



The Malleability of Personality Traits in Adolescence

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NON-TECHNICAL SUMMARY

Personality traits have been shown to predict success in areas such as employment, health, social relationships, and educational attainment. A fundamental assumption in economic decision-making models is that these personality traits are stable over time and do not change in response to life experiences. However, these assumptions have rarely been convincingly tested, especially during adolescence and young adulthood—a critical period of development characterised by dramatic physical and psychosocial changes.

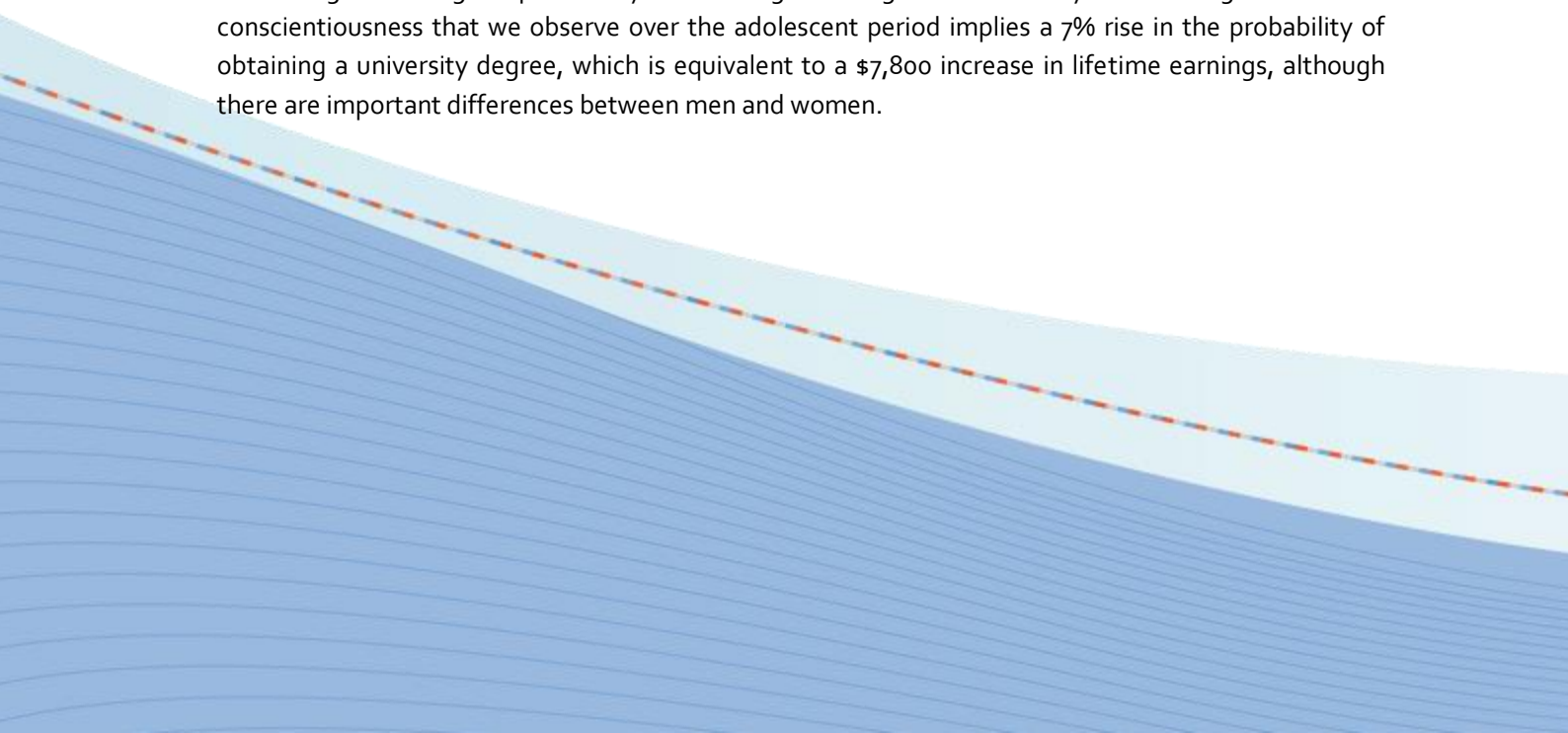
We want to understand how personality traits evolve over this developmentally interesting period, and the degree to which personality traits respond to life experiences. This will help us to understand the value of targeted interventions to shape those non-cognitive skills that are important for positive life outcomes, such as healthy habits and academic success. For example, should schools and universities focus on developing non-cognitive skills of their students? Are such investments worthwhile even into young adulthood when personality is thought to have stabilised?

We focus on the classic 'Big-Five' personality traits (conscientiousness, extraversion, openness to experience, emotional stability, and extraversion) as well as a trait called 'locus of control', which measures how much a person feels they have control over the outcomes in their life. We use large samples of individuals aged between 15 and 24 from the Household Income and Labour Dynamics in Australia (HILDA) Survey.

We first observe how the personality traits of our sample change on average over an eight-year period and how reliable these shifts are. Most personality traits show small and unreliable changes, with two exceptions. Over the eight-year period, respondents became more conscientious and openness to experience shows an interesting pattern of change that differs by gender.

Next, we estimated the degree to which a number of life experiences, both positive (e.g. improvement in finances) and adverse (e.g. death of a close friend), shaped the personality of our sample. Overall, we find very little evidence that one-off life events systematically influence personality. However, respondents affected by long-term health problems tended to have a more external locus of control (in other words, they tended to believe they had less control over the outcomes in their life), and were less agreeable compared to the rest of the sample.

Finally, we examined how economically meaningful the observed personality changes were, by calculating the 'marginal probability effect' of graduating from university. The average increase in conscientiousness that we observe over the adolescent period implies a 7% rise in the probability of obtaining a university degree, which is equivalent to a \$7,800 increase in lifetime earnings, although there are important differences between men and women.



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Abstract

Models of economic decision-making usually assume that personality is stable over time. We assess the validity of this assumption in adolescence and young adulthood using nationally representative panel data from Australia. Our study shows that mean changes in personality traits are moderate because most individuals do not change their scores in a statistically reliable way during adolescence and young adulthood, or changes occur in equal proportions in opposite directions. The largest changes over an eight-year window are found for conscientiousness. Its average increase implies a 7% rise in the probability of obtaining a university degree – equivalent to a \$7,800 net increase in lifetime earnings. Youth also reduce on average their external locus-of-control and extraversion, and increase their agreeableness and emotional stability. Important gender differences emerge for changes in openness to experience with increases in this trait over time for males and decreases for females. Moreover, an examination of the extent to which personality responds to personal or environmental shocks indicates that intra-individual trait changes are not systematically predicted by one-off life events. However, the experience of repeated health problems increases external control perceptions and reduces agreeableness – altering the normal maturation process of the two traits; we demonstrate that the size of this effect is economically meaningful.

Keywords: Non-cognitive skills; big five personality traits; locus of control; stability; adolescence; life events

1. Introduction

Personality traits are an important component of human capital. Often referred to as life or non-cognitive skills, they comprise a great variety of traits that have positive or negative productivity effects in school, in the labor market, at the workplace, and in social relationships (see Almlund et al., 2011 for an overview). Traditionally, personality psychologists have assumed that personality traits are a stable component of human capital. Children were assumed to be endowed with a temperament from birth, which was thought to mature almost deterministically into a stable portfolio of behavioural styles and patterns of thought in adulthood (Costa and McCrae, 1988; McCrae and Costa, 1994). These assumptions of stability and deterministic evolution have been criticized in the past decade (see Roberts et al., 2009). Many empirical studies have since shown that most people experience increases in their levels of conscientiousness, agreeableness, and emotional stability between adolescence and young adulthood (e.g. Bleidorn et al. 2013, Hopwood et al. 2011), especially during the process of increased social responsibilities (Roberts et al. 2006).

What is less well understood is whether personality changes stochastically, as a response to personal or environmental shocks. The question is, are there systematic deviations from underlying baseline personality traits as a response to shocks or can personality traits be completely reversed? An oft-cited case is *Phineas Gage*, a patient who experienced dramatic changes in his personality following a severe brain injury resulting from a work accident (Damasio et al., 2005). A small empirical literature has explored the role of more common life events or ongoing life experiences in explaining personality change, demonstrating that personality-type reversal observed in patient Gage is certainly not the norm (Schurer et al., 2015, Cobb-Clark and Schurer, 2012; 2013; Lüdtke et al., 2011; Specht et al., 2011; 2013).

Even more so, recent work by Cobb-Clark and Schurer (2012, 2013) showed for high-quality Australian personality data that over shorter time-periods of half a decade, both the Big-Five personality traits and locus-of-control, two of the most widely researched personality inventories, are surprisingly stable. Focussing on a working-age population of ages 25 to 60, they find that trait reversal is not common, and observed trait changes cannot be meaningfully predicted by individual or aggregated life events. Although personality traits are not perfectly stable, they can be assumed reasonably fixed and exogenous to most of income-, health-, and family-related shocks. They conclude that most of the time-varying characteristics in personality change may be attributable to measurement error.

In this article we built on Cobb-Clark and Schurer (2012, 2013) by exploring the malleability of the Big-Five personality traits and locus-of-control during the sensitive period of adolescence. Our data allow us to follow over eight years the lives of over 770 adolescents and young adults aged between 15 and 24 years at baseline assessment. With the analysis, we will answer the following questions: (1) What are the mean-level changes in personality of adolescents over an eight-year window?; (2) How many individuals change in a statistically reliable way, and how many increase or decrease their traits in a significant way?; (3) Are there important gender differences in personality change?; (4) Which life events – positive or negative – predict changes in personality traits? and (5) Are the observed changes in any way economically meaningful?

To conduct the analysis, we use nationally-representative panel data from the Household, Income, and Labour Dynamics in Australia (HILDA) survey. HILDA has the advantage that it has three waves of high-quality, consistently measured personality traits in addition to annually-collected measures of a number of positive (e.g. promoted at work) and negative (e.g. unemployment) life events. These life-events data are particularly useful given that some of them may drive what psychologists refer to as ‘non-normative’ changes in personality, changes that occur to most people in the same way during specific periods of the life course (McCrae et al., 2000). Moreover, many of these events are outside individuals’ control (e.g. death of a spouse) and thus can be used to capture the important, exogenous shocks that Seligman (1975) suggests may cause helplessness. We use these life-events data to gain important insights into the determinants of individuals’ personality change.

