Early self-control development:

Prevalence, persistence and change in a NZ cohort

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Disclaimer

The views and interpretations in this report are those of the researchers and are not the official position of the Ministry of Social Development.

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Contents

Table of Contents

Tables

List of Figures

List of Tables in Appendix

Executive summary

Research has shown that higher levels of self-control in childhood are associated with improved health and financial outcomes, life satisfaction and decreased levels of substance abuse and criminal convictions in adulthood (Moffitt et al., 2011). Based on this retrospective analysis, the positive development of self-control is of interest to policy makers looking to promote success across the health, education, economic and social domains in adulthood.

Few studies to date have assessed early self-control at a population level; thus, less is known about the emergence of self-control in the early years of life. One exception is *The Dunedin Multidisciplinary Health and Development Study* which assessed self-control using a single composite self-control measure created from assessments taken between the ages of 3-11 years. They found that lower self-control was related to later poor health and financial outcomes and increased criminal offending in adulthood (Moffitt et al., 2011, 2013).

This study uses data from the contemporary longitudinal *Growing Up in New Zealand* (GUiNZ) study to increase our understanding of self-control development in the first five years of life. The GUiNZ study follows the development of around 6,800 children born in 2009 and 2010. Children were assessed using a variety of self-control related measures when they were 9 months, 2 and 4.5 years of age. Our primary aims were to:

1. Devise indices of self-control using relevant measures of children's behaviour at 9 months, 2 years and 4.5 years of age.
2. Validate the indices of self-control against the internationally recognised *Strengths and Difficulties Questionnaire* (SDQ).
3. Identify the early childhood familial and situational factors that promote or undermine the development of self-control.
4. Describe the stability of pre-schoolers' self-control and explore if there is an age where children at greater risk can be identified.
5. Identify factors that distinguish children with low self-control from those without low self-control across the preschool period.

Indices of self-control (SC) and child behaviour

Guided by an integrative developmental model of self-control (Gagne, 2017), indices were constructed that assessed three overlapping self-control domains: effortful control, delay of gratification and executive function. Our SC indices were found to significantly relate to children's behaviour on the *Strengths and Difficulties questionnaire* (SDQ) at 9 months, 2 years and 4.5 years of age.

- Higher levels of self-control at 9 months, 2 and 4.5 years of age were associated with greater prosocial behaviour.
- Lower levels of self-control at all three time points were associated with greater hyperactive behaviours.

- The self-control indices significantly predicted prosocial and hyperactive behaviours over and above factors already known to be predictive of these behaviours.

Factors that promote self-control development

We found that, over time, higher self-control was primarily associated with parenting behaviours, including telling and reading stories to their children, children having less screen time, families having more rules around a child's media exposure, warm and responsive parenting, and reporting warm rather than hostile couple relationships. Positive early neighbourhood environments were also consistently related to higher self-control over time. These effects were found after controlling for a range of socio-demographic factors.

Patterns of self-control development

We identified 26 distinct patterns of self-control development (low, medium, high) across our three time points (9 months, 2 years and 4.5 years).

- The developmental pattern for the majority of the sample (63%) did not include a classification of low self-control.
- Only 8% of the sample were classified as exhibiting two or more periods of low self-control and less than 1% of children were classified as persistently low across all time points.
- Children who demonstrated one or more period of low self-control were more likely to demonstrate fewer prosocial behaviours and greater hyperactivity at 4.5 years of age.
- Children with two or more periods of low self-control were distinguished from children with no periods of low self-control by a number of demographic, child, family and environmental factors and maternal behaviours.

Conclusions

- At the individual level, we demonstrated considerable change in our classification of low self-control during the preschool period.
- Using our early measures (9 months, and 2 years) of self-control, it is not possible to identify individual children with certainty who are likely to experience poor self-control at 4.5 years.
- Our findings do not support targeting individual pre-schoolers for self-control intervention, instead our results suggest that promoting universal population-based strategies to optimise the development of self-control in pre-schoolers may still be worthwhile and potentially valuable.
- Our findings suggest that self-control can be promoted at the population level. We found that behaviours such as reading books or telling stories to children, implementing rules around children's screen time, and encouraging shared parent-child interactions may help in developing children's self-regulatory strategies.

- Our findings also suggest that at the population level, those children with two or more periods of low self-control may benefit from strategies that increase support for families living in more deprived areas, mothers experiencing postnatal depression, and those living in neighbourhoods with fewer resources. Strategies that encourage parents to have more shared and respectful parent-child interactions and to have rules around their child's screen time may also be beneficial for helping children use their capacity for self-control more effectively.

Introduction

Development of self-control

Self-control is the capacity for altering one's responses to bring them into line with appropriate standards (Duckworth & Kern, 2011), or the strength required to resist an impulse. It is argued to be a subset of self-regulation (which involves managing the frequency and intensity of emotions and impulses and recovering) which makes self-control (resisting the impulse) possible (Shanker, 2016).

Retrospective studies have found that children with high self-control in their early years have better educational achievement, less involvement with the criminal justice system, and better physical and mental health throughout life (Caspi et al., 2016; Moffitt et al., 2011). Consequently, self-control is increasingly portrayed as a powerful way to address many of society's problems resulting in growing interest in self-control from government agencies, educators and the general public.[1]

Increasingly there has been a distinction made between trying to develop a child's capacity for self-control and a child developing knowledge, skills, and strategies to help with the implementation of this capacity (see, Duckworth, Gendler & Gross, 2016). Numerous programmes have been developed to try to raise self-control capacity (e.g., computerised training to improve executive functioning), however the effectiveness of these programmes is increasingly debated: many studies show minimal gains and low transference across tasks (for a review, see Diamond, 2012).

Rather than looking at developing self-control capacity directly, there is a growing trend to look at how parents and caregivers can use co-regulation to help children develop strategies and motivation to use their self-control (Rosanbalm & Murray, 2017). Co-regulation is argued to involve providing warm and responsive relationships, structured environments and the coaching and modelling of self-regulatory skills (Rosanbalm & Murray, 2017) that will help a child to use their self-control. In this study we seek to explore some of these individual and family factors that may help to promote self-control within a large and diverse New Zealand cohort of pre-schoolers.

[1] Notably, there has been little discussion of the costs of focusing on self-control improvement and if more self-control is always better (see, Uziel, 2018). Further, what is meant by the term *self-control* also differs with some arguing the discourse should instead be one of patience, tolerance, self-reflection and spontaneity rather than self-control.

Aotearoa New Zealand context

The importance placed on early self-regulation (a term often used interchangeably with self-control) is reflected in the *Aotearoa New Zealand, Early Childhood Curriculum: Te Whāriki* (Ministry of Education, n.d.). In line with international evidence, and a co-regulation approach to developing self-control, *Te Whāriki* highlights the need for early childhood teachers to give children the time, space, and opportunities 'to practise and rehearse activities that build their self-regulation competence'. *Te Whāriki* also recommends that curriculum designers consider whether teachers themselves have sufficient knowledge about the development of self-management skills to role-model them and support children's learning outcomes.

Reflecting the importance being placed in New Zealand on the early development of self-regulation, the Ministry of Education has recently funded a trial of The ENGAGE (Enhancing Neurobehavioural Gains with the Aid of Games and Exercise) programme developed by researchers at the University of Otago. ENGAGE is based on studies that show that children's involvement in structured play may improve their self-regulation abilities (Healey & Healey, 2019).

Given the expense often associated with running interventions, there is a growing call for ways to identify individuals who might benefit from targeted interventions such as ENGAGE. The current study in part responds to this call by also exploring whether it is possible to reliably identify pre-schoolers at risk of lower self-control, as well as some of the factors (e.g., parenting behaviours) that might be useful to promote within such programmes.

Measuring early self-control

Traditionally, the development of self-control was considered homogenous and stable. However, recent evidence shows that self-control development occurs dynamically during childhood (Pan & Zhu, 2018) and displays heterogeneous growth patterns (Coyne & Wright, 2014; Duckworth & Steinberg, 2015; Diamond et al., 2015). That is, self-control development over time shows continuity in its general purpose or function, but changes in its behavioural manifestation over time (Petersen et al., 2016).

This changeability in how self-control is expressed in infancy and childhood makes it difficult to measure, which in turn has implications for the extent to which we can reliably identify individuals with low levels of self-control for possible intervention. In other words, although there is a common conceptual thread of voluntary self-governance underpinning self-control (Duckworth & Kern, 2011), different developmentally appropriate and sensitive measures are needed to assess self-control across childhood (Petersen et al., 2016) and great care is needed when seeking to identify individuals with particular levels of self-control at any given point in time.

In part due to the complexity of measuring early self-control, very little is known about the emergence and change in self-control in the first years of life. Arguably one well known exception is New Zealand's *Dunedin Multidisciplinary Health and Development Study* which assessed childhood self-control by creating a composite measure which included assessments taken in the 3-11 year age range (Moffitt et al., 2011). The *Dunedin Study* researchers also constructed a separate measure of *early* self-control using *only* the observer ratings taken at ages 3 and 5 years (i.e., observer reports on child assertiveness, concentration, focus, etc.), however most of their published research focuses on the associations they found using the single composite self-control measure based on the much wider age range (3-11 years), as this reported larger effects.

Using their 3-11 year composite self-control index, Moffitt and colleagues found that their self-control index was related to later poor health and financial outcomes and increased criminal offending in adulthood (Moffitt et al., 2011, Moffitt et al., 2013). While, their *early* self-control index (based on observer reports of 3-5 year olds) was also found to predict outcomes at aged 32, these had small effect sizes and hence were not the primary focus of their papers (Moffitt et al., 2011).

Unlike the *Dunedin Study*, our study set out to create three early composite measures of self-control (at 9 months, 2 years and 4.5 years) and where possible we drew on self-control data collected from multiple sources (child proxy questionnaire, behavioural observations, and child cognitive test performance), rather than just using observations. In addition, while we were to some extent limited developmentally by what aspects of self-control we could assess when the children were infants, where possible we chose measures that sought to capture a range of self-control behaviours that aligned with Gagne's (2017) multidimensional model of self-control (described below).

Finally, unlike the *Dunedin Study*, which primarily focused on what self-control from ages 3-11 predicts, our study briefly validated our index against an established scale of behaviour (The *Strengths and Difficulties Questionnaire*, Goodman, 1997), then focused on what factors predict early self-control to try to inform policy-relevant strategies aimed at optimising children's early self-control capacities.

Theoretical model of self-control

A multi-theoretical and multi-methodological approach is required to gain a comprehensive understanding of early self-control development (Gagne, 2017). This study was guided by an integrative developmental model of self-control comprised of three overlapping domains: effortful control, delay of gratification, and executive function (see Figure 1).

- **Effortful control (EC)** is a dimension of temperament related to the early self-regulation of emotional reactivity and behaviour (Liew, 2012). It is typically measured using parental report questionnaires.
- **Delay of gratification** is the ability to sustain self-imposed control of impulses in order to obtain a delayed reward (Mischel, Shoda, & Rodriguez, 1989). It is typically measured using observational tasks.
- **Executive functions** are the set of processes that underpin the ability to engage in self-control and include working memory (WM), inhibitory control, planning and attentional flexibility (Diamond, 2013; Gagne 2017). It is typically measured using cognitive experimental tasks.

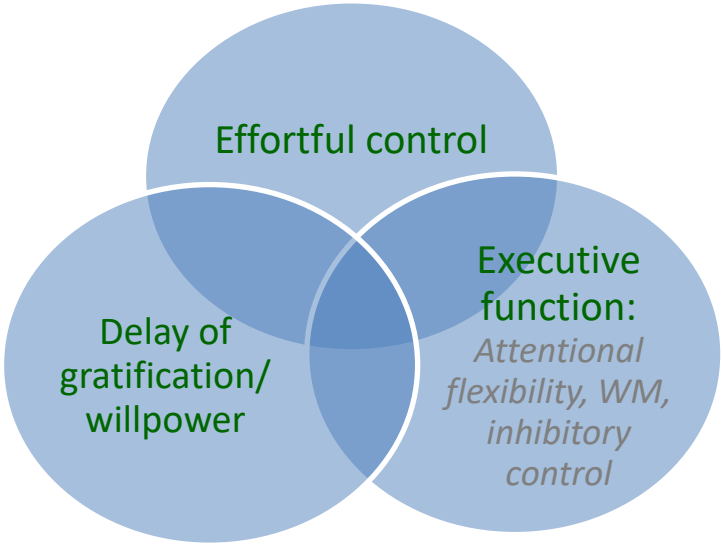

Figure 1. Gagne's (2017) integrated model of self-control in children

Gagne (2017) argued that "Integrating these perspectives will allow developmental scientists to reach more informed conclusions about this increasingly important construct" (p. 131). However, the self-control related competencies of children at 9 months and 2 and 4.5 years differ considerably from each other. As a result, it is not possible to assess all three domains of Gagne's model of self-control at 9 months. Accordingly, the SC indices were developed to capture developmentally appropriate components of self-control that could be measured using Growing Up in New Zealand data. The indices were also constructed so that they could be readily used by others in the field.

