: Increasing	1.83	0.05	0.16	441 (8.86)
Class 4: High & Rising	3.02	1.99	-0.36	277 (5.57)

Table 5: *Intercepts, Slopes and Proportions for Four Class Quadratic Trajectory Model when Split by Gender (n = 4831; male =2456, female =2375)*

Classes	Intercept	Slope	Quadratic Function	n (%) in class
Class 1: Low & Stable				
1: Male	1.11	0.04	-0.002	1897 (77.23)
2: Female	1.11	0.04	0.005	1705 (71.79)
Class 2: Decreasing				
1: Male	4.72	-1.28	0.16	250 (10.18)
2: Female	4.53	-1.15	0.15	264 (11.12)
Class 3: Increasing				
1: Male	1.98	0.31	0.11	149 (6.07)
2: Female	1.71	-0.19	0.22	265 (11.15)
Class 4: High & Rising				
1: Male	2.84	2.08	-0.39	160 (6.51)

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2: Female	2.93	1.85	-0.30	141 (5.93)

Note: Patterns of missing data resulted in less cases than the total sample after splitting between gender. Percentages in each trajectory class are presented using respective denominators for gender breakdown.

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Table 6

Odds Ratio for Effects of Covariates on the Probability of Belonging to an Increasing/Decreasing/High & Unstable Trajectories vs. Low & Stable Trajectories for Males.

	Increasing Trajectory (1) vs. Low & Stable (0;c)*	Decreasing Trajectory (1) vs. Low & Stable (0;c)*	High & Unstable (1) vs. Low & Stable (0;c)*
Warm Parenting (Age 4)	1.56, p =.204	1.26, p =.385	0.95, p =.909
Parental Anger (Age 4)	0.94, p =.855	1.06, p =.806	1.65, p =.217
Maternal Depression (Age 4)	1.12, p =.696	1.29, p =.299	**1.84, p =.005**
Maternal Depression (Age 6)	1.40, p =.221	**1.88, p =.020**	1.01, p =.969
Sociable Temperament (Age 4)	1.00, p =.942	0.93, p =.637	1.18, p =.404
Persistent Temperament (Age 4)	0.69, p =.196	0.82, p =.261	1.23, p =.346
Reactive Temperament (Age 4)	1.06, p =.794	1.22, p =.376	**1.51, p =.054**
Sociable Temperament (Age 6)	0.91, p =.735	1.04, p =.846	**0.64, p =.051**
Persistent Temperament (Age 6)	0.76, p =.355	0.83, p =.339	0.85, p =.537
Reactive Temperament (Age 6)	**1.76, p =.012**	1.17, p =.408	0.82, p =.454
SEIFA (Above vs Below Average)	0.82, p =.413	0.97, p =.856	0.83, p =.279

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Birth	0.78, *p* =.201	1.00, *p* =.996	0.82, *p* =.135

Bold= predictors at or below p=.05

Table 7

Odds Ratio for Effects of Covariates on the Probability of Belonging to an Increasing/Decreasing/High & Unstable Trajectories vs. Low & Stable Trajectories for Females.

	Increasing Trajectory (1) vs. Low & Stable (0;c)*	Decreasing Trajectory (1) vs. Low & Stable (0;c)*	High & Unstable (1) vs. Low & Stable (0;c)*
Warm Parenting (Age 4)	1.70, *p* =.067	1.05, *p* =.808	1.41, *p* =.396
Parental Anger (Age 4)	0.89, *p* =.652	**1.81, *p* =.001**	1.93, *p* =.129
Maternal Depression (Age 4)	**2.01, *p* =.001**	1.34, *p* =.096	1.43, *p* =.282
Maternal Depression (Age 6)	1.01, *p* =.980	1.38, *p* =.061	1.23, *p* =.442
Sociable Temperament (Age 4)	1.16, *p* =.238	0.88, *p* =.254	0.90, *p* =.678
Persistent Temperament (Age 4)	1.20, *p* =.231	1.06, *p* =.697	1.50, *p* =.235

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Reactive Temperament (Age 4)	0.72, p =.105	1.10, p =.489	1.00, p =.990
Sociable Temperament (Age 6)	0.87, p =.330	0.89, p =.343	0.78, p =.382
Persistent Temperament (Age 6)	**0.58, p < .001**	0.86, p =.334	0.68, p =.206
Reactive Temperament (Age 6)	**1.64, p =.004**	**1.35, p =.014**	**1.75, p =.038**
SEIFA (Above vs Below Average)	0.89, p =.386	0.95, p =.627	0.97, p =.882
Birth	1.06, p =.636	0.90, p =.275	1.10, p =.682

Bold= predictors at or below p=.05

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