We establish that most of the Big-Five personality traits and external locus-of-control show small to moderate malleability between adolescence and young adulthood. Over an eight-year window, youth reduce on average their external locus-of-control, and extraversion, but increase their conscientiousness, agreeableness and emotional stability. Yet, mean population changes for most of these traits do not exceed 0.15 standard deviations. The reason for small mean-changes is that 75-85% of individuals do not change their scores in a statistically reliable way, and for those who do, some decrease and others increase their self-assessments. The exception is youth conscientiousness, which increases for men and women by 0.36 standard deviations. The average increase in conscientiousness implies a 5% and 10% increase in the probability of having obtained a university degree – equivalent to a \$6,000 and \$12,000 net increase in lifetime earnings – for women and men, respectively.

Intra-individual changes are not predicted by one-off life events. However, the experience of persistent health problems is significantly associated with an increase in

external control tendencies by 0.31 standard deviations and a decrease in agreeableness by 0.23 standard deviations. These effects are economically meaningful as they are equivalent in magnitude to the treatment effects of education initiatives on personality development (for a summary see Schurer, 2016). We conclude that conscientiousness in particular – often referred to as a proxy for executive function (Kern et al., 2009) – evolves strongly between adolescence and young adulthood, and persistent health problems partially offset the maturation process of locus of control and agreeableness.

Our results contribute to the literature in two important ways. First, our findings can be used to benchmark the effectiveness of education programs aimed at boosting life skills during adolescence (Schurer, 2016 for a review of such outcomes). Second, our findings demonstrate that – if at all – personality traits in adolescence are not specifically malleable with respect to shocks, with the exception of consistent effects of ongoing health effects that have not been demonstrated in the literature before.

The remainder of the paper is as follows: In Section 2 we review the literature on what is known about mean-level and intra-individual changes in personality. Section 3 describes the HILDA data. In Section 4 we describe the estimation strategy and present our results. We discuss our findings and contributions to the literature in Section 5.

2. Literature Review

Personality is generally viewed in the economics literature as an alternative skill set that is reflected in economically-relevant outcomes and decisions in areas such as employment, educational attainment, and health (Almlund et al., 2011). This conceptualisation of personality as a set of skills motivates the incorporation of such constructs into economic decision-making models – a development which enriches our understanding, firstly, of the complex manner in which personality drives human capital investments and returns, and secondly, of the value of investing in the enhancement of traits that are important for producing positive outcomes (Borghans et al., 2008; Heckman et al., 2006). These models fundamentally assume that such traits are stable and determined exogenously. The validity of this assumption may be subject to particular scrutiny during the life stages of adolescence and young adulthood, given that it is a period characterised by dramatic physical and psychosocial changes including puberty, the development of mature relationships, education and vocational decisions, and embarking on important social roles and associated adult responsibilities (Arnett, 2000; Robins et al., 2001). Indeed, it is not only the transition from

childhood to adulthood, but also from dependence to independence (Klimstra et al., 2009). In this section we briefly define the five-factor model of personality and locus-of-control, their relevance to a range of economically-relevant life outcomes, and the available empirical evidence about the stability of these constructs during adolescence and young adulthood.

The five-factor personality structure is generally accepted by psychologists as a meaningful and reliable mechanism for describing and understanding human differences (Goldberg, 1992, 1993). According to the Dictionary of Psychology of the American Psychological Association (2007), these five dimensions include: Openness to experience (or intellect), which is the tendency to be open to new aesthetic, cultural, or intellectual experiences; conscientiousness, the tendency to be organized, responsible, and hardworking; extraversion, defined as an orientation of one's interests and energies toward the outer world of people and things rather than the inner world of subjective experience, and characterized by positive affect and sociability; agreeableness, which is the tendency to act in a cooperative, unselfish manner; and finally, neuroticism, a chronic level of emotional instability and proneness to psychological distress.

An extensive array of literature has demonstrated the importance of the Big-Five and locus-of-control both in terms of their value to employers and in terms of the labour market returns to those who possess certain traits. Higher scores on scales of openness to experience and extraversion are associated with higher earnings, whilst neuroticism and agreeableness are negatively associated with earnings and may impair academic performance (Chamorro-Premuzic and Furnham, 2003; Fletcher, 2013; Gensowski, 2014; Heineck and Anger, 2010; Mueller and Plug, 2006; Nyhus and Pons, 2005). Conscientiousness is frequently credited as a super-trait that is associated with better health behaviours, academic performance (Chamorro-Premuzic and Furnham, 2003; Furnham et al., 2003; Kappe and van der Flier, 2012; Nofle and Robins, 2007; Trapmann et al., 2007) and higher wages at the beginning of young people's careers (Fletcher, 2013; Nyhus and Pons, 2005). Agreeableness is closely related to economic preferences such as reciprocity and altruism (Becker et al. 2012), or prosociality (Hilbig et al. 2014), and thus has high social benefits.

Although not part of the Big-Five personality inventory, locus-of-control is another widely researched personality trait that describes a person's generalised expectancy about the degree of control they possess over the events and outcomes in their life (Rotter, 1966). An individual with a tendency to attribute life's outcomes to their own actions is considered to be internally controlled – they believe that they will benefit from payoffs to their investments of effort; in contrast, someone who tends to attribute life's outcomes to factors outside their

control (such as chance or luck), is considered to have an external locus-of-control (Gatz and Karel, 1993).

Locus-of-control has been the focus of extensive empirical research examining its role in important health, educational, and labour market outcomes (Cobb-Clark, 2015; Adolfsson, et al., 2005; Andrisani, 1977; Coleman and DeLeire, 2003; Findley and Cooper, 1983; Heckman et al., 2006). For example, people who are more internally-controlled earn higher wages (Heineck and Anger, 2010), have higher workplace satisfaction and motivation (Ng et al., 2006), and cope more effectively in the face of health shocks (Schurer, 2016) or unemployment (Caliendo et al., 2015, McGee 2015). Of particular importance to the adolescent and young-adulthood period of development, the locus-of-control construct is related to human and health capital investment decisions, success in educational pursuits and academic performance (Cobb-Clark et al., 2014; Barón and Cobb-Clark, 2010; Coleman and DeLeire, 2003). Indeed, research has suggested that locus-of-control (and self-esteem) can be just as important as cognitive skills in predicting such outcomes (Heckman et al., 2006), reinforcing efforts to account for such constructs in models of human capital.

Though little doubt exists regarding the importance of personality constructs to a vast array of individual outcomes, not enough is known about the stability of these traits over the lifecycle, particularly during the developmentally interesting period of adolescence. This lack of concrete knowledge is problematic because researchers often rely fundamentally on the assumption that such traits are not just stable over time but also that they are determined exogenously and therefore not subject to influence by the very outcomes they are often employed to predict. If we incorrectly assume stability and exogeneity of traits over time, our models may be subject to bias from reverse causality or simultaneity (Cobb-Clark and Schurer, 2013).

Psychologists have typically relied on a number of different strategies for evaluating the consistency of personality traits. Measures of mean-level consistency have been employed to detect increases or decreases in the average personality score of a group of people, and is used to study normative changes that occur as a result of typical maturational or social processes (Roberts et al., 2006). Rank-order consistency, on the other hand, is about the relative position of peoples' personality scores over time; a high rank-order consistency implies that individuals maintain the same relative position to one another over time in their personality traits (Roberts and Delvecchio, 2000). Mean-level consistency and rank-order consistency are such that one can exist without the other, with normative change often characterised by the coexistence of both mean-level changes and stable rank-order (Klimstra

et al., 2009). A third and less examined method of evaluating stability is intra-individual consistency, which is focussed on how traits change within an individual over time. Even if a trait is mean-level consistent over time, this tells us nothing about how each individual within the group might be shifting in their traits; for example, if some individuals are increasing on a trait whilst others are decreasing, this offsetting effect may be largely obscured in group-level analyses (Cobb-Clark and Schurer, 2013; De Fruyt et al., 2006).

The influential early work by psychologists arguing that personality develops throughout adolescence and remains relatively stable from age 30 onwards (Costa and McCrae, 1988; McCrae and Costa, 1994) has been challenged by more recent evidence suggesting that that mean-level personality changes may occur in samples up until the age of 50 or later (Mroczek and Spiro, 2003; Roberts and Mroczek, 2008; Roberts et al., 2006).

In general, evidence pointing toward patterns of “stability and change” tend to characterise much of the personality development literature for the adolescent and young adulthood life stage (Blonigen et al., 2008; De Fruyt et al., 2006; Pullmann et al., 2006; Robins et al., 2001; Stein et al., 1986). Although there is a lot of heterogeneity across findings, there is general agreement that individuals tend to demonstrate personality changes most strongly before they reach working age beyond which they become more consistent (Cobb-Clark and Schurer, 2012, 2013; Lüdtke et al., 2011; Pullmann et al., 2006; Specht et al., 2011), and that the nature of these changes is toward increasing levels of agreeableness, conscientiousness, and emotional stability (Bleidorn et al., 2013; Roberts et al., 2006; Soto et al., 2011). Bleidorn et al. (2013) found evidence that such changes were culturally universal, but also that personality maturity occurred earlier in those cultures with earlier onset of adult responsibilities. Hopwood et al. (2011) found that twin samples showed particularly salient intra-individual changes between the ages of 17 and 24, and that these changes continued until the end of the 20s.

Sex differences in age-related personality maturation are frequently described in such studies (Branje, 2007; Klimstra et al., 2009; Soto et al., 2011). In one example, Klimstra et al. found that adolescents demonstrated mean-level increases in agreeableness and emotional stability, though girls matured earlier than boys. Studies specifically investigating age-related changes in locus-of-control over the adolescent period are sparse and have also produced heterogeneous results. Some report that young people become more internally-controlled over time (Chubb et al., 1997), whilst others suggest that locus-of-control is relatively stable over the adolescent period (Kulas, 1996).