Conceptual framework for exploring the predictors of early self-control

Drawing on both *Growing up in New Zealand's* conceptual framework (Morton et al., 2010) for understanding child development and Bronfenbrenner's (1994) *Ecological Model of Human Development*, this study explored how a broad range of socio-demographic factors (e.g., ethnicity, age), child factors (e.g., health, disability), maternal factors (e.g., mental health, employment), child environment factors (e.g., child care attendance), Family factors (family stress, parenting behaviour and practices), and societal factors (e.g., Neighbourhood belonging, access to social services) were associated with self-control development in pre-schoolers. Of particular interest to this study are the contextual factors that parents, educators and those working with young children can potentially promote to enhance self-control development. The variables used in our study are described in more detail in Tables A1 and A2 in the Appendix.

Aims and objectives of this study

Overall in this study we set out to measure early self-control drawing on Gagne's (2107) multi-theoretical and multi-methodological approach to help identify appropriate tools. We constructed three developmental indices of self-control (9 months, 2 years and 4.5 years) and then briefly validated these against a well-known and widely used measure of behaviour used in the *Growing Up in New Zealand* study at the 2 and 4.5 year data collection waves.

Next, drawing on our conceptual framework, we sought to identify if there were individual, family and societal factors associated with development of self-control at 9 months, 2 years and 4.5 years as well as how stable self-control was across this pre-school period. Finally, we explored if there are factors that could be used to distinguish those at risk of low self-control across the preschool period with a view to mitigating against such trajectories.

More specifically we aimed to:

1. Devise indices of self-control using measures from 9 months, 2 years and 4.5 years.
2. Validate the indices of self-control against the validated, internationally recognised *Strengths and Difficulties Questionnaire* (SDQ).
3. Identify the early childhood familial and situational factors that promote or undermine the development of self-control.
4. Describe the stability of pre-schoolers' self-control and explore if there is an age that children at greater risk of developing low self-control can be identified.
5. Identify factors that distinguish children with low self-control from those without a pattern of low self-control across the preschool period.

Method

Engagement with policy collaborators

This project has been a collaboration between researchers at the University of Auckland and the Ministries of Education, Health and Treasury, Education and Population Agencies team, and Plunket. Early in the research, a working group was established with these key partners to try to ensure we investigated questions that are of interest to the Ministries and Plunket and that our report could inform the needs of policy makers.

The policy working group was led by our research partner within the Ministry of Education, Siobhan Murray (Senior Manager, ECE policy). We met with the working group three times (February, April and August 2019) to review the project aims, identify areas of priority interest in children's self-control, and to discuss preliminary and final research findings.

At the outset of the project, the research team also met with the Office of the Prime Minister's Chief Science Advisors for the Ministry of Education (Professor Stuart McNaughton) and Justice Sector (Associate Professor Ian Lambie) to discuss relevant self-control factors to include in the study.

A draft of this report was shared with our research partners, who provided important feedback. This process helped to ensure we produced a high-quality output that, where possible, answered questions that were of interest to policy makers.

Participants

Participants were the mothers and their children who are part of the *Growing Up in New Zealand* (GUiNZ) longitudinal pre-birth cohort. Mothers were recruited during pregnancy from three contiguous District Health Boards: Auckland, Counties Manukau and Waikato. These regions were chosen because of their ethnic and socio-economic diversity (Morton et al., 2012). Eligible for inclusion were all pregnant women who lived in this region who were due to give birth between 25th April 2009 and 25th March 2010. A multi-faceted strategy was used to recruit a sample broadly generalisable to the contemporary New Zealand national birth cohort (Morton et al., 2014). The enrolled child cohort included 11% of the births in New Zealand during the recruitment period and is broadly representative of all births between 2007 and 2010 with respect to ethnicity, maternal age, parity and socio-economic position (Morton et al., 2015).

Ethical approval was obtained from the Ministry of Health Ethics Committee. Written informed consent was obtained from all participating mothers. In total, 6,822 mothers were interviewed during pregnancy, who collectively gave birth to 6,853 children (Morton et al., 2012).

Procedure

Mothers were interviewed about topics across the multiple domains described in the GUiNZ conceptual framework. These domains include health, psychosocial and cognitive development, family and whānau, education, culture and identity, and neighbourhood and societal context (Morton et al., 2012). Trained interviewers conducted interviews in mothers' homes when the cohort children were approximately 9 months, 2 years and 4.5 years old. Interviews were face-to-face and computer-assisted and took approximately 90 minutes to complete. More details on interviewer training and reliability is given in Appendix 1.

Measures

Self-control indices

The development of our indices of self-control were informed by Gagne's (2017) integrative developmental model of self-control and derived from GUiNZ multimodal assessments administered when the children were approximately 9 months, 2 years and 4.5 years of age.

Starting with children in the 4.5 year data collection wave, a self-control index was calculated for each child who had data on the measures included in the 4.5 year, 2 year and 9 month self-control indices. As a result, the self-control indices were calculated for 5835 children at 4.5 years, 5697 children at 2 years and 5689 children at 9 months. Where the analysis involved matching a child's self-control index over time, only children with complete data at each time point were included in the analysis. In addition, if more than one child was born, only one child was entered into the analysis.

The self-control (SC) indices consisted of the following broad areas (more details on the measures making up each index and the index construction is given in Appendix 1).

- 9 month SC index: maternal reports of their child's emerging temperament, specifically their effortful control and attention;
- 2 year SC index: mother-reported child regulation along with an age appropriate observational task that measured executive function, inhibitory control and attention; and
- 4.5 year SC index: maternal reported effortful control (temperament), an experimental executive function task that assessed inhibitory control and attention, an observational delay of gratification task and an observer report of the child's affective behaviour and emotional self-management.

Patterns of self-control

At each time point, participants were classified as having high, average or low self-control using one standard deviation (SD) as the strict cut-off. Participants were categorised as having low self-control relative to the rest of the sample if their mean SC index score was less than 1 SD below the mean, average if their mean SC index score was between -1 SD and 1 SD, and high if their mean SC index score was greater than 1 SD above the mean.

Strength and Difficulties Questionnaire (SDQ; Goodman, 1997)

The *Strengths and Difficulties Questionnaire* (SDQ) is a 25-item internationally recognised behavioural screening questionnaire for children and adolescents. In the GUiNZ study, SDQ ratings for each child were provided by mothers at 2 years and at 4.5 years of age.

The questionnaire consists of five subscales, each measured by five items, which include emotion (positive, negative), peer problems, hyperactivity-inattention, conduct problems and prosocial behaviour. Items are rated on a 3-point Likert Scale as either not true, somewhat true, or certainly true. The scales have been validated within the GUiNZ cohort (e.g. D'Souza et al., 2017; D'Souza et al., 2019). The total difficulties score is a sum of the difficulties subscales and ranges from zero to 40. Higher scores reflect greater difficulties.

Socio-demographic, ethnicity and predictor variables

In this study, data from the antenatal and 9 month interviews were used for socio-demographic and ethnicity variables and maternal background characteristics. Mothers were asked a range of standard demographic questions at the antenatal interview. Socio-economic deprivation was measured using the decile scale of the *NZ Index of Deprivation* (Salmond et al., 2007) grouped in tertiles where 1-3 was low deprivation, 4-7 was medium deprivation and 8-10 was high deprivation. Maternal education was based on mothers' highest qualification. Mothers' self-prioritised ethnicity was grouped into the following categories: European, Māori, Pacific, Asian and Other. Mother's age at the time of the child's birth was included. Child parity was measured as whether the cohort child was the mother's first or subsequent child. Rurality was measured by mother's report as to whether they lived in a rural or urban area. Tables A1 and A2 in the Appendix 2 present a summary of the demographic, caregiver, child, family and environmental predictor variables used in this study. More detail on each measure can be found on www.growingup.co.nz.

Data analysis

A series of multivariate regression analyses were used to examine (1) the relationship between the self-control indices and the SDQ at 2 and 4.5 years of age and (2) identify predictors of self-control at 2 and 4.5 years of age. A series of independent t-tests was also conducted to examine factors that distinguished

a developmental pattern of low self-control and a logistic regression. A *p* value of < 0.05 was considered statistically significant, although a more conservative *p* value was set for the t-tests ($p<.001$). All analyses were carried out using IBM SPSS Statistics version 25.0.

Missing data

Typical of longitudinal studies, at all three time points a number of participants had incomplete data on some variables used in this study. We used multivariate imputation by chained equations (MICE), an established procedure for imputing missing data. Next, we examined whether the imputed and observed data sets systematically differed according to a set of sociodemographic predictors of the self-control indices. The results showed that there was no statistical advantage to using the imputed data set and therefore, as observed data is more transparent than imputed data, the data set was subsequently analysed using partial missing data. The default method (listwise deletion) used for regression in SPSS was the method of handling missing data. In large samples, listwise deletion has been demonstrated to be a reasonable management strategy (Kang, 2013).

Results

In this study we set out to create three indices of early self-control development and to briefly validate these against the SDQ. We then identified if there were individual, family and societal factors associated with development of self-control at 9 months, 2 years and 4.5 years. Following this, we explored how stable self-control was across this pre-school period and if any factors could predict these different patterns of stability. Finally, we explored if there were factors that could be used to distinguish those at risk of low self-control across the preschool period.

Correlations between self-control (SC) indices

We found that the SC indices were significantly ($p < .001$) and positively related to each other (see Table 1). Correlation coefficients ranged from $r = .06$ (9 months - 2 Years) to $r = .15$ (2 Years - 4.5 years). The small correlation coefficients suggest that the SC indices may be picking up different aspects of self-control across the preschool years and / or that that there is considerable change in self-control across time leading to instability.

Table 1. Correlations between Self-Control indices

		1	2
1	9-month Self Control Index (N = 5689)		
2	2-year Self Control Index (N= 5697)	.063**	
3	4.5-year SC Index (N= 5835)	.096**	.153**

*Note: **p<.01*

Validation of self-control (SC) indices

Relationship between SC indices and the Strengths and Difficulties Questionnaire

Self-control is associated with childhood behaviour (Rosanbalm & Murray, 2017). In line with evidence that the Strengths and Difficulties Questionnaire (SDQ) contains items likely to be affected by self-control abilities (Lakes, 2013), we validated the SC indices in two ways:

(1) we tested the extent to which the SC indices predicted the prosocial, hyperactivity, emotion, conduct and peer problem subscales and total difficulties on the 2 and 4.5 year SDQ;
(2) we tested the extent to which the SC indices predicted the SDQ over and above factors known to be predictive of childhood strengths and difficulties.

Relationship between SC and two-year and 4.5-year SDQ

Overall, the findings indicate that our SC indices at each time point were consistently and significantly associated with higher levels of prosocial behaviour and lower levels of hyperactivity and total difficulties at 2 years and 4.5 years of age. Tables 2 provides a summary of the main regression analyses findings presented in Tables 3 and 4.

For the most part, the three SC indices explained little or no variance (≤ 1%) in the peer problem, conduct and emotion subscales of the SDQ at 2 years. At 4.5 years, the SC indices explained slightly more (< 6%) of variance in these SDQ subscales (see Tables 3 and 4).

