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Adult Temperament and Childbearing over the Life Course

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Abstract

Emerging evidence suggests that temperament may predict childbearing. We examined the association between four temperament traits (novelty seeking, harm avoidance, reward dependence and persistence of the Temperament and Character Inventory) and childbearing over the life course in the population-based Cardiovascular Risk in Young Finns study (n = 1535; 985 women, 550 men). Temperament was assessed when the participants were aged 20–35 and fertility history from adolescence to adulthood was reported by the participants at age 30–45. Discrete-time survival analysis modelling indicated that high childbearing probability was predicted by low novelty seeking (standardized OR = 0.92; 95% confidence interval 0.88–0.97), low harm avoidance (OR = 0.90; 0.85–0.95), high reward dependence (OR = 1.09; 1.03–1.15) and low persistence (OR = 0.91; 0.87–0.96) with no sex differences or quadratic effects. These associations grew stronger with increase in numbers of children. The findings were substantially the same in a completely prospective analysis. Adjusting for education did not influence the associations. Despite its negative association with overall childbearing, high novelty seeking increased the probability of having children in participants who were not living with a partner (OR = 1.29; 1.12–1.49). These data provide novel evidence for the role of temperament in influencing childbearing, and suggest possible weak natural selection of temperament traits in contemporary humans. Copyright © 2009 John Wiley & Sons, Ltd.

Key words: evolutionary psychology; fertility; reproductive success; temperament and character inventory

INTRODUCTION

The growing integration of personality psychology with evolutionary psychology and behavioural ecology has opened up new perspectives on the origins and functions of

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temperament and personality traits in humans and non-human animals (Buss & Greiling, 1999; Denissen & Penke, 2008b; Penke, Denissen, & Miller, 2007; Reale, Reader, Sol, McDougall, & Dingemanse, 2007; Sih, Bell, & Johnson, 2004; Sih, Bell, Johnson, & Ziemba, 2004). This line of research argues that individual variation in emotional and behavioural dispositions needs to be considered from an evolutionary point of view (Buss, 2009; Dingemanse & Reale, 2005; Denissen & Penke, 2008a; Nettle, 2006; Reale et al., 2007). While some researchers have suggested that personality variation may be mostly random noise around evolved psychological adaptations (Tooby & Cosmides, 1990), others have pointed out that even small reproductive differentials associated with personality would be relevant over evolutionary time (Penke et al., 2007).

The most direct research question arising from evolutionary theorizing of personality is whether temperament and personality traits are associated with reproductive success, i.e. the number of offspring. Such associations have been demonstrated in non-human animals (Both, Dingemanse, Drent, & Tinbergen, 2005; Cote, Dreiss, & Clobert, 2008; Reale, Martin, Coltman, Poissant, & Festa-Bianchet, 2009; Smith & Blumstein, 2008), and a few recent studies suggest that temperament and personality traits may predict having children also in humans. In one of our earlier studies in the Cardiovascular Risk in Young Finns cohort, we observed that high adult sociability and low negative emotionality, and high activity in men, increased the probability of having children over a 9-year period (Jokela, Kivimäki, Elovainio, & Keltikangas-Järvinen, 2009). In another study with the same cohort, adolescents with high leadership personality (a subscale of type-A personality) were more likely than those with low leadership to have children as adults (Jokela & Keltikangas-Järvinen, 2009). Other studies have reported associations between number of children and specific dimensions of personality, e.g. high achievement motivation (Elder & Macinnis, 1983), high conscientiousness (Roberts & Bogg, 2004) and a combination of high extraversion/low neuroticism or low extraversion/high neuroticism (Eaves, Martin, Heath, Hewitt, & Neale, 1990), or have not found associations between childhood personality traits and adult fertility (Mealey & Segal, 1993).

Although temperament appears to be important in predicting fertility behaviour, the evidence to date is based on limited conceptualizations of temperament. The purpose of the present study was to extend previous research by examining whether the temperament traits of Cloninger's psychobiological personality model (Cloninger, 1987; Cloninger, Svrakic, & Przybeck, 1993) are related to childbearing propensity. The Temperament and Character Inventory (TCI) postulates four temperament traits (novelty seeking, harm avoidance, reward dependence and persistence) that are thought to reflect automatic biases in perceptual memory and habit formation, and to relate to specific neurobiological mechanisms. According to the neurotransmitter hypothesis of the TCI, novelty seeking is primarily associated with dopamine, harm avoidance with serotonin and reward dependence with noradrenalin functioning, and this hypothesis has received supporting evidence (Gerra, Zaimovic, Timpano, Zambelli, Delsignore, & Brambilla, 2000; Hansenne et al., 2002; Jokela, Lehtimäki, & Keltikangas-Järvinen, 2007; Keltikangas-Järvinen et al., 2009; Peirson et al., 1999). Furthermore, several twin studies have demonstrated moderate broad-sense heritability for the TCI traits in adults (Table 1).