Although these studies tell us about typical patterns of personality maturation over time, they provide little information about the capacity for personality to respond to environmental factors or life experiences; in fact, few empirical studies have investigated this topic convincingly for either the Big-Five traits or locus-of-control. A very recent literature has emerged on the effectiveness of the education sector in boosting personality traits of young people (see Schurer, 2016 for a review). One German study exploited a high school reform that increased learning intensity in an effort to identify whether schooling had a causal impact on personality change (Dahmann and Anger, 2014). As predicted by the authors, the reform made individuals more extraverted and neurotic. Another German study tracked 2,000 students over a four-year period from high school to university, vocational training, and work (Lüdtke et al., 2011), showing that adolescents in vocational training increase their conscientiousness more, and their agreeableness less, than adolescents who go to university. Schurer et al. (2015) find no significant difference in the development of conscientiousness over eight years between university students and adolescents in alternative occupational pathways, but find a significantly weaker decrease in extraversion for college students.

Other social institutions may also impact on the personality of a whole cohort. A series of studies on US school children showed that those born between the 1950s and 1990s increasingly became more anxious and neurotic through a general decline in social connectedness, measured by divorce rates and crime (Twenge, 2000). China's One-Child Policy (OCP) made children born just after the OCP's introduction in 1979 less conscientious, more neurotic, and less optimistic relative to children born just before (Cameron et al., 2013). Macroeconomic conditions are also likely to affect a cohorts' personality traits; for example, a recent study indicated that young people in the US who enter the labour market in recessions exhibit fewer narcissistic traits (Bianchi, 2014). Unemployment was shown to significantly affect personality traits over a four-year period, such that agreeableness, conscientiousness and openness declined relative to those who were reemployed (Boyce et al., 2015).

Our study contributes to this literature by investigating the malleability of the Big-Five personality traits and locus-of-control of a nationally representative sample of Australian adolescents and young adults between 15 and 24 years of age at baseline in the sensitive period of adolescence over a time window of eight years. More specifically, we analyse the contribution of a range of life events – some of them which lie outside individuals' control (e.g. death of a spouse, financial shocks) - on changes in personality.

3. Data

We conduct our analysis using individual-level data from the nationally representative Household Income and Labour Dynamics in Australia (HILDA) survey. The HILDA is a household-based panel survey that began in 2001 with 19,914 individuals from 7,682 households (Summerfield et al., 2014). In 2011 (wave 11), the sample was topped up with a further 2,153 households and 5,477 individuals. Data is collected annually from all household members aged 15 and older through face-to-face interviews and self-completion questionnaires covering a diverse range of social, health, education and economic topics. A broad set of standard topics are administered annually whilst others rotate periodically every couple of waves.

3.1. Five Factor Model

HILDA respondents were administered an inventory designed to elicit measures of the Big-Five personality traits in 2005, 2009, and 2013 (waves 5, 9 and 13, respectively). We thus restrict our Big-Five sample to those respondents who a) were between 15 and 24 years of age in 2005 (the Big-Five base year), b) were interviewed in each wave between 2005 and 2013, and c) completed the Big-Five inventory for all three waves in which it was administered (2005, 2009, and 2013). Of the 2,348 individuals who were aged between 15 and 24 in 2005, only 55% (1,279) were interviewed through to wave 13 – and of these, the 770 respondents who provided complete information for the Big-Five items for all three waves resulted in our final sample.

The Big-Five personality traits of respondents were measured using a 36-item personality inventory based on Goldberg (1992) and Saucier's (1994) trait descriptive adjective approach. The inventory was included as part of the HILDA self-completion questionnaire in relevant waves. Respondents are asked to indicate by self-report the degree to which each of 36 adjectives describe them, on a scale from 1 ("not at all") to 7 ("very well"). The adjectives include (see **Table A1** for a list):

- *Extroversion* – talkative, bashful (reversed), quiet (reversed), shy (reversed), lively, and extroverted.
- *Agreeableness* – sympathetic, kind, cooperative, and warm.
- *Conscientiousness* – orderly, systematic, inefficient (reversed), sloppy (reversed), disorganised (reversed), and efficient.

- *Emotional stability* – envious (reversed), moody (reversed), touchy (reversed), jealous (reversed), temperamental (reversed), and fretful (reversed).
- *Openness to experience* – deep, philosophical, creative, intellectual, complex, imaginative.

Following testing for item reliability and principal components factor analysis, eight items are discarded on the basis that their reliability is low or their highest loading is not on the expected factor (see Losoncz, 2009). Thus, the Big-Five personality dimensions (agreeableness, conscientiousness, emotional stability, extraversion, and openness to experience) are derived from a total of 28 trait descriptive adjective items, and are considered to represent personality “at the broadest level of abstraction” (John and Srivastana, 2001). The five dimensions have a very high internal consistency in terms of identifying one underlying factor, with Cronbach alphas ranging between 0.75 (openness to experience) and 0.79 (emotional stability). Previous evidence has suggested that the personality of adolescents can be meaningfully understood through the Big-Five framework, and also that self-report is a valid and reliable strategy by which to elicit Big-Five traits in this age group (De Fruyt et al., 2006; Soto et al., 2011).

3.2. *Locus-of-control*

Data on locus-of-control was collected in 2003, 2004, 2007, and 2011 (waves 3, 4, 7 and 11, respectively) as part of the self-completion component of the HILDA survey. In a similar fashion to the Big-Five sample, our locus-of-control sample was thus restricted those who a) were between 15 and 24 years of age in 2003 (the locus-of-control base year), b) were interviewed in each wave between 2003 and 2011, and c) provided complete information on the locus-of-control measures for waves 3, 7, and 11. Of the 2,178 individuals aged between 15 and 24 in wave 3, only 50% (1,090) were interviewed through to wave 11 – of these, we have complete information on the locus-of-control measures for our final sample of 777 respondents.

In HILDA, respondents’ locus-of-control is elicited using the seven-item Psychological Coping Resources inventory, which is one component of Pearlin and Schooler's (1978) Mastery Module. Mastery measures the degree to which a person believes that the outcomes in their life are under their control. Respondents were asked to indicate by self-report the extent to which each of seven statements is true of them on a scale of 1 (“strongly disagree”) to 7 (“strongly agree”). The seven items are: (a) I have little control over the things that

happen to me; (b) There is really no way I can solve some of the problems I have; (c) There is little I can do to change many of the important things in my life; (d) I often feel helpless in dealing with the problems of life; (e) Sometimes I feel that I am being pushed around in life (f) What happens to me in the future mostly depends on me; and (g) I can do just about anything I really set my mind to do. The seven items have very high internal consistency in measuring one underlying factor, with a Cronbach alpha of 0.85 (see **Table A1** in the Appendix for individual items and alpha estimates).

Factor analysis suggests that the items load onto two factors, which are generally interpreted as external (items (a) to (e)) and internal ((f) and (g)) attribution tendencies. Someone with an internal attribution style has a tendency to believe that life's outcomes are attributable to their actions; in other words, they believe they have a lot of control over what happens to them. A person with external control beliefs, on the other hand, tends to attribute outcomes in their life to factors outside their control. We create a combined locus-of-control scale that is increasing in external control tendencies by subtracting the person's internal score (the sum of items (f) and (g)) from their external score (the sum of items (a) to (e)) and adding 16 (Cobb-Clark and Schurer, 2013; Pearlin and Schooler, 1978). Our locus-of-control scale thus ranges from 7 (completely internal) to 49 (completely external).

4. Estimation Results

The aim of our paper is to analyse personality trait stability over the developmentally interesting periods of adolescence and young adulthood, focussing on the Big-Five taxonomy and locus-of-control. Here we present our results on: (1) mean-level trait stability over an eight-year period; (2) variation in trait stability across age and sex; (3) the degree to which the Big-Five and locus-of-control are responsive to important life events experienced by individuals; and (4) whether the observed changes are economically meaningful.

4.1. How stable are the Big-Five traits and locus-of-control during adolescence and young adulthood?

We first examine the degree of stability in personality over adolescence and young adulthood by calculating the overall mean-level consistency of traits over an eight-year period. Mean-level consistency measures the degree to which a group increases or decreases on average in a particular trait over time, and provides a method by which to detect normative changes that may be driven by typical maturational and social processes (Caspi and Roberts, 1999). We

are interested in better understanding which traits change over this developmental period, as well as the direction and magnitude of observed shifts.

Our measure of the eight-year mean-level change for each of the Big-Five traits is constructed according to $\Delta Big5^j = T_{2013}^j - T_{2005}^j$, where $j \in \{\text{extraversion, agreeableness, conscientiousness, emotional stability, openness to experience}\}$ and T represents the average trait score for the specified year. For the Big-Five traits, the eight-year period of interest occurs between 2005 (wave 5) and 2013 (wave 13), and the sample comprises of respondents who were aged between 15 and 24 years old in the base year of 2005 (N=770). Changes in Big-Five traits can range from -6 to 6, with negative values indicating a self-reported reduction in the particular trait over time and positive values indicating an increase.

The equivalent mean-level change measure for locus-of-control is $\Delta LoC = T_{2011} - T_{2003}$. The eight-year period of change observed for locus-of-control occurs between 2003 and 2011, and the sample is comprised of respondents who were between 15 and 24 years old in the base year of 2003 (N=777). The locus-of-control scale is increasing in external attribution tendencies, with changes bounded between -42 (a change that would theoretically indicate an extreme shift from a completely external to completely internal locus-of-control) and 42 (which would indicate the opposite extreme shift).

The mean-level changes in each dimension of the Big-Five and locus-of-control over an eight-year period are presented in **Table 1**. For comparability, the mean change in each trait has been transformed into standard deviations (SD) of 2005 scores for Big-Five traits and standard deviations (SD) of 2003 scores for locus-of-control (see column 6). On average, respondents' self-reported scores indicate that they become somewhat more agreeable and emotionally stable (by magnitudes of 0.15 SD), and somewhat less extraverted (-0.11 SD) over an eight-year period. No significant mean-level change was found for openness (-0.06 SD). The greatest mean-level change observed was for the trait of conscientiousness, which increased by 0.36 SD over the period of interest. In addition, participants on average showed a reduction in external locus-of-control scores, suggesting that they became more internal in their attributional tendencies by a magnitude of 0.12 SD. Overall, we detect small to modest mean-level changes in most of the traits of interest over an eight-year period; however, the magnitude of these changes is typically fractions of a standard deviation and in no case do we find evidence for particularly dramatic normative shifts in personality traits over adolescence and young adulthood.