Table 2. Summary of the amount of SDQ variance explained by the self-control indices in a step wise regression

		SC index		
Variance explained in SDQ scales		**9 months**	**2 years**	**4.5 years**
Prosocial behaviour	At 2 years	2.8%	5.4%	-
	At 4.5 years	3.0%	4.7%	12.1%
Hyperactivity	At 2 years	2.3%	3.2%	-
	At 4.5 years	1.1%	1.6%	15.2%*
Total difficulties	At 2 years	1.7%	2.0%	-
	At 4.5 years	1.1%	1.2%	11.4**

* For hyperactivity at 4.5 years, the variance explained by the 2 year SC index was not statistically significant. This finding suggests that including the 4.5 year SC index may remove variance explained in hyperactive behaviour by the two-year SC index.
** For total difficulties at 4.5 years, the variance explained by the 2 year SC index was also not statistically significant. This finding suggests that including the 4.5 year SC index may remove variance explained in total difficulties behaviour by the two year SC index

Somewhat surprisingly we found no significant relationship between our 9 month and 2 year indices and the 2 year SDQ emotion subscale. The positive association between the 2 year SC index and the emotion problems subscale at 4.5 years was also unexpected. One possible explanation is that the SDQ Emotion subscale contains items related to being fearful (a behaviour associated with emerging regulation: see Rothbart, 2011) as well as items about being worried and unhappy (associated with less self-control). This mix of items that are potentially both positively and negatively associated with later self–regulation may account for these mixed results between on our SC index and emotion problems.

Relationship between self-control and two year and 4.5 year SDQ over and above known predictors of SDQ

Next we investigated whether the SC indices predicted prosocial and hyperactivity subscales of the SDQ over and above a range of demographic, family and child factors, maternal behaviours and environment factors. This was done to ensure that the indices were predicting something unique over and above a wide range of possible individual, family and societal factors that may also be related to hyperactivity and prosocial behaviour. To do this we entered

the self-control indices in the last block of a hierarchical regression. A summary of the types of factors in each block and the order they were entered is presented in Table 5. The amount of change in variance explained by the self-control indices entered in the final step in each model is shown in Table 6.

Our main finding was that the relationships between the SC indices at each time point and prosocial and hyperactivity at 2 and 4.5 years remained statistically significant over and above a wide range of known demographic, child, parent, family and environmental predictors. The amount of change in the variance explained by the SC indices in hyperactivity and prosocial behaviour entered in over and above the predictors was small, but statistically significant. The change in the variance explained by the SC indices was greater for the 4.5 year SDQ outcomes than for the 2 year outcomes, particularly for hyperactivity.

Notably, the amount of change in the variance explained by the 2 year SC index in 4.5 year prosocial behaviour is reduced (and is decreased to zero for hyperactivity) when the 4.5 year SC index is entered in the model. This finding suggest that the aspects of self-control assessed by the 2 year and 4.5 year indices (which assess two and three domains of self-control respectively) may be more similar than those captured by the 9 month index which measures one domain.

In summary, taken together, the findings (see Tables 1-5) provide provisional evidence of the validity of our SC indices.

- Our three SC indices were found to be related to children's hyperactivity and prosocial behaviours subscales on the Strengths and Difficulties Questionnaire. Overall, higher levels of self-control were associated with higher prosocial behaviour and lower hyperactivity. Of note, including the SC index at 4.5 years appeared to remove the variance explained in hyperactivity by the SC index at 2 years.
- As expected, proximal SC indices had a greater impact on SDQ outcomes at 4.5 years compared to those from more distal time points.
- Although the 9 month SC index explains relatively little variance in hyperactivity and prosocial behaviour, it remains statistically significant, as does the 4.5 year SC index. The 2 year SC index predicts hyperactivity and prosocial behaviour at 2 years, but becomes non-significant for 4.5 year outcomes when the 4.5 year SC index is added to the model.

Table 3. Regression analysis predicting strengths and difficulties at 2 years from child's self-control at 9 months (Step 1) and 2 years (Step 2).

	Step 1						***Step 2***					
Predictors	*B*[a]	*SE*	*p*	*R*	R^2	$\triangle R^2$	*B*[a]	*SE*	*p*	*R*	R^2	$\triangle R^2$
Prosocial Behaviour				.167	.028	.028				.232	.054	.026
(N= 5577)												
9mth Self-control	**.167**	**.024**	**< .001**				**.157**	**.024**	**< .001**			
2Yr Self-control							**.161**	**.024**	**< .001**			
Emotional Problems				.017	.000	.000				.017	.000	.000
(N=5578)												
9mth Self-control	-.017	.021	.206				-.017	.021	.206			
2Yr Self-control							.004	.022	.747			
Conduct Problems				.104	.011	.011				.108	.012	.001
(N=5578)												
9mth Self-control	**-.104**	**.026**	**< .001**				**-.102**	**.026**	**< .001**			
2Yr Self-control							**-.031**	**.026**	**.020**			
Hyperactivity				.152	.023	.023				.180	.032	.009
(N=5577)												
9mth Self-control	**-.152**	**.028**	**< .001**				**-.146**	**.028**	**< .001**			
2Yr Self-control							**-.097**	**.028**	**< .001**			
Peer Problems				.063	.004	.004				.069	.005	.001
(N=5575)												
9mth Self-control	**-.105**	**.022**	**< .001**				**-.102**	**.022**	**< .001**			
2Yr Self-control							**-.045**	**.022**	**.043**			
Total Difficulties				.129	.017	.017				.142	.020	.004
(N= 5580)												
9mth Self-control	**-.129**	**.068**	**<.001**				**-.125**	**.068**	**< .001**			
2Yr Self-control							-.06-	.068	**< .001**			

NB: a = standardised beta weight

Table 4. Regression analysis predicting strengths and difficulties at 4.5 years from self-control (SC) at 9 months (Step 1), 2 years (Step 2) and 4.5 years (Step 3).

	Step 1						***Step 2***						***Step 3***					
Predictors	*B*[a]	*SE*	*p*	*R*	R^2	$\triangle R^2$	*B*[a]	*SE*	*p*	*R*	R^2	$\triangle R^2$	*B*[a]	*SE*	*p*	*R*	R^2	$\triangle R^2$
Prosocial Behaviour (N= 5576)				.173	.030	.030				.216	.047	.017				.349	.121	.075
9mth SC	**.173**	**.024**	**< .001**				**.165**	**.024**	**< .001**				**.141**	**.023**	**< .001**			
2Yr SC							**.130**	**.024**	**< .001**				**.089**	**.023**	**< .001**			
4Yr SC													**.278**	**.023**	**< .001**			
Emotional Problems (N= 5577)				.027	.001	.001				.040	.002	.001				.087	.008	.006
9mth SC	**-.027**	**.024**	**.043**				**-.029**	**.024**	**.031**				-.022	.024	.100			
2Yr SC							**.030**	**.024**	**.026**				**.041**	**.024**	**.002**			
4Yr SC													**-.078**	**.024**	**< .001**			
Conduct Problems (N= 5576)				.099	.010	.010				.101	.010	.000				.249	.062	.052
9mth SC	**-.099**	**.024**	**< .001**				**-.097**	**.024**	**< .001**				**-.077**	**.024**	**< .001**			
2Yr SC							-.019	.025	.144				.014	.024	.291			
4Yr SC													**-.232**	**.024**	**< .001**			
Hyperactivity (N=5577)				.107	.011	.011				.128	.016	.005				.390	.152	.136
9mth SC	**-.107**	**.030**	**< .001**				**-.102**	**.030**	**< .001**				**-.069**	**.028**	**< .001**			
2Yr SC							**-.070**	**.030**	**< .001**				-.016	.029	.199			
4Yr SC													**-.374**	**.029**	**< .001**			
Peer Problems (N= 5577)				.041	.002	.002				.051	.003	.001				.176	.031	.029
9mth SC	**-.041**	**.021**	**.002**				**-.039**	**.021**	**.003**				-.024	.021	.068			
2Yr SC							**-.030**	**.021**	**.024**				-.006	.021	.678			
4Yr SC													**-.171**	**.021**	**< .001**			
Total Difficulties (N= 5576)				.103	.011	.011				.110	.012	.001				.337	.114	.102

9mth SC	**-.103**	**.069**	**< .001**	**-101**	**.069**	**< .001**	**-.072**	**.066**	**< .001**
2Yr SC				**-.037**	**.070**	**.006**	**.010**	**.067**	**.430**
4Yr SC							**-.324**	**.067**	**< .001**

NB: a = standardised beta weight

Table 5. Factors entered step wise into hierarchical regressions for predicting 2 and 4.5 year prosocial behaviour and hyperactivity.

Sequence of steps predicting 2year hyperactivity and prosocial behaviour		
Input order (steps)	Factor grouping	Constructs
1	Socio-demographics	Child gender, gestational term, planned pregnancy, age of mother, self-prioritised ethnicity of mother, education of mother, area deprivation.
2	Family factors	Maternal depression, parental conflict, maternal employment, parental relationship warmth, family stress, parental job
3	Child factors: 9M	Child health, child language development
4	Maternal behaviours: 9M	Engagement with child, parenting confidence, closeness with the child, child screen time, reading books, singing songs
5	Environmental factors: 9M	Childcare, rurality, siblings
6	Child factors: 2Yr	Sleep, health
7	Maternal behaviours: 2Yr	Engagement with child, telling stories to child, reading books to child, child plays instruments, rules around child's tv, video and DVD watching, discipline
8	Environmental factors: 2Yr	Siblings, Childcare, positive neighbourhood environment, neighbourhood safety, family social services accessed, rurality
9	Self-control 9M	9 month SC Index
10	Self-control 2Yr	2 year SC index
Additional sequence of steps for hierarchical regression predicting 4.5 year hyperactivity and prosocial behaviour		
Input order (steps)	Factor grouping	Constructs
9	Child factors: 4.5Yr	Sleep, health, age at 4.5 year interview, child activity level
10	Maternal behaviours: 4.5Y	Mother dominated parent-child interaction, child dominated parent child interaction, read books to child, tell stories to child, rules around child's TV and DVD time, parenting style (warm and empathetic- authoritative, authoritarian, permissive and corporal punishment).
11	Environmental factors: 4.5Yr	Social services accessed, rurality, siblings
12	Self-control 9M	9 month SC Index
13	Self-control 2Yr	2 year SC index
14	Self-control 2Yr	4.5 year SC index

Table 6. Change of variance explained in 2 and 4.5 year prosocial and hyperactivity behaviour by self-control (SC) at 9 months, 2 years and 4 years over and above a set of predictors entered in earlier blocks

Prosocial 2 years (N= 4619)	R^2 change	Prosocial 4.5 years (N=4114)	R^2 change
9 month	0.7% ***	9 month	0.6% ***
9 month, 2 year	1.5% ***	9 month, 2 year	0.2% ***
		9 month, 2 year, 4.5 years	2.9% ***
Hyperactivity 2 years (N=4619)		Hyperactivity 4.5 years (N=4144)	
9 month	0.8% ***	9 month	0.4% ***
9 month, 2 year	0.4% ***	9 month, 2 year	0%
		9 month, 2 year, 4.5 years	6.8% ***

Note: *** $p < .001$; Predictors in the model included: demographic factors, child factors, parental factors, parenting behaviours and environmental factors (see Table 5).

Predictors of self-control

A series of hierarchical regressions was used to explore the demographic and family factors, and child, mother behaviours and environmental factors that predict higher levels of SC at 2-and 4.5-years. We used the same set of predictors that were used in Table 5, but the order of entering predictors into the model differed, with prior self-control controlled for by being entered into the model in the first rather than the last steps, followed by demographics and family contextual factors. Next, child, maternal behaviours and environmental factors were entered in steps in temporal order. Table 6 (2 year SC) and Table 8 (4.5 year SC) present the results of the final model for the stepped hierarchical regressions analyses.

Predictors of self-control index at 2 years

We found that higher self-control scores on our index at age 2 years was significantly associated with the following factors (see Table 7):

- Higher scores on the 9 month SC index.
- Demographics: being a girl, being born to a young mother (< 20 years) or a mother with no secondary education and living in an area with lower deprivation compared to middle deprivation.
- Family factors: greater couple warmth (2 years).
- Child factors at 9 months: higher levels of infant communication development.
- Child environment 9 months: living in a rural environment.
- Maternal behaviours at 9 months: Mother's lower engagement with the child and child exposed to less screen time.
- Child factors 2 years: child health reported as good or excellent.
- Maternal behaviours 2 years: tells stories to child more often, mother plays with musical instruments or toys with child, rules around hours of TV, videos and DVDs a child watches.
- Environmental factors 2 years: positive neighbourhood environment.