Novelty seeking reflects exploratory behaviour and reactivity to novel and rewarding stimuli, and consists of four subscales (exploratory excitability, impulsiveness, extravagance, disorderliness). In relation to the Five Factor Model of personality, novelty seeking correlates with high extraversion and low conscientiousness (De Fruyt, Van de Wiele, & Van Heeringen, 2000). Harm avoidance is associated with behavioural inhibition

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Table 1. Heritability estimates for temperament traits of the Temperament and Character Inventory in adults

	Temperament trait				
	Novelty seeking	Harm avoidance	Reward dependence	Persistence	n^*
Classical Twin Design					
Ando et al., 2002	0.18	0.36	0.39	0.31	592
Ando et al., 2004	0.34	0.41	0.44	0.37	1234
Gillespie et al., 2003	0.39	0.41	0.35	0.30	1600
Heath et al., 1994					
Men	0.41	0.42	0.39	—	1242
Women	0.41	0.44	0.37	—	2944
Heiman et al., 2003					
Age 50–65	0.43	0.49	0.40	0.16	878
Age 66–89	0.46	0.48	0.35	0.27	820
Stallings et al., 1996					
Men	0.29	0.44	0.38	0.03	394
Women	0.43	0.49	0.38	0.23	1766
Weighted Average[†]	0.39	0.44	0.38	0.26	11 470
Twin + Sibling Design					
Keller et al., 2005					12 913
Men					
Additive variance	0.05	0.16	0.24	0.00	
Non-Additive variance	0.35	0.29	0.11	0.35	
Women					
Additive variance	0.05	0.15	0.07	0.00	
Non-Additive variance	0.35	0.27	0.31	0.35	

Note: Values are estimates of broad-sense heritability (additive + non-additive genetic variance) unless otherwise indicated.

[*]Values are number of participants in the study.

[†]Weighted averages are calculated by weighting the heritability estimate by the number of participants. A dash (−) indicates no data.

and reactivity to negative and threatening stimuli, and has four subscales (anticipatory worry, fear of uncertainty, shyness with strangers, fatigability). It is related primarily to high neuroticism and low extraversion. Reward dependence is expressed as affectionateness and maintenance of behaviour in response to cues of social reward, and consists of three subscales (sentimentality, attachment, dependence). It correlates with high extraversion and high agreeableness, and also with high neuroticism. Persistence refers to an industrious, hard-working, eager and persevering disposition (no subscales), and it is correlated with conscientiousness.

Miller (1992, 1994) has proposed that there is a general trait of childbearing motivation that can be divided into positive and negative subcomponents. Positive childbearing motivation reflects the joy and excitement people experience in having children, while negative childbearing motivation reflects the distress and worries associated with having to take care of children. Presumably, positive childbearing motivation increases the probability of having children whereas negative childbearing motivation decreases it. From the perspective of temperament, the former can be interpreted to reflect approach behaviour and the latter avoidance behaviour. In Cloninger's temperament model, these behavioural

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tendencies are assessed by novelty seeking and harm avoidance, respectively. Hence, we hypothesize that novelty seeking increases childbearing probability whereas harm avoidance decreases it. Individuals with high reward dependence, in turn, feel strong and nurturing emotions towards other people, so we hypothesized that high reward dependence increases childbearing probability. We did not have a specific hypothesis for persistence.

The present study takes advantage of new data collected in the Young Finns study after the completion of our two previous studies on the topic (Jokela & Keltikangas-Järvinen, 2009; Jokela et al., 2009). Combining prospectively and retrospectively assessed fertility data, we examined how adult temperament traits predict childbearing probability over the life course using survival analysis. The findings were then replicated using only prospective fertility data collected after the assessment of temperament. We also assessed whether the present findings were independent of the association between EAS (emotionality, activity, sociability) temperament and childbearing observed in our previous study (Jokela et al., 2009). Marital status and education were included as sociodemographic covariates.