Table 1 Mean-level change over an eight-year period between 2005 and 2013 for Big-Five traits and between 2003 and 2011 for locus-of-control

Personality trait	N	Mean change (SD)	Min	Max	Est. change in SDs of base year score
Agreeableness	770	0.13 (0.92)	-3	3.25	0.15**
Conscientiousness	770	0.36 (0.97)	-2.5	3.8	0.36**
Emotional stability	770	0.16 (1.07)	-3.2	4.3	0.15**
Extraversion	770	-0.12 (0.92)	-3.5	3.5	-0.11**
Openness to experience	770	-0.06 (0.99)	-3.5	3.5	-0.06
External locus-of-control	777	-0.86 (8.16)	-28	26	-0.12**

Note: The original Big-Five scores are bound between 1 (low) and 7 (high) in 2005 and 2013, which are averaged scores across four (agreeableness) to six (conscientiousness) items. The original external locus of control scores are bound between 7 (low=internal) and 49 (high=external) in 2003 and 2011. Statistical significance levels: + $p < 0.10$, * $p < 0.05$, ** $p < 0.01$.

4.2. Are the observed mean-level changes reliable?

One reason why we find only small changes in personality traits is that some individuals increase while others decrease their traits, thus neutralizing any observed changes. To understand the proportion of respondents who increased or decreased in their personality traits in a statistically reliable way, we calculated a *Reliable Change Index* (RCI; Jacobson and Truax, 1991) for each individual in the sample, on each trait of interest. The RCI compares the individual's change score to the spread of scores that would be expected in a benchmark population where no true change occurs (that is, the change distribution expected from measurement error alone).

Equation (1) describes the construction of the Reliable Change Index (RCI) using personality scores for trait j from both period 1 and 2, Cronbach's α_j , and the spread of change in personality across the two time periods that would be expected if no actual change had occurred ($\sigma\Delta P_j$). The latter is usually approximated by the spread in the personality score in the general population (in our case - all adult groups) weighted by the reliability of the personality measurement (α_j), i.e. $\sigma\Delta P_j = \sqrt{2(\sigma\Delta P_k)(1 - \alpha_j)^2}$.

$$RCI_i = \frac{P_{Ti,2}^k - P_{Ti,1}^k}{\sqrt{2(\sigma\Delta P_k)(1 - \alpha_j)^2}} \quad (1)$$

If the personality measure contains a lot of noise (small α_j), then large changes in personality scores from period 1 to 2 cannot be reliably interpreted as true changes. Further, if the spread in the general population score of personality is very large (σ/P_j), which implies a large deviation from the population norm, then any changes in personality must be very large as well to be considered as true changes. Assuming a normal distribution of the personality scores in the population in both time periods considered (which we find to be true in our data), the individual change in personality scores is considered reliable if the absolute value of the RCI is greater than 1.96; below this cut-off, it is considered unreliable. This measure has been used previously in the literature to assess reliability in personality changes over time (see Lüdtke et al., 2011, p. 3 for an overview of this literature).

Table 2 presents the RCI results for changes in each personality trait between 2005 and 2013 for the Big-Five, and between 2003 and 2011 for locus-of-control. The second column gives the proportion of individuals who reliably decreased in their trait scores over the eight-year period; the third column gives the proportion of individuals whose changes were either zero or too small to be considered reliable; and the fourth column is the proportion of respondents who reliably increased on the trait.

For each trait of interest, the overwhelming majority of respondents neither reliably increased nor decreased their scores over the eight-year period. For each of the Big-Five traits, between 16% and 20% of the sample changed their scores in either direction, with agreeableness demonstrating the greatest degree of malleability. The proportion of those demonstrating reliable change was larger for locus-of-control than any of the Big-Five traits (approximately 26%). Conscientiousness was notable in that around four times more respondents increased than decreased on the trait (13% compared to 3%). A similar but less pronounced asymmetry was observed for agreeableness (12% increased vs. 7% decreased). All other traits exhibited a more even distribution across increases and decreases in scores.

Table 2 Reliable Change Index for changes in personality over an eight-year period between 2005 and 2013 for the Big-Five traits, and between 2011 and 2003 for locus-of-control

Personality trait	Decrease (%)	Unreliable (%)	Increase (%)
Agreeableness	7.27	80.39	12.34
Conscientiousness	2.86	84.42	12.73
Emotional stability	7.01	83.12	9.87
Extraversion	10.39	83.38	6.23
Open. to experience	8.70	84.42	6.88
Ext. locus-of-control	14.93	73.62	11.45

Note: Reliable Change Index is calculated according to Eq. 1.

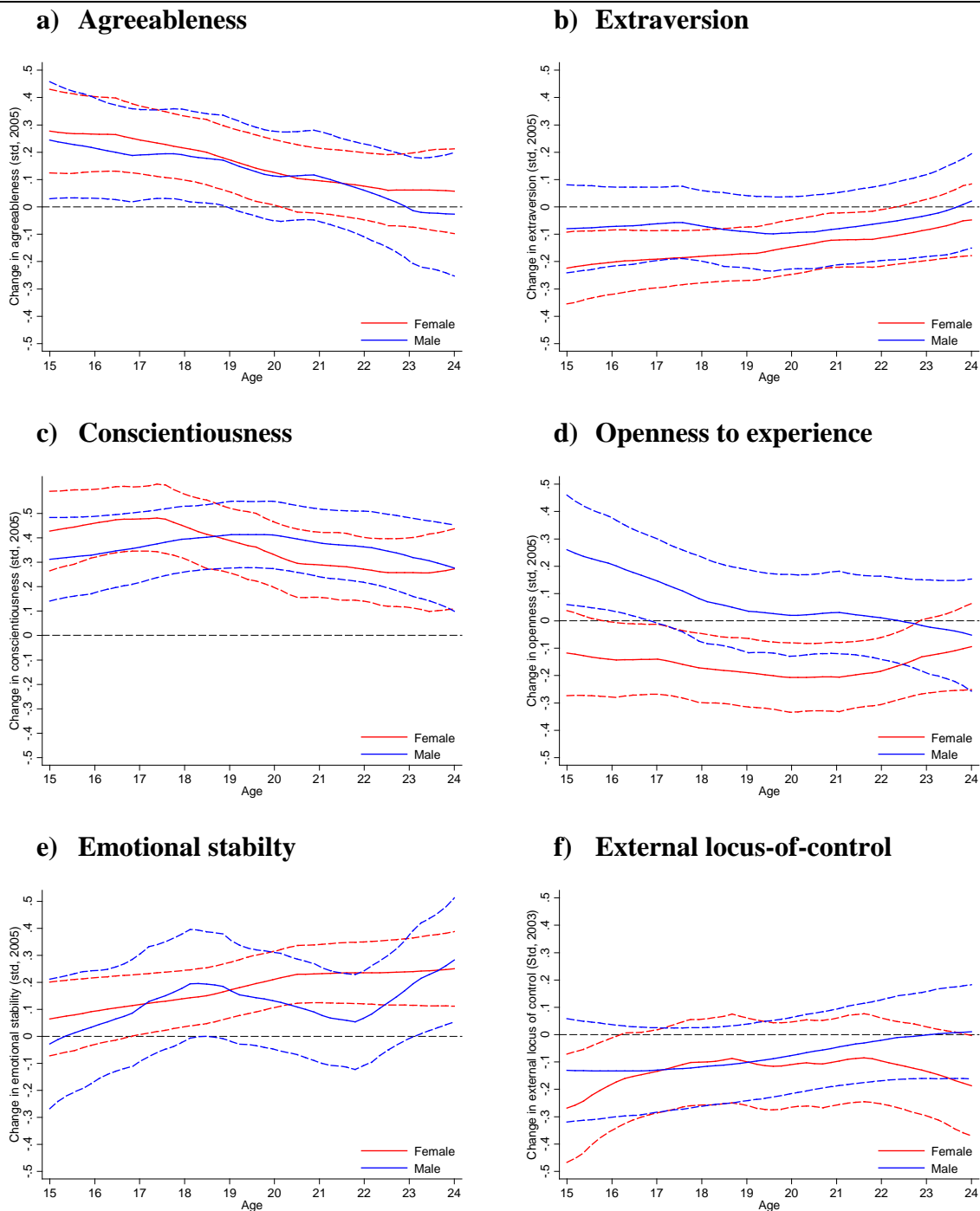
4.3. Malleability of traits by birth cohorts

We now examine how the stability of personality traits varies with age as respondents move from adolescence to young adulthood. We can examine this pattern of change to answer questions such as: Do personality traits tend to be unstable in adolescence and slowly stabilise as respondents mature, or do they continue to show some propensity to change well into young adulthood? Do female and male respondents have similar age-related trajectories?

Figures 1 (a) to (f) provide the non-parametric bivariate regression estimates of mean-level changes in the Big-Five traits and locus-of-control by age, for both males (illustrated in blue) and females (illustrated in red). Trait changes have been standardised such that the mean change is zero, and values above (below) the mean level indicate increases (decreases) on the trait of interest over an eight-year period. The magnitude of changes is thus expressed as standard deviations of the mean trait scores reported in 2005 for the Big-Five (see **Figure 1(a) to (e)**), and in 2003 for locus-of-control (see **Figure 1(f)**). In the figures, dashed lines parallel to the mean changes for males and females represent the corresponding 95% confidence intervals.

Respondents who were adolescents (15-19 years old) in 2005 increased significantly in agreeableness over an eight-year period, whilst those beyond age 20 in 2005 no longer showed significant increases (**Figure 1(a)**). This pattern suggests a general trend whereby agreeableness increases during adolescence before gradually stabilising by young adulthood. In contrast, conscientiousness increased significantly for all age groups throughout adolescence and young adulthood, for both sexes. Across the age groups, the average magnitude of these increases ranges between 0.2SD and 0.5SD above 2005 levels, and suggest that respondents continue to demonstrate significant increases in self-reported conscientiousness well into adulthood (**Figure 1(b)**).