Predictors of self-control index at 4.5-years

We found that higher self-control scores on our index at 4.5-years was significantly associated with the following factors (see Table 8):

- Higher scores on the 9-month and 2-year SC indices.
- Demographics: not being born pre-term, being a planned pregnancy, being a girl, being born to an Asian or Pacifika mother (vs European) and mother completing secondary school.
- Family environment: greater couple warmth (9 months and 2 years) and increased family stress.
- Maternal behaviours 2 years: rules around TV, videos and DVDs watching by the child, and reading books to child.
- Environmental factors 2 years: positive neighbourhood environment.
- Child factors at 4.5 years: child age at interview date and good child health.
- Maternal behaviours at 4.5 years: maternal praise and encouragement, reading books to child, telling stories, rules around child's TV and DVD time, low permissive and corporal punishment parenting style, higher emotionally supportive and relational parenting and shared mother - child interactions (vs mother-or-child dominated interactions).
- Environmental factors 4.5 years: less use of family social services.

Summary of the predictors of the self-control index

The results suggest that there are potentially modifiable factors that could increase self-control or mitigate a decline in self-control across the preschool years.

Controlling for demographic factors, the modifiable factors that over time contributed most to differences in scores on the self-control indices were maternal behaviours[2].

We found that having rules for the child around screen time at 9 months was associated with increased self-control at 2 years, and having rules for the child about TV, video and DVD watching and reading books to your child at 2 years was associated with better 4.5 year self-control.

In general, contemporaneous measures of maternal behaviours and self-control revealed stronger effects. For example, reading books, telling stories, and having rules around a child's screen time at 2 years related to higher self-control at 2 years. Likewise, reading books, telling stories, shared mother child interactions, more warm and empathetic parenting and having some parenting rules (but not physically punitive parenting) was related to 4.5 year self-control. Similarly, we also found that couple warmth at 2 and 4.5 years of age was consistently linked with higher self-control at 2 and 4.5 years of age.

In terms of demographic and environmental factors associated with self-control, we found that being a girl was consistently associated with high self-control over time. In addition, living in a positive neighbourhood environment when their child was 2 years old was associated with higher self-control at 2 years and 4.5 years, whereas being raised in a rural environments at 2 was only associated with 2 year self-control.

The results also revealed some unexpected findings. For instance, less maternal engagement at 9 months was associated with increased self-control at 2 years, and more family stress at 2 years was associated with increased self-control at 2 and 4.5 years. It may be that mothers who do not respond immediately to their infant's needs at 9 months, due to perhaps dealing with other family stressors, may inadvertently promote the child's ability to exert early self-control. It is important to note that while these families may be stressed and the children may receive less maternal attention, the dominant parenting style is one where the mother is emotionally connected and responsive to the child and the inter-parental relationship is warm.

Also of note is our finding that the demographic predictors of 2 year and 4.5 year self-control changed. At 2 years, being a young mother or a mother with incomplete secondary education or living in a socioeconomically deprived area was associated with higher self-control. In line with emerging evidence within *Growing Up in NZ*, this finding suggests that children who start life experiencing more disadvantaged circumstances initially perform well on measures of self-control, although this advantage doesn't persist as it is not detectable by school entry. Instead by 4.5 years of age, children of mothers' with higher education were found to show greater self-control development.

[2] It is important to note that partner reported data was not used in any of our analysis as more data was available from the mothers, however the effects reported are likely to be similar for either parent.

Table 7. Predictors of the 2 year self-control (SC) index (N=4621)

	B[a]	*t*	*SE*	*p*
Self-control index				
Self-control index 9m	**.043**	**2.703**	**.016**	**.01**
Demographics				
Pre term <37 weeks	.009	.611	.066	.54
Post term >41weeks	.005	.354	.088	.72
Pregnancy unplanned	.004	.273	.033	.79
Parity (subsequent born)	.031	1.083	.056	.28
Baby girl	**.077**	**5.299**	**.028**	**<.001**
Age mum (20-29 years old vs >20)	**-.094**	**-1.945**	**.098**	**.05**
Age mum (30-34 years old vs >20)	**-.083**	**-1.654**	**.102**	**.10**
Age mum (35+ years old vs >20)	**-.106**	**-2.224**	**.104**	**.03**
Māori vs European	0	.004	.052	1.00
Pacifika vs European	.01	.559	.057	.58
Asian vs European	-.005	-.279	.049	.78
Other Ethnicity vs European	-.013	-.878	.081	.38
Secondary education vs No secondary	**-.078**	**-2.459**	**.075**	**.01**
Diploma vs No secondary education	**-.083**	**-2.372**	**.074**	**.02**
Degree vs No secondary	**-.067**	**-1.876**	**.078**	**.06**
Higher degree vs No secondary	**-.066**	**-2.015**	**.082**	**.04**
Deprivation middle vs Low deprivation- Antenatal	**-.041**	**-2.348**	**.035**	**.02**
Deprivation high vs Low deprivation- Antenatal	-.029	-1.416	.042	.16
Family factors				
Mother Depression at 9M	-.009	-.577	.059	.56
Couple warmth 9M	-.007	-.372	.003	.71
Family stress 9M	.008	.451	.004	.65
Couple warmth 2Yr	**.066**	**3.397**	**.003**	**<.001**
Family stress 2Yr	.011	0.647	.003	.52
Maternal paid job 2Yr	-.009	-0.518	.034	.60
Child factors 9 months				
Communication development	**.065**	**4.113**	**.004**	**<.001**
No health/developmental problem	.009	0.633	.048	.53
Child environment 9 months				
Childcare attendance	0.001	0.064	.032	.95
Rural	**0.059**	**2.261**	**.091**	**.02**
Siblings at 16 weeks	-0.001	-0.049	.056	.96
Maternal behaviours 9 months				
Low maternal engagement	**.033**	**1.987**	**.066**	**.05**
Maternal confidence	.007	.444	.034	.66

	B[a]	*t*	*SE*	*p*
Mother child closeness	.005	.338	.049	.74
Child watches screens several times per day[3]	**-.033**	**-2.016**	**.013**	**.04**
Reads books with baby	-.027	-1.60	.013	.11
Sings songs to baby	-.002	-.115	.015	.91
Child factors 2 years				
Total sleep (day and night)	-.019	-1.212	.010	.23
Poor Child health	**-.026**	**-1.739**	**.018**	**.08**
Maternal behaviours 2 years				
Low maternal engagement	-.010	-0.583	.048	.56
Rule for child about hours of TV, videos, DVDs watched	**.049**	**3.253**	**.030**	**<.001**
Play musical instruments (toy or real)	**-.026**	**-1.70**	**.014**	**.09**
Tell stories with your child	**.086**	**5.556**	**.012**	**<.001**
Read books with your child	.028	1.506	.016	.13
Child environment 2 years				
Childcare attendance	.02	1.171	.034	.24
Positive neighbourhood	**.036**	**2.142**	**.033**	**.03**
Unsafe neighbourhood	-.010	-.648	.057	.52
Social services accessed	.013	.489	.090	.63
Rural	-.016	-1.06	.062	.29

Note: (N = 4621) a = standardised bet a weight, ethnicity is self-prioritised ethnicity

[3] Child watches screen time several times a day is considered a maternal behaviour as it is likely to be parent led at this early age, and rules around amount of screen time refers to rules for the child around amount of screen time.

Table 8. Predictors of the 4.5 year self-control (SC) index (N=4144)

	B[a]	*t*	*SE*	*p*
Self-control index				
Self-control index 9M	**.039**	**2.438**	**.015**	**.02**
Self-control index 2Yr	**.092**	**6.254**	**.015**	**<.001**
Demographics				
Pre term <37 weeks	**-.037**	**-2.568**	**.062**	**.01**
Post term >41weeks	.007	.478	.082	.63
Pregnancy unplanned	**-.033**	**-2.044**	**.032**	**.04**
Parity (subsequent born)	.038	1.316	.054	.19
Baby girl	**.209**	**13.61**	**.029**	**<.001**
Age mum (20-29 years old vs >20)	-.044	-.870	.098	.38
Age mum (30-34 years old vs >20)	-.044	-.844	.102	.40
Age mum (35+ years old vs >20)	-.045	-.896	.104	.37
Māori vs European	-.005	-.307	.051	.76
Pacifika vs European	**.034**	**1.839**	**.058**	**.07**
Asian vs European	**.052**	**2.94**	**.050**	**<.001**
Other Ethnicity vs European	.006	.410	.079	.68
Secondary education vs No secondary	**.077**	**2.362**	**.075**	**.02**
Diploma vs No secondary education	**.078**	**2.138**	**.075**	**.03**
Degree vs No secondary	**.120**	**3.213**	**.078**	**<.001**
Higher degree vs No secondary	**.121**	**3.473**	**.081**	**<.001**
Deprivation middle vs Low dep-Antenatal	-.005	-.308	.033	.76
Deprivation high vs Low dep- Antennal	-.013	-.649	.040	.52
Family factors				
Mother Depression at 9M	-.005	-.344	.057	.73
Couple warmth 9M	**-.053**	**-2.69**	**.003**	**.01**
Family stress 9M	-.010	-.546	.004	.59
Couple warmth 2Yr	**.059**	**2.998**	**.003**	**<.001**
Family stress 2Yr	**.031**	**1.802**	**.003**	**.07**
Maternal paid job 2Yr	.007	.405	.034	.69
Maternal Depression 4.5Yr	.017	1.105	.055	.27
Maternal paid job 4.5Yr	.008	.454	.034	.65
Child factors 9 months				
Communication development	.017	1.056	.004	.29
No health/developmental problem	-.001	-.080	.045	.94
Child environment 9 months				
Childcare attendance	-.026	-1.619	.031	.11
Siblings at 16 weeks	.024	.916	.088	.36
Rural	.017	.581	.055	.56
Maternal behaviours 9 months				
Low maternal engagement	-.017	-1.007	.065	.31
Maternal confidence	.020	1.231	.032	.22
Mother child closeness	-.017	-1.078	.046	.28
Child watches screens several times per day[2]	.023	1.372	.013	.17
Reads books with baby	-.014	-.819	.013	.41

	B[a]	*t*	*SE*	*p*
Sings songs to baby	.001	.065	.015	.95
Child factors 2 years				
Total sleep (day and night)	.021	1.333	.010	.18
Poor Child health	.013	.870	.018	.38
Maternal behaviours 2 years				
Low maternal engagement	-.006	-.337	.048	.74
Rule about hours of TV, videos, DVDs[2]	**.04**	**2.633**	**.029**	**.01**
Play musical instruments (toy or real)	.006	.363	.013	.72
Tell stories with your child	-.006	-.358	.012	.72
Read books with your child	**.035**	**1.865**	**.016**	**.06**
Child environment 2 years				
Childcare attendance	-.012	-.715	.033	.48
Positive neighbourhood	**.035**	**2.052**	**.031**	**.04**
Unsafe neighbourhood	.014	.939	.056	.35
Social services accessed	-.014	-.968	.061	.33
Rural	-.020	-.710	.091	.48
Child factors 4.5 years				
Child sleep (hours night)	.013	.853	.013	.39
Child age 4.5 year interview	**.041**	**2.777**	**.010**	**.01**
Active child	.023	.476	.090	.63
Active child not including dancing	-.049	-1.00	.080	.32
Poor child health	**-.028**	**-1.807**	**.019**	**.07**
Mother behaviours 4.5 years				
Mother dominated parent child intxn	**-.075**	**-4.991**	**.052**	**<.001**
Child dominated parent child intxn	**-.043**	**-2.952**	**.166**	**<.001**
Parent interaction open questions	.009	.602	.017	.55
Maternal praise and encouragement	**.085**	**5.583**	**.018**	**<.001**
Reading books several times per day	**.059**	**3.232**	**.017**	**<.001**
Telling stories several times per day	**.037**	**2.277**	**.013**	**.020**
Rules for child around amount of TV and DVD[2]	.023	1.51	.031	.13
Authoritarian parenting style	.010	.558	.029	.58
Permissive parenting style	**-.118**	**-6.972**	**.025**	**<.001**
Warm and empathetic parenting style	**.071**	**4.259**	**.036**	**<.001**
Corporal punishment parenting style	**-.036**	**-2.082**	**.028**	**.04**
Environmental factors 4.5 years				
Social services accessed	**-.051**	**-3.425**	**.064**	**<.001**
Rural	-.009	-.406	.068	.69
Siblings	.006	.370	.051	.71

Note: a = standardized beta weight, ethnicity is self-prioritised ethnicity, N = 4144

Developmental patterns of self-control

To assess the extent of flux or churn in self-control over the pre-school period we used the SC indices to explore the extent to which children move across levels of self-control. At each of the three time points (9 months, 2 years and 4.5 years), we categorised children into levels of self-control using a strict categorisation of 1 standard deviation (SD) below the average as low self-control, those between -1 SD and 1 SD as average self-control, and those 1 standard deviation above the mean as high self-control.