METHODS AND MATERIALS

Participants

The participants were 1535 individuals (985 women and 550 men) participating in the population-based Cardiovascular Risk in Young Finns study (Åkerblom et al., 1991; Raitakari et al., 2008). The original sample consists of 3596 Finnish healthy children and adolescents derived from six birth cohorts, aged 3, 6, 9, 12, 15 and 18 years at baseline in 1980. In order to select a broadly representative sample in terms of sociodemographic background, Finland was divided into five areas according to locations of university cities with a medical school (Helsinki, Kuopio, Oulu, Tampere and Turku). In each area, urban and rural boys and girls were randomly selected on the basis of their unique personal social security number. The sample has been followed subsequently in seven follow-up phases in 1983, 1986, 1989, 1992, 1997, 2001 and 2007. A more detailed description of the cohort can be found in Åkerblom et al. (1991) and Raitakari et al. (2008). The analytic sample of the present study included all participants who participated in the 2007 follow-up phase and had temperament data available from the follow-up phase in 1997. The study was approved by local ethics committees and all participants gave their written informed consent.

Measures

The participants completed the Temperament and Character Inventory (TCI; Cloninger et al., 1993) in 1997. The 40 items of novelty seeking (Cronbach $\alpha = 0.85$), 35 items of harm avoidance ($\alpha = 0.92$), 24 items of reward dependence ($\alpha = 0.79$) and 8 items of persistence ($\alpha = 0.63$) were rated on a 5-point Likert-type scale. In the 2007 follow-up the participants reported the birth years of their children and whether each of the children was a biological or non-biological child of the respondent. These data were used to construct age-specific fertility history of the participants. Only biological children were included in the analysis.

Data for marital history were collected from all available follow-up phases in which the participants reported their current marital status, changes in marital status since the

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previous follow-up phase, and the years of these changes. A time-varying variable indicating the participant's marital status at each study year was created from these data (0 = not married/divorced/separated, 1 = married/cohabiting). Education was assessed on the basis of the highest achieved educational qualifications reported on a 7-point scale (1 = mandatory school, 7 = higher education).

In a previous study of the cohort (Jokela et al., 2009), temperament traits assessed using the EAS (emotionality, activity, sociability) temperament inventory (Buss & Plomin, 1984) were observed to be associated with childbearing between years 1992 and 2001. To test whether the associations observed in the present study were independent of these previously identified associations, we included the three temperament traits as additional covariates. This inventory was administered in the 1992 follow-up phase, and the 12 items of emotionality ($\alpha = 0.82$), 10 items of activity ($\alpha = 0.65$) and 5 items of sociability ($\alpha = 0.78$) were rated on a five-point scale. Novelty seeking correlated with activity ($r = 0.18$) and sociability ($r = 0.23$); harm avoidance with emotionality ($r = 0.46$), activity ($r = -0.28$) and sociability ($r = -0.27$); reward dependence with sociability ($r = 0.39$); and persistence with activity ($r = 0.28$). These correlations indicated that there was only moderate overlap between the EAS and TCI traits.

Statistical analysis

The association between temperament and having children was assessed using discrete-time survival analysis (Singer & Willett, 1991, 1993). Survival analysis is the appropriate method for studying even occurrences (e.g. births) as it tracks individuals over time and takes into account the fact that not all possible events occur during a given follow-up period for all participants. In other words, survival analysis adjusts the statistical estimates for censoring. First we applied a multispell design (Willett & Singer, 1995) predicting the birth of the first to the sixth child in a single model. Each child was modelled as a separate 'spell', so that the participant was first followed for the birth of the first child, and after the birth of the first child the participant was then followed for the birth of the second child, and so on up to the sixth child. Time was clocked with interaction effects between spell and linear and quadratic effects of time and their lower-order main effects. This allowed the hazard functions of each birth to change nonlinearly over time. After the multispell analysis, we fitted separate survival analysis models in which the birth of the first, second, third and fourth child was assessed in separate models (fifth and sixth children were not included because there were too few participants with more than four children; Table 2). In these models, time was clocked with linear and quadratic terms of age, as age-specific fertility is known to follow a bell-shaped curve.

Statistical estimates were expressed as odds ratios of differences in hazard functions (probabilities of having a child at a given year in participants who had not had a child by that year) associated with one unit difference in the independent variable. All the odds ratios were calculated for standardized temperament scales (mean = 0, standard deviation = 1) to facilitate the interpretation of effect magnitudes. In all survival analysis models, temperament traits were all mutually adjusted, i.e. included all at the same time in the model. As data for time-varying covariates in survival analysis models need to be complete, missing values of marital status were imputed with data from the previous follow-up.