Figure 1 Changes in personality traits over eight years by age



Note: Presented are non-parametric, bivariate estimates of the relationship between mean change in personality and age. Values are standardized to have a mean of zero relative to baseline personality. Black dashed line represents no self-reported change in personality trait relative to baseline; values above mean indicate increases in the trait; values below mean indicate reductions in the trait. Changes are represented as standard deviations of the 2005 trait level (for Big-Five traits) and 2003 trait level (for locus-of-control). Locus-of-control is increasing in external control tendencies. Dashed lines are the 95% confidence intervals corresponding to mean changes, which are represented by the solid colored lines.

Female respondents older than age 17 in 2005 appear to become significantly more emotionally stable over an eight-year period, a pattern that is evident well into young adulthood (see **Figure 1(c)**). The average magnitude of these increases ranges from 0.1 SD to 0.2 SD and does not appear to taper off with age within the period of interest. Emotional stability results for male respondents, however, were more erratic.

Age-related changes also suggest that female respondents become significantly less extroverted by a magnitude of around 0.2 SD over the course of adolescence, gradually stabilising by young adulthood (**Figure 1(d)**). For male respondents however, changes in extraversion were not significant at any age, suggesting that the trait remains on average more stable for men than women over adolescence and young adulthood.

Whilst our results on the whole indicate few age-related sex differences in personality change over time, the Big-Five trait of openness to experience is an exception (see **Figure 1(e)**). Males tend to exhibit significant but declining *increases* in openness through adolescence, whilst females between 17 and 23 years of age in 2005 show significant *reductions* in the trait over an eight-year period. This maybe the case because during puberty and entry into young adulthood gender roles emerge that require girls to be less open to new experiences. Finally, respondents appear to become more internal in their locus-of-control tendencies over an eight-year period; however, the magnitude of these age-related changes is generally only marginally significant for either sex.

Overall, our results suggest that some significant age-related changes in personality do occur over the period of adolescence and young adulthood. However, the magnitude of these changes is small and, with the exception of conscientiousness, do not exceed a 0.3 SD shift in either direction. This result is perhaps surprising, given that this developmental period is characterized by vast changes in areas such as physical maturation, social responsibilities, relationships, employment and education.

4.4. Intra-individual consistency: Is personality shaped by important life events?

Our results up to this point have indicated that some modest age-related personality trait changes are evident through the period of adolescence and young adulthood. These mean-level results, however, do not tell us anything about intra-individual change – and in fact the mean-level changes observed may obscure larger, but offsetting, shifts in individuals' personality traits over this developmental period.

This section describes the results of an investigation into the degree to which personality changes are impacted by important life events. We examine whether changes in

our traits of interest respond to a range of experiences – some that are typically seen as positive (e.g. an improvement in finances) and others that are considered adverse (e.g. the death of close friend). In addition, some of the life events are perceived to be somewhat under the control of the individual (e.g., a promotion at work), whilst others are more outside the individual’s control (e.g. being a victim of a property crime). This latter distinction may be particularly important for the locus-of-control trait, given previous research suggesting that the repeated experience of uncontrolled or unanticipated events can drive a tendency for a more external style of attribution (i.e. Goldsmith et al, 1996)

The results presented in this section are relevant to an important econometric challenge: that personality may not only play a role in driving the behaviour and choices of individuals, but also be endogenously shaped by, or simultaneously determined with, certain life events and experiences. If the latter is true, and we treat personality traits as exogenous inputs when they are in fact likely to respond endogenously to life experiences, our estimations can suffer from bias due to simultaneity and reverse causality (Cobb-Clark and Schurer, 2013). Examining the impact of shocks on individual personality changes can develop our understanding of the extent to which these traits are endogenously determined, and may challenge the assumption inherent in many economic decision-making models that such constructs are “given”. In addition, understanding the degree to which personality is malleable in response to experiences, especially during the adolescent period, may inform us about the value of investing in the enhancement of those aspects of personality that are linked to positive outcomes (e.g. successful labour market outcomes).

We investigated 27 “shocks” in total, including 21 one-off life events and six high-intensity life events (see **Appendix A2** for full description). High-intensity life events were included to determine whether the intensity of the event matters to its effect on personality change. We included only shocks that occurred after the baseline measure of personality. This means we defined the shocks between 2006 (wave 6) and 2013 (wave 13) for the Big-Five traits, and shocks that occurred between 2004 (wave 4) and 2011 (wave 11) for locus-of-control.

To understand the impact of each shock upon changes in personality, we entered individual trait change as the dependent variable, and estimated regressions of the form:

$$\Delta Big5_{i,13/05}^j = S_i^k \gamma^{j,k} + \mathbf{X}_{i,05} \boldsymbol{\beta}^{j,k} + \varepsilon_i^{j,k}. \quad (2)$$

Following Cobb-Clark et al. (2012) we estimated Equation (2) separately for each of the Big-Five traits (indexed by j) and for each shock (indexed by k). Equivalently, individual regressions of the form below were estimated for changes in locus-of-control:

$$\Delta LoC_{i,11/03} = S_i^k \gamma^k + \mathbf{X}_{i,03} \boldsymbol{\beta}^k + \varepsilon_i^k, \quad (3)$$

In each regression equation, S_i^k represents an indicator variable which is equal to 1 if shock k occurred during the specified period, and 0 otherwise. The term \mathbf{X}_i^k is a vector of control variables measured during 2005 for the Big-Five traits and during 2003 for locus-of-control. We controlled for age, sex, parental occupation, parental educational attainment, income, education level, employment status, marital status, number of children, whether or not the individual still lives at home, country of birth, Indigenous status, and location of residence (see **Table A3** for summary statistics for both estimation samples).

In total, 27×6 separate regressions were run to estimate the treatment effect of each shock on each of the Big-Five traits and locus-of-control. Our change measure is standardised to have a mean of 0 and standard deviation of 1; thus, the treatment effect of each shock can be interpreted in terms of standard deviation changes in the relevant trait. The total sample size for the Big-Five traits was $N=770$, and for locus-of-control, $N=777$.

Table 3 presents our estimation results of Equations (2) and (3) of the effect of one-off shocks on personality change. For the majority of life events, most personality traits did not appear to respond significantly; however, there are some notable exceptions. The trait of openness declined significantly in response to the birth or adoption of a new child and a job change, whilst those who retired from the workforce became considerably more open to experience—exhibiting an increase in the trait of more than 1 SD. However, given that only 5(11) individuals in the sample retired at such a young age, this effect is identified for a very special group of individuals and may be highly sensitive to outliers. A small and marginally significant decline in conscientiousness was found for those who were the victim of a property crime. Respondents who had experienced separation from their partner became significantly more extroverted by almost 0.30 SD.

Table 3 Regression results – treatment effect of one-off positive and negative shocks on Big-Five personality traits (columns 2 to 5) and locus-of-control (column 6).

Life events (N=Number of obs.)	Open.	Consc.	Extrav.	Agree.	Emot. Stab.	Ext. LOC
	(1)	(2)	(3)	(4)	(5)	(6)
Birth/adoption of new child (N _{Big5} = 150; N _{LoC} = 182)	-0.230* (0.110)	0.0943 (0.112)	-0.103 (0.113)	-0.0647 (0.112)	0.00669 (0.113)	-0.00415 (0.108)
Death of a close friend (N _{Big5} = 161; N _{LoC} = 170)	0.0480 (0.0937)	0.145 (0.0947)	0.143 (0.0956)	0.110 (0.0954)	0.312** (0.0949)	0.144 (0.0937)
Death close family member (N _{Big5} = 289; N _{LoC} = 321)	0.133 (0.0847)	0.0321 (0.0858)	0.0877 (0.0865)	0.0661 (0.0864)	0.0296 (0.0865)	0.0550 (0.0847)
Death of spouse or child (N _{Big5} = 9; N _{LoC} = 11)	-0.380 (0.343)	0.154 (0.348)	-0.257 (0.350)	-0.0152 (0.350)	0.225 (0.350)	0.0977 (0.320)
Major improve. in finances (N _{Big5} = 80; N _{LoC} = 101)	-0.0133 (0.124)	0.0752 (0.126)	0.114 (0.127)	0.127 (0.126)	0.126 (0.127)	0.112 (0.112)
Major worsening in finances (N _{Big5} = 54; N _{LoC} = 53)	0.198 (0.149)	0.194 (0.151)	0.0710 (0.152)	0.0312 (0.152)	-0.302* (0.151)	0.248 (0.147)
Fired or made redundant (N _{Big5} = 143; N _{LoC} = 129)	-0.0743 (0.0984)	-0.0767 (0.0995)	-0.0685 (0.100)	-0.132 (0.100)	-0.00360 (0.100)	-0.0139 (0.103)
Serious injury/illness family (N _{Big5} = 281; N _{LoC} = 300)	-0.0147 (0.0854)	0.0870 (0.0863)	-0.0203 (0.0871)	-0.0903 (0.0868)	0.0635 (0.0871)	0.0246 (0.0850)
Serious personal injury/illness (N _{Big5} = 135; N _{LoC} = 147)	0.137 (0.0996)	-0.0064 (0.101)	-0.165 (0.102)	0.0973 (0.101)	0.0347 (0.102)	0.0377 (0.0972)
Family member detained jail (N _{Big5} = 29; N _{LoC} = 44)	-0.307 (0.197)	-0.202 (0.199)	0.224 (0.201)	-0.449* (0.200)	0.188 (0.201)	0.0148 (0.162)
Detained in jail (N _{Big5} = 7; N _{LoC} = 6)	0.409 (0.400)	0.616 (0.405)	-0.126 (0.409)	0.258 (0.408)	0.276 (0.408)	0.0102 (0.421)
Changed jobs (N _{Big5} = 468; N _{LoC} = 465)	-0.178+ (0.107)	0.0796 (0.108)	0.0121 (0.109)	-0.0724 (0.109)	0.195+ (0.109)	-0.0302 (0.105)
Got married (N _{Big5} = 170; N _{LoC} = 179)	-0.138 (0.0958)	-0.0401 (0.0971)	-0.0807 (0.0978)	0.0768 (0.0976)	-0.0837 (0.0978)	0.0791 (0.0966)
Changed residence (N _{Big5} = 490; N _{LoC} = 506)	0.0217 (0.116)	0.0638 (0.118)	-0.0945 (0.119)	0.270* (0.118)	-0.127 (0.119)	0.0547 (0.121)
Victim of a property crime (N _{Big5} = 152; N _{LoC} = 151)	-0.0424 (0.0949)	-0.167+ (0.0958)	0.107 (0.0967)	-0.0531 (0.0967)	-0.0453 (0.0968)	0.0794 (0.0972)
Pregnancy (N _{Big5} = 192; N _{LoC} = 213)	-0.107 (0.104)	-0.0216 (0.105)	-0.0867 (0.106)	-0.0989 (0.105)	-0.0857 (0.106)	-0.00644 (0.100)
Promoted at work (N _{Big5} = 268; N _{LoC} = 285)	-0.135 (0.0882)	0.0940 (0.0894)	-0.0242 (0.0902)	-0.0004 (0.0900)	0.00736 (0.0901)	-0.0115 (0.0859)
Got back with spouse (N _{Big5} = 32; N _{LoC} = 37)	0.0900 (0.186)	-0.0932 (0.188)	-0.159 (0.190)	0.0812 (0.189)	-0.0851 (0.190)	-0.00483 (0.177)
Retired from the workforce (N _{Big5} = 5; N _{LoC} = 11)	1.115* (0.453)	-0.423 (0.460)	0.126 (0.464)	-0.369 (0.463)	-0.656 (0.463)	0.0306 (0.315)
Separated from partner (N _{Big5} = 154; N _{LoC} = 156)	-0.0687 (0.0960)	-0.0896 (0.0971)	0.297** (0.0974)	-0.138 (0.0977)	0.100 (0.0979)	-0.0309 (0.0947)
Victim of physical violence (N _{Big5} = 62; N _{LoC} = 69)	-0.199 (0.138)	0.143 (0.139)	0.0490 (0.141)	-0.263+ (0.140)	0.206 (0.140)	0.0257 (0.131)