In line with the heterogeneous nature of self-control development, we identified 26 distinct developmental patterns of self-control (low, medium and high) across the three time points (9 months, 2 years and 4.5 years) (see Table 9). These patterns were then grouped to consider movement in and out of the category of low self-control compared to either average or high self-control (see Figure 2).

A summary of the churn in low self-control is presented in Table 10. It displays the percentage of children that had no lows across all three time points, one early low at either 9 months or 2 years, one late low at 4.5 years and two or more lows across the 3 time points.

Overall, the findings suggest that the classification of children with low self-control changes considerably over the pre-school period. The majority of children (N=3482, 63%) are consistently classified as average/high self-control across the 9 months to 2 years period and 2 year to 4.5 year period. Only 8% of children experience two or more lows across the 9 month, 2 and 4.5 year period and less than 1% (N=36) of children were classified as persistently low in self-control across all three time points.

Table 9. Frequency of the different self-control patterns (1 = Low, 2 = average, 3 = high) at each time point (9 months, 2 years and 4.5 years)

Pattern	Freq	%	Pattern	Freq	%	Pattern	Freq	%
111	36	.6	211	113	2.0	311	16	.3
112	112	2.0	212	341	6.0	312	92	1.6
113	7	.1	213	53	.9	313	18	.3
121	127	2.2	221	400	7.0	321	82	1.4
122	459	8.1	222	1948	34.2	322	407	7.1
123	71	1.2	223	442	7.8	323	113	2.0
131	12	.2	231	48	.8	331	8	.1
132	76	1.3	232	358	6.3	332	91	1.6
133	8	.1	233	96	1.7	333	27	.5

Missing = 274 (4.7%)

Table 10. Percentage of children with different patterns of SC across the three time points.

Patterns	Frequency	Percentage
No lows at each time point	3482	62.6%
One early or mid low	1126	20.2%
One late low	538	9.7%
Two or more lows	423	7.6%

Relationship between developmental patterns of low self-control, prosocial and hyperactive behaviours

We examined the relationship between different patterns of self-control over the pre-school period and their association with prosocial and hyperactive behaviours at 4.5 years (see Table 11).

The results showed that patterns of self-control development that included any classification of low self-control in early childhood predicted lower scores on prosocial behaviour, and higher scores on hyperactivity at 4.5 years compared to those children who had no low self-control scores. The variance explained by these patterns was small (between 6% and 7%), but consistent. The results suggest that children who had two or more lows, or a late low (at 4.5 years), were more likely to exhibit the least prosocial behaviour and the greatest levels of hyperactivity at 4.5 years of age.

Table 11. Patterns of self-control and their relationship with prosocial behaviour and hyperactivity at 4.5 years of age.

	B[a]	*SE*	*p*	*R*	R^2
Prosocial behaviour (N=5557)				.239	.057
One early or mid low vs no lows	-.090	.090	< .001		
One late low vs no lows	-.154	.081	< .001		
Two or more lows vs no lows	-.203	.090	< .001		
Hyperactivity behaviour (N = 5558)				.265	.070
One early or mid low vs no lows	.039	.075	.003		
One late low vs no lows	.202	.102	< .001		
Two or more lows vs no lows	.200	.113	< .001		

Note:(*N* = 5558) *Standardised Beta weights*

Factors that distinguish membership of the two or more lows self-control pattern

We investigated factors that distinguished children whose developmental patterns included two or more lows in self-control across the 9 month, 2 and 4.5 year time periods compared to those who had no lows. Table 12 highlights the differences that are statistically significantly at a more conservative $p < .001$. We found that children classified as having two or more lows in self-control at any two of the three time points were more likely to be characterised as follows:

- Demographics: male, an unplanned pregnancy, more likely to be born to mothers under 20 years of age (as opposed to over 35) and more likely to have mothers with no secondary education (as opposed to a degree). Of note, mothers aged less than 20 years seemed to be less likely to have a child with two or more low periods of self-control compared to those who were 20-29 years of age.
- Family factors: mothers who were working and had postnatal depression when their child was 9 months and depression when their child was 4.5 years.
- Child and Environment factors at 9 months: more likely to be a child with health or developmental problems and less likely to have a child with a sibling.
- Maternal behaviours 9 months: less maternal closeness with child, less parenting confidence and less maternal engagement and mothers were less likely to sing regularly to their child.
- Maternal behaviours 2 years: lower maternal engagement, fewer books read to the child and fewer rules around child's screen time.
- Environmental factors 2 years: more family support service accessed and more likely to live in an urban environment.
- Maternal behaviours: less likely to have shared parent-child interactions, less maternal praise and encouragement, fewer rules around child's screen time, more permissive parenting and less warm and empathetic parenting.
- Environmental factors 4.5 years: more contact with family social services.

In summary, the findings suggest that children with two or more low measures of self-control during the pre-school period compared to those with no lows were likely to be experiencing a cluster of risk factors often associated with poor wellbeing in general. They were more likely to be born to younger, less educated mothers and grow up in families that have greater contact with social support services. They were more likely to have a mother who had postnatal depression, engaged less with their child and their child was more likely to have a health or developmental problem. The children also seem to have experienced less regular exposure to shared activities with their parents, such as reading books, and they seemed to grow up with fewer rules around child's screen time.

We also ran a logistic regression to simultaneously model the predictors of having no lows versus two or more low periods of self-control (see Table A3, Appendix 2). When modelling the predictors together, experiencing no low

periods of self-control was associated with greater odds of being female and greater odds of living in areas with the least deprivation. The children with no lows had greater odds of having stronger communication skills at 9 months and were more likely to be raised in households with rules around their child's screen time at aged 2 and to be living in a positive neighbourhood environment. At 4.5 years of age, those children with no lows were less likely to dominate the parent child interactions, and more likely to have parents with a warm and empathetic parenting style and they were the least likely to be accessing family support services at 4.5 years of age.

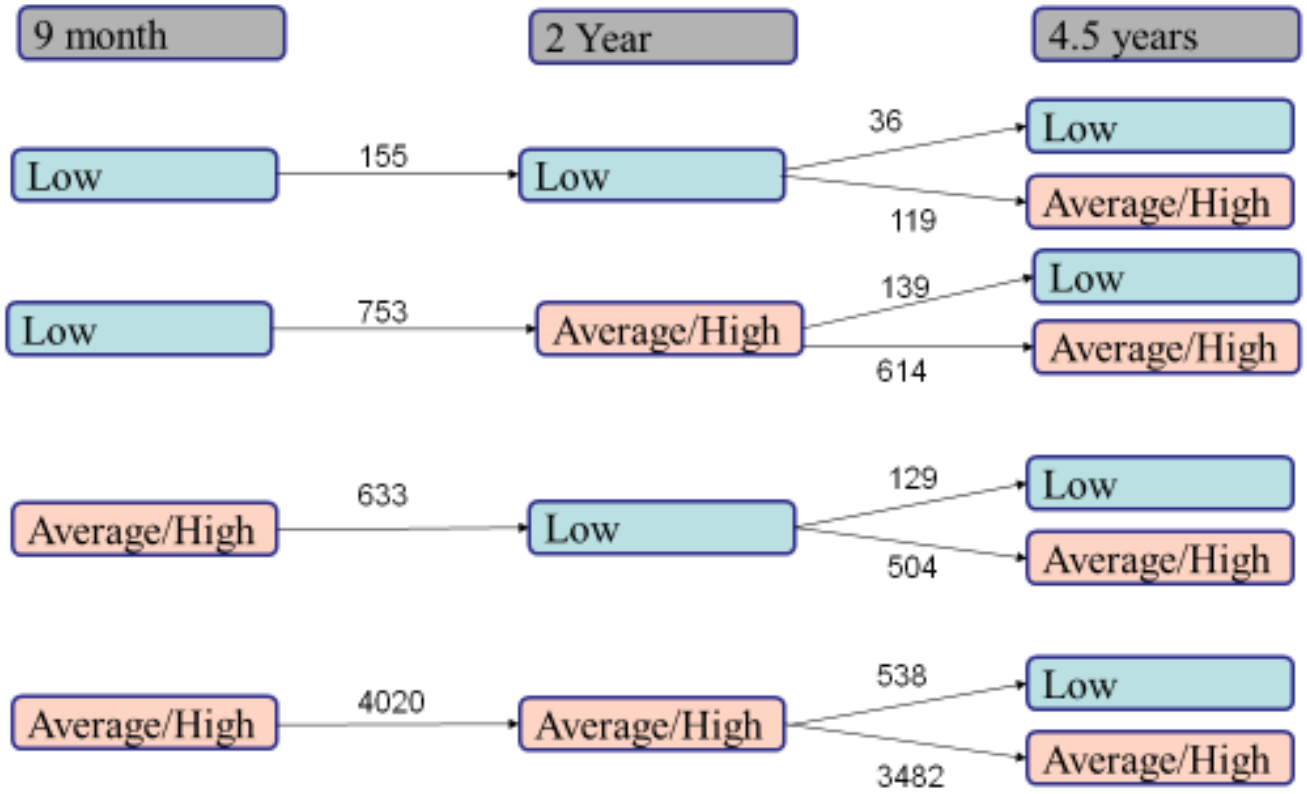

Figure 2. Churn in the classification of low self-control throughout the preschool period

Table 12. Comparison between individual, family and demographic factors associated with children with 2 or more lows compared to no lows across the three time points.

	No lows			Two or more lows					
	Mean	SD	N	Mean	SD	N	*t*	df	sig
Demographics									
Pre term <37 weeks	0.05	0.22	3441	0.07	0.25	418	1.312	497.7	.004
Post term >41weeks	0.03	0.16	3441	0.03	0.16	418	0.09	520.2	.856
Pregnancy unplanned	**0.35**	**0.48**	**3451**	**0.44**	**0.50**	**416**	**3.704**	**511.0**	**<.001**
Parity (subsequent born)	0.59	0.49	3462	0.58	0.49	417	-0.232	520.6	.65
Baby girl	**0.53**	**0.50**	**3476**	**0.32**	**0.47**	**420**	**-8.901**	**542.0**	**<.001**
Age mum (20-29 years old vs >20)	**0.35**	**0.48**	**3482**	**0.41**	**0.49**	**423**	**2.4**	**522.7**	**<.001**
Age mum (30-34 years old vs >20)	0.33	0.47	3482	0.32	0.47	423	-0.641	532.3	.188
Age mum (35 + years old vs >20)	**0.28**	**0.45**	**3482**	**0.20**	**0.40**	**423**	**-3.938**	**560.6**	**<.001**
Māori vs European	**0.11**	**0.32**	**3482**	**0.20**	**0.40**	**423**	**4.228**	**488.3**	**<.001**
Pacifika vs European	0.12	0.32	3482	0.11	0.31	423	-0.452	536.2	.373
Asian vs European	0.12	0.33	3482	0.14	0.35	423	1.313	513.8	.007
Other Ethnicity vs European	0.03	0.18	3482	0.02	0.14	423	-1.353	583.5	.019
Secondary education vs No secondary	0.21	0.41	3482	0.24	0.43	423	1.398	519.1	.005
Diploma vs No secondary education	0.3	0.46	3482	0.3	0.46	423	-0.153	530.3	.759
Degree vs No secondary	0.26	0.44	3482	0.24	0.43	423	-0.855	535.5	.084
Higher degree vs No secondary	**0.18**	**0.38**	**3482**	**0.12**	**0.32**	**423**	**-3.421**	**574.6**	**<.001**
Deprivation middle vs Low dep-Antenatal	0.37	0.48	3482	0.4	0.49	423	0.957	527.0	.075
Deprivation high vs Low dep Antenatal	0.33	0.47	3482	0.37	0.48	423	1.448	524.3	.007
Family factors									
Mother Depression at 9M	**0.07**	**0.25**	**3467**	**0.11**	**0.31**	**417**	**2.41**	**485.2**	**<.001**
Couple warmth 9M	46.48	7.50	3218	43.65	8.13	373	-6.434	448.5	.086
Family stress 9M	11.67	4.56	3438	12	4.53	414	1.41	518.7	.997
Couple warmth 2Yr	40.94	6.41	3162	38.73	6.49	362	-6.144	445.3	.703
Family stress 2Yr	13.22	4.89	3457	13.769	4.77	420	2.202	531.8	.653
Maternal paid job 2Yr	0.45	0.50	3431	0.47	0.50	411	0.769	512.4	.211