*Note: Standard errors in parentheses: + p<0.10, * p<0.05, ** p<0.01; trait changes are standardized to mean = 0 and standard deviation = 1; effects can be interpreted as standard deviation changes in the relevant trait.*

A significant increase in agreeableness was found in response to changing residence (0.27 SD), whilst declines in agreeableness were observed in response to the adverse experiences of having a close family member detained in jail (-0.45 SD), and being the victim of physical violence (-0.26 SD), although the latter was significant only at the 10% level. The final Big-Five trait of emotional stability increased significantly in response to the death of a close friend (0.31 SD) and a job change (0.20 SD, marginally significant), whilst those who experienced a major worsening in finances became significantly more emotionally unstable (-0.30 SD).

Given the large amount of hypotheses tested, we would need to adjust the p-values of the t-test statistics to obtain certainty that an effect is statistically significant. If we test 20 hypotheses, we would find by chance at least one effect that is statistically significant at the five percent level. With 162 individual hypotheses, we would expect to find eight statistically significant effects attributable to chance, which is exactly the case. Similar to Cobb-Clark and Schurer (2012; 2013), we therefore conclude that one-off life events do not systematically predict changes in personality.

Table 4 Regression results – treatment effect of high-intensity negative life events on Big-Five personality traits (columns 2 to 6) and locus-of-control (column 6).

Life event (LE) (Number ind. with LE)	Open. To Exp. (1)	Consc. (2)	Extrav. (3)	Agree. (4)	Emot. Stab. (5)	External LOC (6)
Unemployed 3+ yrs (N _{Big5} = 21; N _{LoC} = 24)	0.0442 (0.235)	0.389 (0.237)	0.119 (0.240)	-0.205 (0.239)	0.325 (0.239)	0.197 (0.221)
Chronic pain 4+ yrs (N _{Big5} = 5; N _{LoC} = 6)	-0.839 (0.520)	-0.622 (0.526)	-0.912+ (0.530)	-0.299 (0.530)	-0.700 (0.530)	-0.680 (0.511)
Restrictive cond. 4+ yrs (N _{Big5} = 5; N _{LoC} = 8)	-0.200 (0.523)	0.236 (0.529)	-0.123 (0.534)	0.245 (0.532)	-0.654 (0.533)	0.261 (0.495)
Ill/injured 2+ yrs (N _{Big5} = 42; N _{LoC} = 49)	0.129 (0.164)	0.057 (0.166)	0.0521 (0.167)	0.0507 (0.167)	-0.105 (0.167)	0.252+ (0.152)
Health condition 4+ yrs (N _{Big5} = 84; N _{LoC} = 91)	-0.048 (0.120)	-0.006 (0.121)	-0.022 (0.122)	-0.233+ (0.121)	-0.119 (0.122)	0.312** (0.115)
Death 2+ family member (N _{Big5} = 101; N _{LoC} = 107)	0.105 (0.112)	0.102 (0.113)	-0.007 (0.114)	0.100 (0.114)	0.0955 (0.114)	-0.124 (0.110)

Note: Standard errors in parentheses: + p<0.10, * p<0.05, ** p<0.01; trait changes are standardized to mean = 0 and standard deviation = 1; effects can be interpreted as standard deviation changes in the relevant trait.

It may be possible that these one-off life events have no lasting impact on the individual's personality assessment because individuals adapt to new situations. The overall

conclusion does not change when considering the effect of high-intensity shocks (see **Table 4**), with one important exception. Long-term experiences of health problems affect individuals' personality. For instance, respondents' locus-of-control tendencies became more external in response to the high-intensity experiences of being ill or injured for greater than two years (0.25 SD, significant at the 10% level) and having a long-term health condition for four or more years (0.31 SD). The experience of a long-term health condition is also associated with a 0.23 SD decline in the trait of agreeableness (significant at the 10% level), while four or more years living in chronic pain are significantly associated with a reduction in extraversion of almost 1 SD (however, only 5(6) adolescents in the sample experienced such intensive periods of chronic pain). We next consider the extent to which these changes in personality induced by life-events are economically meaningful.

4.5. Are the observed changes in personality traits economically meaningful?

Can we judge whether the above-discussed changes are large or small? One way to express the magnitude of the personality trait change over time has been provided in Cobb-Clark and Schurer (2012, 2013). The authors expressed the change in personality traits observed for an adult population over a four-year window as the implied wage equivalent. By knowing the effects of personality traits on hourly wages – usually expressed in terms of standard deviation change - one can calculate the hourly wage difference for the estimated standard-deviation change in personality over four years. In our setting, this may not be the most appropriate benchmark, since many of our sample members are not in full or meaningful employment (because they are still in training, for example).

A more intuitive strategy is to calculate the probability effect of youth personality on graduating from university. A university degree has a private monetary benefit over the life course, and therefore is a desirable economic outcome. In Australia, a university degree on average is associated with a net increase in lifetime earnings of \$120,000 (Daly et al., 2015). Once we know the marginal probability effect of a one-standard-deviation increase in each of our personality traits -- measured in mid- to late adolescence -- on having a university degree, this estimate can be used to calculate the equivalent increase in the probability of a university degree for the estimated personality change observed in our sample over an eight-year window.

Table 5 reports the marginal probability effects (MPE) of the six personality traits (PT), measured in 2005 (Big-5) and 2007 (locus-of-control - LOC), on the probability of having graduated from university in 2013, for a sample of individuals who are between 23

and 30 years of age (columns 1, 4, and 7). In our sample, 38% of women and 31% of men have a university degree, which is representative of the national average (OECD, 2013). Overall, the personality trait changes that we observe for women and men over an eight-year window are not substantially boosting the probability of a university degree.

The only exception is for conscientiousness for which we find both a strong effect on university graduation and a large, average change over eight years. For instance, a one standard deviation increase in youth conscientiousness is associated with a 6.4 percentage point increase in the probability of a university degree in young adulthood. This MPE translates into an increase in the probability of obtaining a university degree of over 18%. Given that we observed on average a significant increase in conscientiousness from adolescence to young adulthood of 0.36 SD away from the mean of conscientiousness in adolescence, this implies an increase in the probability of obtaining a university degree of 6.5 percent (18.3×0.36). This increase is particularly large for men (10%); we observe only half of this effect for women (5%). Given the net increase in lifetime earnings of a university degree in the magnitude of \$120,000, the expected financial returns of an increase in conscientiousness is \$12,000 for men and \$6,000 for women.

Gender heterogeneity is also found for openness to experience. Women decrease their openness scores over an eight-year window by 0.15 SD, but a one-standard deviation increase in openness to experience is associated with a 36% increase in the probability of a university degree. Therefore, for women the implied reduction in the probability of obtaining a university degree, due to a reduction in openness to experience, is equal to 5%, or a loss of \$6,000 in lifetime earnings. For the four remaining personality traits, the eight-year change in personality implies a change in the probability of a university degree by 1 to less than 3%.

In accordance with Cobb-Clark and Schurer (2012, 2013), we therefore conclude that although personality traits do change over an eight-year window for adolescents, the implied changes are not economically meaningful, with the exception of conscientiousness and openness to experience for women.

Table 5: Education equivalent of personality trait (PT) change.

	Pooled sample			Female sample			Male sample		
	PT effect uni degree MPE ^a [% effect] (1)	Mean Δ PT over 8 years SD (2)	Equiv. percent change uni (3)	PT effect uni degree MPE ^a [% effect] (4)	Mean Δ PT over 8 years SD (5)	Equiv. percent change uni (6)	PT effect uni degree MPE ^a [% effect] (7)	Mean Δ PT over 8 years SD (8)	Equiv. percent change uni (9)
External LOC	-0.070 ^{***} (0.021) [20.0]	-0.116 ^{***} (0.040)	2.3	-0.067 ^{**} (0.029) [17.6]	-0.153 ^{***} (0.053)	2.7	-0.088 ^{***} (0.032) [28.4]	-0.075 (0.060)	2.1
Agreeableness	-0.028 (0.023) [8.0]	0.150 ^{***} (0.037)	1.2	-0.034 (0.032) [8.9]	0.166 ^{***} (0.046)	1.5	-0.031 (0.034) [10.0]	0.129 ^{**} (0.061)	1.3
Conscientiousness	0.064 ^{***} (0.022) [18.3]	0.355 ^{***} (0.034)	6.5	0.053 [*] (0.028) [13.9]	0.362 ^{***} (0.043)	5.0	0.089 ^{**} (0.036) [28.7]	0.347 ^{***} (0.056)	10.0
Emotional stab.	0.029 (0.023) [8.3]	0.147 ^{***} (0.036)	1.2	0.026 (0.031) [6.8]	0.168 ^{***} (0.046)	1.1	0.013 (0.037) [4.2]	0.118 ^{**} (0.058)	0.5
Extraversion	-0.070 ^{***} (0.020) [20]	-0.112 ^{***} (0.031)	2.2	-0.059 ^{**} (0.026) [16.0]	-0.150 ^{***} (0.040)	2.3	-0.092 ^{***} (0.035) [29.7]	-0.060 (0.050)	1.8
Openness to exp.	0.115 ^{***} (0.022) [32.9]	-0.055 (0.034)	1.8	0.136 ^{***} (0.029) [35.8]	-0.153 ^{***} (0.043)	5.5	0.084 ^{**} (0.035) [27.0]	0.080 (0.055)	2.2
N	459			266			190		
Base probability	0.35			0.38			0.31		

Note: a MPE: Marginal Probability Effect calculated from a binary choice model in which the dependent variable is whether the individual has a university degree by age 30 (1=yes, 0 no) and the independent variables are Big-Five personality traits, locus of control, controls for birth-cohort indicators, family background, language background, and location of residence (Columns (1), (4), (7)). Columns (3), (6), and (9) report the equivalent percent increase in the probability of a university degree for the observed 8-year personality change in our sample. Standard errors in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

5. Discussion and Conclusion

In this study we explored the malleability of the Big-Five personality traits and locus-of-control from adolescence into young adulthood. Using nationally-representative, high-quality panel data, we demonstrated that most of these traits show malleability between adolescence and young adulthood, although mean population changes do not exceed 0.15 SD. The reason for small mean-changes is that most individuals in our sample do not change their scores in a statistically reliable way, and for those who do, some decrease and others increase their self-assessments.

The most important finding is that conscientiousness, often referred to as a proxy for executive function (Kern et al., 2009), and openness to experience, which has been linked to crystallized intelligence (Borghans et al., 2011), are the most malleable in this sensitive time-period. The average increase in conscientiousness implies a 5% and 10% increase in the probability of having obtained a university degree – equivalent to a \$6,000 and \$12,000 net increase in lifetime earnings – for women and men, respectively. One-off life events do not systematically predict these changes in personality traits. Long-term health problems do however impact on individuals' control perceptions and agreeableness by up to 0.3 SD. Therefore, the impact of long-term health problems on control perceptions and agreeableness are partially offsetting a general trend in the population of decreasing external control and increasing agreeableness.

Our results contribute to the literature in two important ways. First, our findings can be used to benchmark the effectiveness of adolescent education programs aimed at boosting life skills. Reviewing the empirical evidence on the role of the education sector in building life skills during adolescence, Schurer (2016) finds that most programs, that find significant positive impacts, are boosting life skills roughly between 0.1 SD and 0.4 SD. These effect sizes are similar in magnitudes to the personality changes we observe during adolescence. We therefore conclude that the effects of these education programs are reasonably large.

Second, our findings demonstrate that – if at all – personality traits in adolescence are not specifically malleable with respect to common and less common life events that occur only once. For instance, adolescents who have lost a close family member or a partner do not seem to become less emotionally stable or more externally controlled, although such life events have the characteristic of “hopelessness” as described by Seligman (1975). Our results are in line with the findings in Cobb-Clark and Schurer (2012; 2013) who also do not find

any evidence that one-off life events have statistically or economically significant effects on personality change over four years for working adults.

Our finding that long-lasting or recurring health problems are associated with a more external locus-of-control has also been demonstrated in Cobb-Clark and Schurer (2013) for working age women, although the effect sizes are smaller (0.2 SD). This finding is important from a policy perspective as it implies that programs aimed at increasing health in adolescents may have positive effects on participants' personality over and above the obvious health benefits later in life. Furthermore, this finding has implications for applied researchers who seek to identify and interpret the effects of young adulthood control perceptions (or agreeableness) on life-time outcomes: Without controlling adequately for differences in past health, researchers cannot interpret the treatment effects of control perceptions or agreeableness as causal.

There are some important limitations to our analysis that should be discussed. On the one hand, we cannot overcome the problem that many adolescents in our sample drop out over the eight-year period. This is a common problem in research on adolescents, because adolescence is a time period of constant change and mobility. Second, for many life events, we do not have enough observations to identify a statistically significant effect, and thus we are likely to underestimate the impact of severe life shocks on adolescents' personality change. Third, and possibly most important, we cannot overcome the problem of reference bias inherent in self-assessed personality data that may severely confound our conclusions. West et al. (2016) have proposed that studies seeking to identify the effect of an education intervention on personality traits, may not find any effects or even negative treatment effects, because the subjects may lift the benchmark against which they compare themselves. This may be an issue in our sample too, because some of the adolescents in our sample have started their post-secondary education or training after the baseline measurement of personality trait. However, these issues are common among all studies that aim to assess the effect of shocks or interventions on personality development.

Contrary to most other studies, the advantage of our analysis is that personality measures are consistently collected with the same high-quality instrument and scaling. Furthermore, our dataset is nationally representative and we can follow individuals' personality development over an eight-year time frame. Measures of life events are recorded concurrently and do not suffer from recall bias. Because personality traits continue to be measured in high-quality, longitudinal datasets, it will be possible in the future to follow adolescents' personality development over even longer time spans. This will enable us to

study more effectively and reliably the impact of repeated life-events on personality change in the future.

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APPENDIX

Table A1. Within sample Cronbach's alpha for personality traits

	N*T	Sign	item- test corr	item- rest corr	avg interim covar	alpha if drop item
External locus of control						
I have little control over the things that happen	2331	+	0.716	0.594	0.957	0.826
There is really no way I can solve some of the problems	2331	+	0.791	0.696	0.906	0.811
There is little I can do to change many of the	2331	+	0.769	0.672	0.936	0.815
I often feel helpless in dealing with the problems	2331	+	0.800	0.703	0.886	0.809
Sometimes I feel that I'm being pushed around	2331	+	0.767	0.652	0.903	0.817
What happens to me in the future mostly	2331	-	0.553	0.399	1.086	0.854
I can do just about anything I really set my	2331	-	0.641	0.511	1.029	0.838
<i>Test scale</i>					0.958	0.846
Extraversion						
Talkative	2310	-	0.733	0.587	0.827	0.713
Quiet	2310	+	0.825	0.703	0.702	0.677
Extroverted	2310	-	0.622	0.424	0.928	0.756
Shy	2310	+	0.809	0.678	0.720	0.684
Lively	2310	-	0.577	0.416	1.000	0.755
Bashful	2310	+	0.483	0.274	1.073	0.788
<i>Test scale</i>					0.875	0.767
Emotionally stable (reverse of neuroticism)						
Envious	2310	+	0.668	0.516	0.928	0.770
Moody	2310	+	0.746	0.594	0.823	0.751
Jealous	2310	+	0.725	0.579	0.862	0.755
Temperamental	2310	+	0.747	0.610	0.841	0.747
Fretful	2310	+	0.660	0.496	0.926	0.774
Touchy	2310	+	0.665	0.488	0.909	0.777
<i>Test scale</i>					0.882	0.794
Conscientiousness						
Orderly	2310	-	0.750	0.608	0.762	0.735
Systematic	2310	-	0.598	0.388	0.896	0.791
Inefficient	2310	+	0.690	0.539	0.830	0.752
Sloppy	2310	+	0.624	0.459	0.892	0.770
Organised	2310	+	0.785	0.644	0.709	0.724
Efficient	2310	-	0.728	0.598	0.809	0.740
<i>Test scale</i>					0.816	0.786
Openness to experience						
Deep	2310	+	0.692	0.528	0.796	0.705

Table A1., cont.

	N*T	Sig	item- test corr	item- rest corr	avg interim covar	alpha if drop item
Philosophical	2310	+	0.719	0.541	0.748	0.700
Creative	2310	+	0.645	0.452	0.833	0.726
Imaginative	2310	+	0.690	0.528	0.801	0.705
Complex	2310	+	0.650	0.452	0.825	0.726
Intellectual	2310	+	0.610	0.445	0.891	0.727
<i>Test scale</i>					<i>0.816</i>	<i>0.751</i>
Agreeable						
Sympathetic	2310	+	0.768	0.535	0.568	0.727
Kind	2310	+	0.800	0.647	0.566	0.669
Cooperative	2310	+	0.700	0.472	0.673	0.753
Warm	2310	+	0.801	0.616	0.532	0.677
<i>Test scale</i>					<i>0.585</i>	<i>0.763</i>

Table A2: Description of one-off and aggregated self-reported life events experienced after the baseline measurement of personality traits

One-off Life Events

Negative

Serious personal illness or injury
Serious personal illness to family member
Death of spouse or child
Death of close family member or relative
Death of a close friend
Victim of physical violence
Victim of property crime
Detained in jail
Family member detained in jail
Fired or made redundant
Major worsening of finances

Positive

Got married
Got back together with spouse
Pregnancy
Birth or adoption of new child
Promoted at work
Major improvement of finances
Retired from the workforce

Aggregated Life Events

Experience of unemployment for three years or more
Experience of chronic pain for four years or more
Experience of a medical condition that restricted the individual for four years or more
Experience of an illness or injury for at least two years
Experience of a health condition for four years or more
Experience of death of two or more family members

Table A3. Summary statistics of estimation sample**Panel A. Big-Five estimation sample: Summary statistics**