Maternal Depression 4.5Yr	**0.07**	**0.26**	**3457**	**0.12**	**0.33**	**417**	**3.001**	**480.6**	**<.001**
Maternal paid job 4.5Yr	**0.33**	**0.47**	**3482**	**0.4**	**0.49**	**423**	**3.019**	**519.9**	**<.001**
Child factors 9 months									
Communication development	34.35	4.16	3482	32.787	4.58	423	-6.69	510.2	.010
No health/developmental problem	**0.91**	**0.29**	**3481**	**0.88**	**0.33**	**422**	**-1.688**	**505.0**	**<.001**
Child environment 9 months									
Childcare attendance	0.35	0.48	3467	0.36	0.48	417	0.372	519.7	.465
Siblings at 16 weeks	**0.08**	**0.28**	**3482**	**0.05**	**0.23**	**423**	**-2.505**	**587.5**	**<.001**
rural	0.62	0.49	3482	0.58	0.49	423	-1.288	526.5	.021
Maternal behaviours 9 months									
Low maternal engagement	**1.14**	**0.24**	**3467**	**1.24**	**0.32**	**417**	**6.167**	**475.2**	**<.001**
Maternal confidence	**0.72**	**0.45**	**3467**	**0.59**	**0.49**	**417**	**-5.298**	**502.6**	**<.001**
Mother child closeness	**0.91**	**0.29**	**3467**	**0.8**	**0.40**	**417**	**-5.473**	**468.5**	**<.001**
Child watches screens several times per day[2]	2.04	1.22	3467	2.23	1.26	417	2.825	514.3	.316
Reads books with baby	3.43	1.26	3466	2.94	1.32	417	-7.136	511.0	.314
Sing songs to baby	**4.31**	**0.98**	**3466**	**3.9**	**1.18**	**417**	**-6.798**	**487.4**	**<.001**
Child factors 2 years									
Total sleep (day and night)	12.42	1.43	3481	12.32	1.53	423	-1.32	516.2	.031
Poor child health	1.63	0.81	3481	1.79	0.89	423	3.545	510.4	.021
Maternal behaviours 2 years									
Low maternal engagement	**1.251**	**0.33**	**3468**	**1.349**	**0.38**	**420**	**5.022**	**498.0**	**<.001**
Rule about child's hours of TV, videos, DVDs[2]	**0.61**	**0.49**	**3469**	**0.46**	**0.50**	**420**	**-5.526**	**520.9**	**<.001**
Play musical instruments (toy or real)	3.21	1.07	3440	3.12	1.16	417	-1.599	505.9	.185
Tell stories with your child	2.41	1.22	3444	2.04	1.19	419	-5.952	531.5	.012
Read books with your child	**4**	**1.09**	**3444**	**3.51**	**1.32**	**419**	**-7.276**	**490.6**	**<.001**
Child environment 2 years									

Childcare attendance	0.57	0.49	3478	0.57	0.50	421	-0.369	526.1	.483
Positive neighbourhood	3.146	0.50	3479	3.0836	0.45	421	-2.653	550.7	.004
Unsafe neighbourhood	0.08	0.27	3471	0.1053	0.31	418	1.601	498.6	.001
Social services accessed	**0.06**	**0.26**	**3468**	**0.11**	**0.39**	**419**	**2.901**	**465.5**	**<.001**
Rural	**0.09**	**0.28**	**3419**	**0.06**	**0.24**	**412**	**-2.423**	**567.3**	**<.001**
Child factors 4.5 years									
Child sleep (hours night)	10.86	1.17	3416	10.59	1.24	412	-4.111	502.9	.026
Child age 4.5 year interview	53.97	1.51	3482	54.1	1.75	423	1.427	501.9	.025
Active child	3.03	0.51	3482	2.91	0.54	422	-4.162	514.7	.007
Active child not including dancing	2.91	0.57	3482	2.84	0.58	422	-2.482	525.5	.309
Poor child health	1.62	0.78	3482	1.83	0.85	422	4.907	511.0	.388
Mother behaviours 4.5 years									
Mother dominated parent child intxn	**0.07**	**0.26**	**3290**	**0.14**	**0.35**	**357**	**3.608**	**399.7**	**<.001**
Child dominated parent child intxn	**0.01**	**0.07**	**3290**	**0.03**	**0.16**	**357**	**2.348**	**373.2**	**<.001**
Parent interaction open questions	2.31	0.78	3306	2.27	0.80	366	-1.066	445.4	.427
Maternal praise and encouragement	**1.78**	**0.81**	**3295**	**1.58**	**0.72**	**363**	**-5.121**	**469.2**	**<.001**
Reading books several times per day	3.66	1.00	3479	3.28	1.10	422	-6.808	509.7	.004
Telling stories several times per day	2.78	1.15	3479	2.45	1.21	422	-5.236	518.0	.002
Rules for child around amount of TV and DVD[2]	**0.7**	**0.46**	**3479**	**0.62**	**0.49**	**422**	**-3.452**	**515.2**	**<.001**
Authoritarian parenting style	2.17	0.60	3469	2.32	0.63	420	4.694	514.9	.363
Permissive parenting style	**1.64**	**0.67**	**3473**	**1.94**	**0.77**	**420**	**7.492**	**498.9**	**<.001**
Warm and empathetic parenting style	**4.49**	**0.42**	**3467**	**4.3**	**0.50**	**419**	**-7.601**	**494.1**	**<.001**
Corporal punishment parenting style	1.8	0.58	3459	1.93	0.58	417	4.21	525.6	.644
Environmental factors 4.5 years									
Social services accessed	**0.04**	**0.24**	**3480**	**0.14**	**0.41**	**422**	**4.68**	**455.9**	**<.001**
Rural	0.1	0.31	3459	0.06	0.25	422	-3.104	593.6	.002
Siblings	0.89	0.31	3480	0.86	0.35	422	-1.877	505.0	.061

Note. Differences significant at <.001 are in bold

Discussion

Self-control is argued to play a foundational role in optimising early child development and promoting wellbeing across the lifespan. To our knowledge, this is the first longitudinal cohort study of contemporary society to examine self-control from 9 months of age and to investigate some of the predictors and stability of self-control across the preschool period.

Devising and validating an index of self-control

Given the heterogeneity and rapidity of child development from birth to age five, measuring self-control is difficult, especially in very young children. To get a comprehensive understanding of self-control development in children, researchers need to use a variety of assessment methods to assess what researchers argue are the three key aspects of self-control development: effortful control, delay of gratification and executive functioning (Gagne, 2017).

Guided by Gagne's (2017) integrative model of self-control development, in this study we attempted to construct indices of self-control that included developmentally appropriate measures which theoretically related to the different domains of Gagne's model (see Figure 1). We started with emerging temperament at 9 months and expanded to include all three domains of self-control by 4.5 years of age.

While there is always the possibility that our chosen measures are not measuring self-control at all, the fact that we based our selection of measures on theory should have enabled us to capture something about self-control across these early years. If we accept this, the question then becomes more about whether what we have captured with our proposed SC indices is useful and meaningful.

Related to this, we deliberately chose to include in our index simple and accessible measures so that they would be relatively easy to recreate in the field if required. Having a series of measures that are relatively easy to administer outside of a controlled laboratory environment is potentially a great advantage for those looking to run interventions in the field.

Our results suggest that, while our three indices are related and measuring something in common, the associations are weak and this needs to be kept in mind when reviewing the findings. The 9 month index had the weakest correlations with the other time points and the 2 and 4.5 year index had the strongest. These low correlations suggest that the indices are not measuring exactly the same thing at each time point, and/or that the individual's scores on the index are not stable and change considerably across the early years. We believe that the indices are a product of both of these explanations. Indeed, the indices *are* measuring different aspects of self-control at different times, due to the different developmental behavioural manifestation of self-control at 9

months, 2 years and 4.5 years of age and the different ways they map on to Gagne's model of self-control. The 9 months index contains only two maternal report measures and assesses only two aspects of Gagne's (2017) model of self-control. Whereas the 2 and 4.5 year self-control indices contain a larger number of measures which tap into more domains of self-control. The measures in the 2 and 4.5 year indices also use a mix of maternal report and observations, and the 4.5 years index also includes a cognitive test. Hence the later self-control indices are more comprehensive (in terms of domains of self-control covered and measurement approach) and this is reflected in the higher correlations between the indices at the later time points.

The fact that each index at each time point was meaningfully related to mother-reported early childhood strengths and difficulties, in the expected direction and at each time point, suggests that, although the indices were not highly correlated, they seem to be measuring something persistently over time. Specifically, we found that children with higher levels of self-control on our indices at 9 months and 2 and 4.5 years of age displayed more prosocial behaviours at 2 and 4.5 years of age, whereas those with lower levels of self-control at these three time points exhibited greater hyperactivity at 2 and 4.5 years of age. Hence both ends of the self-control indices (high and low scores) were meaningfully related to two different types of behaviour: prosocial and hyperactivity respectively, giving us further confidence in the potential value of our self-control indices.

The absolute amount of variance explained by the indices in prosocial behaviour and hyperactivity in the preschool period was small, but was statistically significant. This suggests that the indices appear to measure unique aspects of self-control, as they predicted prosocial and hyperactive behaviours at 2 and 4.5 years over and above a wide range of factors already known to be associated with behaviours on the Strengths and Difficulties Questionnaire. For example, the SC indices also predicted hyperactivity and prosocial behaviour over and above factors such as a child being raised in family where the mother has experienced postnatal depression, or in families where there are fewer household rules.

When investigating the impact of SC on prosocial behaviour and hyperactivity at 4.5 years over and above a known set of predictors, the 9 month and the 4.5 year SC indices were stronger predictors of child behaviour than the 2 year SC index in the final mutually adjusted model. This somewhat surprising finding may reflect the fact that the 9 month SC index consisted of early temperament attention and regulation components that capture unique aspects of self-control development. On the other hand, the 2 year and 4.5 year SC indices appear to capture similar aspects of self-control development as entering the 4.5 year SC index in the model reduced the variance explained by the 2 year SC index.

The strongest associations with prosocial behaviour and hyperactivity were found with the contemporaneous self-control measures. For example, the 2 year SC

index predicted more variance in 2 year measures of prosocial and hyperactive behaviours and the 4.5 year SC index with the 4.5 year behaviours. As noted above, the 4.5 year SC index encompasses all three domains of Gagne's (2017) integrative self-control model and thus is a relatively more comprehensive measure of the behavioural manifestation of self-control. This may also be why it captures more variance in prosocial behaviour and hyperactivity at this older age. Another possibility is the degree of change in self-control over the preschool period may underlie the weaker associations between early self-control and later child behaviour.

Identifying factors that promote or undermine the development of self-control over time

We found a number of factors that were consistently related to increased levels of self-control at 2 and 4.5 years of age. While the strongest and greatest number of associations with self-control were with contemporaneous predictors, a number of modifiable parental behaviours at early time points were associated with greater levels of self-control at later time points. For example, having rules around screen time at 9 months was associated with increased self-control at 2 years, and having rules around screens and reading to your child regularly at age 2 was associated with increases in self-control at 4.5 years of age.

Other important factors for increased self-control over time seem to be mothers who report warm (rather than hostile) relationships with their partners and living in positive neighbourhood environments around the age of toddlerhood.

Somewhat surprisingly, we found that self-control in toddlers (up to age 2 years), but not pre-schoolers (at 4.5 years), was associated with families that report greater levels of family stress and that reported slightly less responsive or engaged mothers. It may be that earlier in a child's development, slightly less responsive parents are inadvertently encouraging their children to develop greater regulation. Perhaps with parents being less available, their children are finding ways to self-sooth and self-regulate rather than depending on the attention of a parent to help regulate their emotions. However, this seems to be a temporary effect that is not sustained close to school entry.

Together, the factors associated with increased self-control at 4.5 years of age seem to be consistent with a co-regulation approach to the development of early self-control which Rosanbalm and Murray (2017) argue involves providing warm and responsive relationships, structured environments and the coaching and modelling of self-regulatory skills.

Self-control patterns across the pre-school period

Consistent with evidence of the heterogeneous nature of self-control development, we identified 26 distinct patterns of self-control (low, medium and high) across the three time points (9 months, 2-years and 4.5 years). The

developmental patterns of the majority of children (63%) in this study did not include a classification of low self-control. Children whose developmental patterns included any low (being one standard deviation below the mean at any of the three time points) were more likely to show fewer prosocial behaviours and more hyperactivity at 4.5 years of age.