	Mean	SD	Min	Max	N
<i>Life events that occurred between 2006 and 2013</i>					
Birth/adoption of new child	0.26	0.44	0	1	584
Death of a close friend	0.27	0.45	0	1	591
Death close family member	0.49	0.50	0	1	588
Death of spouse or child	0.02	0.12	0	1	586
Major improve. In finances	0.14	0.34	0	1	587
Major worsening in finances	0.09	0.29	0	1	591
Fired or made redundant	0.24	0.43	0	1	587
Serious injury/illness family	0.48	0.50	0	1	590
Serious personal injury/illness	0.23	0.42	0	1	588
Family member detained jail	0.05	0.22	0	1	592
Detained in jail	0.01	0.11	0	1	592
Changed jobs	0.79	0.41	0	1	592
Got married	0.29	0.45	0	1	592
Changed residence	0.83	0.37	0	1	589
Victim of a property crime	0.26	0.44	0	1	590
Pregnancy	0.33	0.47	0	1	591
Promoted at work	0.47	0.50	0	1	570
Got back with spouse	0.05	0.23	0	1	591
Retired from the workforce	0.01	0.09	0	1	590
Separated from partner	0.26	0.44	0	1	591
Victim of physical violence	0.11	0.31	0	1	590
<i>High intensity life events</i>					
Unemployed 3+ yrs	0.03	0.16	0	1	770
Chronic pain 4+ yrs	0.008	0.45	0	1	589
Restrictive cond. 4+ yrs	0.01	0.34	0	1	592
Ill/injured 2+ yrs	0.07	0.26	0	1	588
Health condition 4+ yrs	0.11	0.31	0	1	769
Death 2+ family member	0.17	0.38	0	1	581
<i>Control variables measured in 2005</i>					
Age	19.30	2.92	15	24	770
Sex=Male	0.42	0.49	0	1	770
Father's highest educational institution					
University	(base)				498
Teachers College/College of Adv Education	0.04	0.20	0	1	498
Institute of Technology	0.03	0.18	0	1	498
Technical College/TAFE/College of Technical and Further Education	0.26	0.44	0	1	498
Employer	0.23	0.42	0	1	498
Other	0.01	0.08	0	1	498
Father completed educational qualification after leaving school	0.71	0.46	0	1	714
How much schooling father completed					
None	(base)				740
Primary school only	0.02	0.15	0	1	740
Some, no more than year 10	0.40	0.49	0	1	740
Year 11 or equivalent	0.09	0.29	0	1	740
Year 12 or equivalent	0.49	0.50	0	1	740
Mother's highest educational institution					
University	(base)				428
Teachers College/College of Adv Educ.	0.11	0.32	0	1	428
Institute of Technology	0.01	0.12	0	1	428

Technical College, TAFE, College of Techn & Further Educ.	0.28	0.45	0	1	428
Employer	0.11	0.32	0	1	428
Other	0.01	0.10	0	1	428
Mother completed educational qualification after leaving school	0.62	0.49	0	1	719
Mother's schooling					
None	(base)				746
Primary school only	0.02	0.13	0	1	746
Some, no more than year 10	0.34	0.47	0	1	746
Year 11 or equivalent	0.13	0.34	0	1	746
Year 12 or equivalent	0.52	0.50	0	1	746
Father's job when respondent 14yo	50.50	24.67	4.9	100	668
Mother's job when respondent 14yo	54.35	24.87	3.4	100	610
Household income	68897.52	55317.50	-478632	556212	770
Labour force status					
Employed	(base)				770
Unemployed	0.06	0.24	0	1	770
Not in labour force	0.23	0.42	0	1	770
Respondent's education level					
Studying degree or above	0.18	0.38	0	1	770
Studying (advanced) diploma	0.11	0.31	0	1	770
Highest education level achieved					
Year 11	(base)				770
Year 12	0.34	0.47	0	1	770
Certificate III/IV	0.10	0.31	0	1	770
Advanced diploma	0.03	0.18	0	1	770
Bachelor degree	0.08	0.28	0	1	770
Graduate diploma	0.01	0.09	0	1	770
Has a partner	0.21	0.41	0	1	770
Number of children					
0	(base)				770
1	0.05	0.22	0	1	770
2	0.01	0.12	0	1	770
3	0.00	0.05	0	1	770
4	0.00	0.04	0	1	770
Lives at home	0.61	0.49	0	1	760
Country of birth					
Australia	(base)				770
Main English speaking country ^a	0.03	0.16	0	1	770
Other	0.06	0.24	0	1	770
Indigenous status	0.03	0.17	0	1	770
State of residence					
NSW	(base)				770
VIC	0.25	0.43	0	1	770
QLD	0.22	0.41	0	1	770
SA	0.08	0.27	0	1	770
WA	0.09	0.28	0	1	770
TAS	0.04	0.20	0	1	770
NT	0.01	0.07	0	1	770
ACT	0.04	0.20	0	1	770
Does not live in major urban area	0.37	0.48	0	1	770

Note: ^aMain English speaking countries include United Kingdom, New Zealand, Canada, USA, Ireland and South Africa (HILDA codebook).

Panel B. Locus-of-control estimation sample: Summary statistics

	Mean	SD	Min	Max	N
<i>Life events that occurred between 2004 and 2011</i>					
Birth/adoption of new child	0.32	0.47	0	1	577
Death of a close friend	0.29	0.45	0	1	587
Death close family member	0.55	0.50	0	1	587
Death of spouse or child	0.02	0.13	0	1	583
Major improve. In finances	0.17	0.38	0	1	586
Major worsening in finances	0.09	0.29	0	1	587
Fired or made redundant	0.22	0.41	0	1	589
Serious injury/illness family	0.51	0.50	0	1	583
Serious personal injury/illness	0.25	0.44	0	1	583
Family member detained jail	0.07	0.26	0	1	590
Detained in jail	0.01	0.10	0	1	589
Changed jobs	0.79	0.41	0	1	589
Got married	0.30	0.46	0	1	594
Changed residence	0.86	0.35	0	1	592
Victim of a property crime	0.26	0.44	0	1	586
Pregnancy	0.36	0.48	0	1	587
Promoted at work	0.50	0.50	0	1	570
Got back with spouse	0.06	0.24	0	1	589
Retired from the workforce	0.02	0.14	0	1	590
Separated from partner	0.27	0.44	0	1	584
Victim of physical violence	0.12	0.32	0	1	588
<i>High intensity life events</i>					
Unemployed 3+ yrs	0.03	0.17	0	1	777
Chronic pain 4+ yrs	0.008	0.49	0	1	583
Restrictive cond. 4+ yrs	0.01	0.51	0	1	595
Ill/injured 2+ yrs	0.07	0.28	0	1	588
Health condition 4+ yrs	0.11	0.32	0	1	769
Death 2+ family member	0.18	0.39	0	1	581
<i>Control variables measured in 2003</i>					
Age	19.25	2.93	15	24	777
Sex=Male	0.47	0.50	0	1	777
Father's highest educational institution					
University	(base)				464
Teachers College/College of Adv Education	0.05	0.23	0	1	464
Institute of Technology	0.05	0.21	0	1	464
Technical College/TAFE/College of Technical and Further Education	0.28	0.45	0	1	464
Employer	0.22	0.41	0	1	464
Other	0.00	0.07	0	1	464
Father completed educational qualification after leaving school	0.66	0.47	0	1	724
How much schooling father completed					
None	(base)				739
Primary school only	0.03	0.18	0	1	739
Some, no more than year 10	0.44	0.50	0	1	739
Year 11 or equivalent	0.09	0.29	0	1	739
Year 12 or equivalent	0.43	0.50	0	1	739
Mother's highest educational institution					
University	(base)				400
Teachers College/College of Adv Educ.	0.11	0.32	0	1	400
Institute of Technology	0.01	0.11	0	1	400
Technical College, TAFE, College of Techn & Further Educ.	0.32	0.47	0	1	400
Employer	0.15	0.36	0	1	400

Other	0.01	0.11	0	1	400
Mother completed educational qualification after leaving school	0.56	0.50	0	1	731
Mother's schooling					
None	(base)				753
Primary school only	0.03	0.17	0	1	753
Some, no more than year 10	0.38	0.49	0	1	753
Year 11 or equivalent	0.14	0.34	0	1	753
Year 12 or equivalent	0.45	0.50	0	1	753
Father's job when respondent 14yo	48.94	24.16	4.9	100	665
Mother's job when respondent 14yo	50.14	24.44	3.4	100	575
Household income	59223.97	44707.22	-275619	462282	777
Labour force status					
Employed	(base)				777
Unemployed	0.08	0.28	0	1	777
Not in labour force	0.25	0.44	0	1	777
Respondent's education level					
Studying degree or above	0.16	0.37	0	1	777
Studying (advanced) diploma	0.13	0.33	0	1	777
Highest education level achieved					
Year 11	(base)				777
Year 12	0.34	0.47	0	1	777
Certificate III/IV	0.12	0.32	0	1	777
Advanced diploma	0.02	0.15	0	1	777
Bachelor degree	0.08	0.27	0	1	777
Graduate diploma	0.00	0.06	0	1	777
Has a partner	0.22	0.41	0	1	777
Number of children					
0	(base)				777
1	0.04	0.20	0	1	777
2	0.01	0.11	0	1	777
3	0.01	0.07	0	1	777
4	0.00	0.04	0	1	777
Lives at home	0.58	0.50	0	1	771
Country of birth					
Australia	(base)				777
Main English speaking country ^a	0.03	0.16	0	1	777
Other	0.08	0.26	0	1	777
Indigenous status	0.02	0.16	0	1	777
State of residence					
NSW	(base)				777
VIC	0.25	0.43	0	1	777
QLD	0.23	0.42	0	1	777
SA	0.08	0.28	0	1	777
WA	0.09	0.28	0	1	777
TAS	0.05	0.21	0	1	777
NT	0.01	0.09	0	1	777
ACT	0.02	0.14	0	1	777
Does not live in major urban area	0.37	0.48	0	1	777

Note: ^aMain English speaking countries include United Kingdom, New Zealand, Canada, USA, Ireland and South Africa (HILDA codebook).