Of particular interest is the movement in and out of low self-control relative to the rest of the sample across the pre-school years. It is particularly reassuring to note that only 36 children (less than 1% of the sample) had persistently low self-control across all three time points. Of the 908 children that had low self-control on our index at 9 months, only 13% of them remained low at 2 years, and of the 788 with low self-control at 2 years only 21% had low self-control at 4.5 years.

This pattern suggests that identifying individual children early in the pre-school period who are likely to demonstrate persistent poor self-control is difficult because at the individual level change in self-control development is the norm.

However, our findings suggest that universal strategies that promote self-control development in the context of the family or the early childhood environment could be broadly beneficial for pre-schoolers. For example, activities such as reading and telling stories to children, having rules around their screen time, and encouraging shared caregiver child interactions as opposed to caregiver-led or child-led interactions appear to be beneficial at a population level for promoting early self-control development.

Factors that distinguish children with patterns of low self-control

Children whose developmental patterns included two or more lows on self-control across the three time points were distinguished from children with no lows by a range of primarily demographic and parental factors. Children with a pattern of low self-control were more likely to be a boy, born to young mothers without a degree, mothers who reported postnatal depression, and those who had greater contact with family support services. Mothers of children with two or more low periods of self-control were also more likely to be less engaged with their child, have fewer shared parent-child interactions, fewer parenting rules in general, and fewer household rules around screen time.

When these predictors of two or more low periods of self-control versus no low periods are modelled together in a logistic regression, we see that only three maternal behaviours remain statistically significant of having greater odds of being in the no low category (having rules around screen time at 2 years, shared parent-child interactions and warm and empathetic parenting at 4.5 years). The remaining predictors were largely contextual with no lows having greater odds of living in less deprived areas, more positive neighbourhoods and they were less likely to be accessing social support services at 4.5 years. Again, these findings are consistent with research which highlights the importance of creating environments where parents and caregivers can work with their children to

foster, model and coach the development of early regulatory skills within safe and secure environments.

Key policy implications

Given the extent of flux in and out of categories of low self-control across the pre-school years, identifying individual children who are likely to demonstrate persistent poor self-control is difficult because, at the individual level, change in self-control development is the norm.

Therefore, our findings suggest it is not possible to identify with certainty children who are likely to experience poor self-control at 4.5 years from SC measures at 9 months or 2 years of age. In other words, while retrospectively we were able to identify children with persistently low self-control across the preschool years, we could not have identified this group using measures from earlier time points.

It is however possible that the amount of flux in self-control between infancy and 4.5 years will decrease after the pre-school years. If self-control becomes less changeable, targeted individual interventions to increase individual's self-control and develop self-control related strategies may well be beneficial. Future Growing Up in NZ data collection waves that follow children into mid childhood and early adulthood should be used to further investigate the stability of self-control and the factors that promote or undermine it beyond the preschool years, as well as the impact of different early life patterns of self-control on later childhood behaviour.

Although our findings do not support targeting individual pre-schoolers for self-control intervention, our results do suggest that promoting universal population-based strategies to inform and support parents, families and professionals working with young children to optimise the development of self-control in pre-schoolers may still be worthwhile and potentially valuable. While our findings do not tell us what interventions will necessarily be effective, they highlight some of the risk and protective factors that are associated with different self-control trajectories which could be further tested within a randomised control trial.

General public messages that could be conveyed (and further tested) that seem to be associated with self-control development include the benefits of activities such as reading and telling stories to children, having rules around children's screen time and encouraging shared caregiver-child interactions, as opposed to caregiver-led or child-led interactions, and having a warm and empathetic parenting style. These are probably beneficial because they provide opportunities for modelling, practising, scaffolding and reinforcing a range of regulatory skills (including cognitive, emotional and social) within a warm and supportive environment. These broad skills and strategies may be more responsive to targeted interventions than attempts to raise children's underlying self-control

capacities through, for example, targeted and narrow executive function interventions (Diamond, 2012). However, more research using a randomised control trial would be needed to investigate this.

Our findings also suggest that families living in more deprived areas, which report living in more negative neighbourhood environments and that are already in contact with social and family services may need additional support for their children to reduce possible inequities in self-control development. Strategies that seek to mitigate the drivers of parental depression (especially in the postnatal period) may also be helpful.

Limitations and future directions

Although a key strength of the GUiNZ longitudinal study is the breadth of information collected across multiple developmental domains, there is a trade-off in the depth to which each domain can be investigated. We included in our index a simple, quick and easy to administer set of tasks and questionnaires of self-control development that could be used in the field. Had we included more in-depth laboratory measures of self-control in our index, we may have been able to capture a greater range of self-control related behaviour and thus, observed more nuanced relations among the factors of interest. That said, to identify policy relevant strategies for improving self-control development, it is important to use simple and reliable screening tools that are ecologically valid.

To create our indices, we combined measures representing different aspects of self-control at each data collection wave. As every instrument could potentially contain a degree of error, it could be argued that by combining multiple measures, we are compounding the amount of error in our combined measures. In fact, the opposite is likely to be true (Schenker & Raghunathan, 2007). By combining a range of measures which have been argued to be theoretically linked to self-control, it is likely that we will be capturing a greater part of the self-control construct. As our 2 year and 4.5 year index contained data from multiple measures related to self-control, they are likely to have greater accuracy than our 9 month measure which contained only two measures. This needs to be considered when interpreting our results.

Another limitation is that in this study we validated our index against maternal reports of child behaviours on the Strengths and Difficulties Questionnaire and did not explore the role that partners may play in the development of self-control. Further validation of the indices is required from partner reported data and subsequent data collection waves as the children age.

The data was also analysed with partial missing data. Although the default method (listwise deletion) used for regression in SPSS is a reasonable management strategy in large samples, we acknowledge that the subset of

children included in the analyses may not be representative of the full Growing Up in New Zealand sample, and pre-schoolers generally.

Finally, it is important to keep in mind that while the findings of this study do not imply causation, they do help us to understand potential causal relationships. This study highlights factors that are associated with self-control over time. For example, we have identified that screen time may be a risk factor for lower self-control. However, it is important to be aware that screen time could be a proxy for some other unmeasured variables. While our analysis did control for multiple known demographic and environmental covariates, the list was not exhaustive.

Future research

In light of current evidence of heterogeneous developmental trends in self-control and the multiple and changing influences on it, examining how our self-control index relates to self-control in middle and late childhood would be useful. In addition, exploring whether self-control stabilises beyond the pre-school period should also be explored.

Future research should also investigate how the different patterns of self-control that we identified in the preschool period impact later childhood wellbeing and developmental outcomes (including engagement and achievement in education). Findings from this research could help inform policy makers about the amount of resources and degree of prioritisation needed to improve self-control in pre-schoolers that would have the most impact.

Finally, to date most of the research has retrospectively examined the impact of low self-control on a range of personal and societal outcomes with little discussion of the potential costs of having high self-control or desiring more self-control (see Uziel, 2018). High self-control and desiring more self-control have also been linked with rigid thinking and behaviour, less creativity and poorer mental health, but more research is needed in this area. Therefore, increasing our understanding of the impact of high self-control alongside low self-control will help develop a more balanced long-term approach to self-control development (Uziel, 2018). Given the potential importance of self-control for numerous outcomes over the lifespan, investigating how self-control continues to develop over childhood is a research priority.

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Appendix 1:

Interviewer training and reliability

All interviewers involved in the GUiNZ study underwent comprehensive training in study protocols. While video recording and coding is the gold standard for observation tasks, for the most part, in largescale national studies this is not feasible. As a result, for the stack and topple task administered at aged two, interviewers were assessed for the reliability of their stack and topple coding on completion of training, before going to field.

Any interviewers who scored less than 75% on their reliability for each individual stack and topple measure were noted as potentially less reliable in the final data set, and if necessary could be excluded from analysis. In the current study removing those deemed less reliable after training reduced the sample size by 1760 cases.

Interviewer-related variation in observational coding is typical in 'real world' fieldwork where data collection is undertaken by multiple assessors using standard operating protocols as a guide to administration in the field (e.g. Well child checks and observational screening done by teachers). Typical of fieldwork in longitudinal studies, it is highly likely that interviewers that did not reach the Growing Up in NZ reliability criteria at the end of their training period, would have increased their reliability in the course of conducting more interviews in the field.

In the current study the 2-year SC index included constructs collected on the stack and topple task. We therefore created the index with all interviewers (N = 5697) and with only the interviewers who were more than 75% reliable (N = 3937).

Overall, our findings from the correlational and regression analyses on the full and reduced two-year sample were highly comparable. As such, findings from the full sample are presented in this report.

Development of the self-control indices

A self-control index was calculated for each child who had data on the measures included in the 9-month, 2- and 4.5-year indices. More detail on how the indices were created and the measures within then are given below.

Nine-month self-control (SC) index variables.

Only two aspect of Gagne's (2017) integrated model of self-control (attention and regulation) were measured at 9 months within the Growing up in New Zealand study. Both were measured with a questionnaire designed to assess infant temperament: the Infant Behavior Questionnaire Revised-Very Short Form (IBQ-R VSF) (Putnam et al., 2014).

While the original IBQ- R VSF was designed to identify three temperament factors: Negative Emotionality, Positive Affect/Surgency and

Orienting/Regulatory Capacity, Peterson et al. (2017a), found that the three-factor structure of the IBQ-R-VSF had poor model fit in the current sample and instead a five-factor structure was preferred. This five factor model included broadly the original three factors: Negative Emotionality, Positive Affect/Surgency and Orienting Capacity (revised from Orienting/Regulatory Capacity), and two new factors: Affiliation/Regulation and Fear.

The new five-factor model demonstrated acceptable model fit on two randomly created samples of more than 2300 participants. The measure was also reported to be similarly precise across the four major ethnic groups included in GUiNZ's cohort (Peterson et al., 2017b).

In the current study the attention/ orienting capacity factor and regulation/affiliation factors identified in Peterson et al., (2017a) study were used to form the 9-months self-control factor. The Regulation/affiliation items included questions such as: When showing the baby something to look at, how often did HE/SHE soothe immediately and; How often during the last week did the baby enjoy gentle rhythmic activities, such as rocking or swaying? The attention/orienting capacity factor included questions such as: How often during the last week did the baby play with one toy or object for 5–10 minutes? and; How often during the last week did the baby look at pictures in books and/or magazines for 5 minutes or longer at a time? The response options to the questions ranged from "1 = Never" to "7 = Always" on a seven-point Likert scale. The additional responses of "Does not apply," "Don't know," and "Refused" included in GUiNZ were coded as missing. The average rating on each factor was then calculated.

The average scores on the attention/orientation and regulation/affiliation factors were then scaled to z-scores. The mean of the two z-scores was then taken to form a 9 month self-control score, which was then z scored again. Higher scores were argued to reflect greater self-control ability.

Two-year Self-control (SC) index variables.

The two-year SC index was calculated using the self-regulation subscale (7 items) of the mother-reported Assessment of Self-Concept in Toddlers questionnaire (DesRosiers, 1996) and the direct observation of each child engaging in a stack and topple task (Ross, 1982; Henderson et al., under review).

The self-regulation subscale assessed a toddler's ability to regulate behaviour and emotion. The total scores on the self-regulation subscale were scaled to z-scores. Higher scores reflect greater self-regulation ability.

The stack and topple task is a brief child-interviewer activity that involves taking turns to build a tower, typically using blocks, and then knocking the tower over

once it has been built (see Henderson et al., in prep). In this study, assessment of the attention orienting, sustained attention and inhibitory control aspects of the stack and topple task were used to calculate the SC index. The scores from each phase of the stack and topple skill were summed and scaled to z-scores.

From the two-year assessments, the mean of the four z-scores (self-regulation subscale, attention orienting, sustained attention and inhibitory control) were computed and z scored to create the SC index. Higher scores reflect greater self-control ability.

Four-and-a half year Self-control (SC) index variables

The four-and a half-year SC index consisted of an effortful control scale from a five factor model of temperament (Schoeps et al., under review) recovered from Child Behaviour Questionnaire–Very Short Form (CBQ-VSF; Putnam & Rothbart 2006) and two tasks from Smith Donald et al.'s 2007 Preschool Self-regulation Assessment (PRSA): the Luria hand clap task and the Gift Wrap Task. Items from the Assessor Report from Preschool Self-Regulation Assessment (PSRA; Smith-Donald, Raver, Hayes & Richardson, 2007) were also included.

The effortful control subscale (9 items) measures a child's ability to manage attention and inhibit or activate behaviour in order to adapt to a current situation. A sample item is "Is good at following instructions". The Preschool Self-Regulation Assessment (PSRA; Smith-Donald et al., 2007) is a battery of tasks to assess children's self-regulatory skills in emotional, attentional and behavioural domains. The Luria hand clap task measured children's inhibitory control and their ability to stay focused (Golden, 1981). The task involves the child clapping once if the interviewer clapped twice (and vice versa). The Gift-Wrapping task, adapted from the original Marshmallow task (Mischel et al., 1972) assessed children's ability to delay gratification. The Assessor Report (8-items), also from the PRSA, involves the interviewer commenting on the child's affective behaviour and emotional self-management during the observational tasks.

The scores on both the hand clap task and the gift wrap task were both heavily positively skewed, therefore we created an ordinal variable whereby those children who scored above the median on the hand clap task and did not peek on the gift wrap task were allocated a score of 3.Those who were either above the median or did not peek scored 2, those below the median and who did peek scored 1.

Individually, total scores on the effortful control subscale, hand clap and Gift-Wrap tasks and PRSA assessor report were scaled to z-scores. The mean of the total self-control z-scores was then computed and z scored. Higher scores reflect greater self-control ability.

Appendix 2:

Table A 1 Sociodemographic, maternal and child factors included as predictors in our study

Construct	Description	Data collection
Sociodemographic variables		
Parity	First or subsequent born child	Antenatal
Pregnancy planned	Planned (yes) or unplanned (no) pregnancy	Antenatal
Pregnancy Term	Pre-term<37-week, term 37-41 weeks, post-term,< 41 weeks	Antenatal
Deprivation	Low (Deciles 1 – 3), Medium (Deciles 4 – 7), High (Deciles 8 – 10).	Antenatal
Ethnicity	European, Māori, Pacifika, Asian, Other	Antenatal
Rurality	Living in a rural vs urban area	9M, 2Yr, 4.5yr
Maternal Factors		
Maternal Age	Age in years: <20; 20-29,30-34, 35 + years	Antenatal
Maternal Education	No secondary, secondary, diploma, degree, higher degree	Antenatal
Post-natal depression	Edinburgh Depression Inventory: (not depressed, depressed)	9M
Depression at 4.5-years	Patient Health Questionnaire 9 (not depressed, depressed)	4.5Yr
Maternal employment	Paid Employment; no paid employment	2Yr and 4.5Yr
Child Factors		
Child gender	Boy or girl	6weeks
Child health	Child health scale (poor, fair, good, very good, excellent)	2Yr and 4.5Yr
Communication development	Communication and Symbolic Behaviour Scales (total score)	9M
No health/developmental problems	Development or health problem diagnosed (no, yes)	9M
Child sleep	Total number of hours sleep (day and night)	2Yr
Child activity	Extent of physical activity (every-day to never) (mean score)	4.5Yr

Note: full descriptions of the items and scales are available in the Growing Up in NZ data dictionaries(www.growingup.co.nz)

Table A 2. Relationship environment, family context, parenting behaviour and practises, social contexts used as predictors in our study

Construct	Description	Data collection
Family Context		
Family stress	Extent and type of family stress e.g. finance, housing (total score)	9M, 2Yr
Couple warmth (Warmth and Hostility Scale	Extent of parental relationship positivity (total score)	9M, 2Yr
Parenting Behaviour		
Reading stories to child	Frequency of reading stories (seldom/never to several times a day)	9M, 2Yr and-4.5Yr
Telling stories to child	Frequency of telling stories (seldom/never to several times a day)	9M, 2Yr and-4.5Yr
Singing songs to child	Frequency of singing songs (seldom/never to several times a day)	9M
Playing musical instruments	Frequency of playing instruments (seldom/never to several times a day)	2Yr
Amount of screen time (child)[2]	Child watches screen several times per day (seldom/never to several times a day)	9M
TV Time rules	Rules about when child watches TV (no, yes)	2Yr
Screen Time rules for child	Rules about number of hours of TV, videos, DVs watched by child (no, yes)	4.5Yr
Parenting Practices		
Maternal efficacy/confidence	Level of confidence as a parent (complete/less than complete confidence)	9M
Maternal closeness	Level of closeness with child (complete/less than complete closeness)	9M
Mother-child engagement	Maternal praise, encouragement and enjoyment of child e.g., says nice things to child, enjoys child, pays an interest etc (Mean score)	9M, 2Yr
Maternal praise and encouragement	Mother praises child in parent child interaction task (no, once, twice or more)	4.5Yr
Parenting style	Warm and empathetic, authoritarian, corporal punishment, permissive (mean score)	2Yr
Parent interaction open questions	Mother uses open questions parent child interaction task (no, once, twice or more)	4.5Yr
Mother-child interaction	Quality of interaction (mother dominated vs other; and child dominated vs other)	4.5Yr
Social Context		
No of siblings	Number of siblings recorded (0, 1 or more)	16w, 4.5Yr
Childcare attendance	Child looked after by others regularly (9M) or childcare attendance (2yr, 4yr) (no, yes)	9M, 2Yr, 4.5Yr
Positive neighbourhood	Neighbourhood conditions e.g., clean, lighting, parks etc (mean score)	9M, 2Yr, 4.5Yr
Neighbourhood safety	Extent of feeling safe in neighbourhood (safe, unsafe)	2Yr
Social services accessed	Contact with social/family services: Family Start, CYF, Whanau Ora, other (Sum)	2Yr, 4.5Yr

Note: full descriptions of the items and scales are available in the Growing Up in NZ data dictionaries (www.growingup.co.nz)

Table A 3. Logistic regression models predicting no low periods of self-control (N= 2933) vs two or more lows.

Likelihood ratio x2(68) 257.54, p < .0001	**Sig.**	**B**	**S.E.**	**OR (95% CI)**
Demographics				
Pre term <37 weeks	0.653	-0.138	0.306	0.87[0.48,1.59]
Post term >41weeks	0.841	-0.082	0.408	0.92[0.41,2.05]
Pregnancy unplanned	0.520	-0.105	0.163	0.9[0.65,1.24]
Parity (subsequent born)	0.835	-0.058	0.281	0.94[0.54,1.63]
Baby girl	**<.001**	**0.728**	**0.153**	**2.07[1.54,2.79]**
Age mum (20-29 years old vs >20)	0.768	-0.134	0.453	0.87[0.36,2.12]
Age mum (30-34 years old vs >20)	0.687	-0.192	0.476	0.83[0.32,2.1]
Age mum (35 + years old vs >20)	0.776	0.139	0.490	1.15[0.44,3]
Māori vs European	0.067	-0.431	0.235	0.65[0.41,1.03]
Pacifika vs European	0.734	0.101	0.297	1.11[0.62,1.98]
Asian vs European	0.801	0.065	0.259	1.07[0.64,1.77]
Other Ethnicity vs European	0.385	0.463	0.533	1.59[0.56,4.52]
Secondary education vs No secondary	0.751	-0.118	0.372	0.89[0.43,1.84]
Diploma vs No secondary education	0.739	0.124	0.373	1.13[0.54,2.35]
Degree vs No secondary	0.560	0.229	0.393	1.26[0.58,2.72]
Higher degree vs No secondary	0.421	0.334	0.415	1.4[0.62,3.15]
Deprivation middle vs Low dep-Antenatal	**0.020**	**-0.424**	**0.182**	**0.65[0.46,0.94]**
Deprivation high vs Low dep Antenatal	0.165	-0.303	0.218	0.74[0.48,1.13]
Family factors				
Mother Depression at 9M	0.539	-0.165	0.268	0.85[0.5,1.43]
Couple warmth 9M	0.283	0.014	0.013	1.01[0.99,1.04]
Family stress 9M	0.115	0.030	0.019	1.03[0.99,1.07]
Couple warmth 2Yr	0.553	0.009	0.015	1.01[0.98,1.04]
Family stress 2Yr	0.553	0.010	0.017	1.01[0.98,1.05]
Maternal paid job 2Yr	0.280	0.196	0.181	1.22[0.85,1.73]
Maternal Depression 4.5Yr	0.930	0.025	0.280	1.02[0.59,1.77]
Maternal paid job 4.5Yr	0.158	-0.246	0.174	0.78[0.56,1.1]
Child factors 9-months				
Communication development	**0.002**	**0.055**	**0.018**	**1.06[1.02,1.09]**
No health/developmental problem	0.512	0.155	0.236	1.17[0.73,1.85]
Child environment 9-months				
Childcare attendance	0.444	-0.123	0.161	0.88[0.64,1.21]
Siblings at 16 weeks	0.595	0.288	0.542	1.33[0.46,3.86]
Rural	0.571	0.164	0.289	1.18[0.67,2.08]
Maternal behaviours 9-months				
Low maternal engagement	0.521	-0.188	0.293	0.83[0.47,1.47]
Maternal confidence	0.151	0.233	0.162	1.26[0.92,1.73]
Mother child closeness	0.210	0.264	0.211	1.3[0.86,1.97]
Child watches screens several times per day[2]	0.736	0.023	0.067	1.02[0.9,1.17]
Reads books with baby	0.080	0.111	0.064	1.12[0.99,1.27]
Sing songs to baby	0.351	0.065	0.069	1.07[0.93,1.22]

Likelihood ratio x2(68) 257.54, p < .0001	**Sig.**	**B**	**S.E.**	**OR (95% CI)**
Child factors 2-years				
Total sleep (day and night)	0.483	0.039	0.055	1.04[0.93,1.16]
Poor Child health	0.411	0.073	0.089	1.08[0.9,1.28]
Maternal behaviours 2-years				
Low maternal engagement	0.449	0.180	0.238	1.2[0.75,1.91]
Rule for child about hours of TV, videos, DVDs [2]	**0.051**	**0.285**	**0.146**	**1.33[1,1.77]**
Play musical instruments (toy or real)	0.852	0.013	0.070	1.01[0.88,1.16]
Tell stories with your child	0.575	0.037	0.067	1.04[0.91,1.18]
Read books with your child	0.292	0.082	0.078	1.09[0.93,1.27]
Child environment 2-years				
Childcare attendance	0.924	-0.017	0.174	0.98[0.7,1.38]
Positive neighbourhood	**0.027**	**0.382**	**0.173**	**1.47[1.04,2.06]**
Unsafe neighbourhood	0.154	0.410	0.287	1.51[0.86,2.64]
Social services accessed	0.515	-0.184	0.283	0.83[0.48,1.45]
Rural	0.334	0.565	0.584	1.76[0.56,5.53]
Child factors 4.5-years				
Child sleep (hours night)	0.208	0.074	0.059	1.08[0.96,1.21]
Child age 4.5-year interview	0.465	0.038	0.052	1.04[0.94,1.15]
Active child	0.383	0.378	0.434	1.46[0.62,3.42]
Poor child health	0.755	-0.029	0.095	0.97[0.81,1.17]
Mother behaviours 4.5-years				
Mother dominated parent child intxn	0.098	-0.387	0.234	0.68[0.43,1.07]
Child dominated parent child intxn	**<.001**	**-1.988**	**0.537**	**0.14[0.05,0.39]**
Parent interaction open questions	0.946	0.006	0.090	1.01[0.84,1.2]
Maternal praise and encouragement	0.216	0.118	0.095	1.13[0.93,1.36]
Reading books several times per day	0.724	-0.030	0.085	1.04[0.91,1.19]
Telling stories several times per day	0.581	0.038	0.069	1.09[0.8,1.48]
Rules for child around amount of TV and DVD watching[2]	0.577	0.087	0.156	0.86[0.64,1.14]
Authoritarian parenting style	0.283	-0.157	0.146	0.8[0.63,1.01]
Permissive parenting style	0.056	-0.226	0.118	2.09[1.49,2.93]
Warm and empathetic parenting style	**<.001**	**0.738**	**0.172**	**1.12[0.84,1.5]**
Corporal punishment parenting style	0.431	0.116	0.147	0.4[0.24,0.65]
Environmental factors 4.5-years				
Social services accessed	**<.001**	**-0.927**	**0.249**	**.396(0.243-**
Rural	0.395	0.358	0.421	1.43[0.63,3.26]
Siblings	0.334	0.244	0.252	1.28[0.78,2.09]