Depending on their birth cohort, participants were censored at ages 30, 33, 36, 39, 42 or 45. Hence, the survival analysis modelling was applied to life-course fertility history

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Table 2. Descriptive statistics for the sample

	Women ($n = 985$)	Men ($n = 550$)
Follow-up in 1997		
Married/cohabiting (%)	53.3	44.1
Novelty seeking	122.4 (16.2)	118.6 (15.5)
Harm avoidance	94.2 (17.9)	88.1 (17.3)
Reward dependence	83.8 (9.7)	75.3 (9.8)
Persistence	25.5 (4.5)	25.9 (4.2)
Follow-up in 2007		
Age (years)	37.4 (5.0)	37.5 (4.9)
Education (7-point scale)	4.0 (2.0)	3.6 (2.0)
Married/Cohabiting (%)	76.6	78.6
Age at first birth (years)	27.3 (4.6)	29.1 (4.5)
Number of children	1.5 (1.3)	1.2 (1.3)
None (%)	30.2	43.6
One (%)	17.0	16.7
Two (%)	30.2	24.0
Three (%)	16.4	11.3
Four (%)	4.5	3.5
Five (%)	0.7	0.4
Six (%)	0.9	0.6

Note: Values are means (and standard deviations) unless otherwise indicated.

ranging between ages 15 and 45 with progressively fewer participants contributing to the dataset after the age of 30. As temperament was assessed in 1997, the time period included both prospective (for children born after 1997) and retrospective (for children born before 1997) fertility data, introducing the possibility of parenthood influencing temperament rather than the reverse. To examine whether temperament was differently related to prospectively and retrospectively assessed childbearing, we created a dichotomous period indicator (0 = data in or before 1997, 1 = data after 1997) and tested interaction effects between this indicator and temperament traits. A significant interaction effect would indicate that temperament is differently related to prospectively than to retrospectively collected fertility data, and that the influence of parenthood on temperament might be confounding the results. As an additional sensitivity analysis excluding this possibility completely, we fitted the models using only fertility data that were collected prospectively, i.e. for children born after 1997. Potential sex differences were tested by sex × tempera-temperament interaction effects in all models.

The role of marital status was examined by assessing interaction effects between marital status and temperament traits, and by stratifying the person-observations by marital status (0 = not living with a partner, 1 = married/cohabiting). The motivation for this analysis was first to test whether the association between temperament and childbearing is confounded by differences in marital status; when the sample is restricted to those who are living with a partner, the confounding effect of marital status is excluded. Second, we were interested in whether some temperament traits predict childbearing differently among participants who are not living with a partner compared to those who are married/cohabiting. As a separate analysis to examine the association between temperament and marital status over the life course, we fitted a multilevel logistic regression model in which repeated person–year observations of marital status were nested within participants ($n = 1535$ participants, 44 098 observations). Multilevel modelling accounted for the non-

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independence of the observations in calculating the standard errors, and the model was further adjusted for sex, birth year and study year.

The results of the survival analysis models of temperament and childbearing were illustrated by calculating the predicted probability of having the first, second, third and fourth child by the age 45 by different levels of temperament traits (Low = 1*SD* below the mean, High = 1*SD* above the mean). To summarize the parity-specific estimates with a single percentage for each temperament trait, we calculated the difference between High versus Low groups in relative percentages and averaged these percentages over the four births. This provided us a summary statistic comparing the relative difference in childbearing probability between High versus Low groups.

Finally, we used linear regression analyses to predict the number of children in 2007 by temperament traits. In this analysis, all temperament traits were mutually adjusted and the analysis was further adjusted for sex and birth year. Standardized beta coefficients were determined in the linear regression models because these estimates can be used to evaluate the strength of natural selection acting on a particular trait associated with reproductive differentials, as described in the Discussion section.

RESULTS

Table 2 shows the descriptive statistics for the sample. The survival analysis models of temperament and childbearing are shown in the upper part of Table 3. In the multispell model assessing overall childbearing, high childbearing probability was predicted by low novelty seeking, low harm avoidance, high reward dependence and low persistence. There were no statistically significant interaction effects between sex and any of the temperament traits (all p-values > 0.38), suggesting no sex differences in these associations. Quadratic effects of temperament traits were also nonsignificant (all p-values > 0.11). The associations remained substantially the same when adjusted for sociability, emotionality and activity (Novelty seeking: OR = 0.93, 95% confidence interval = 0.88–0.98; harm avoidance: OR = 0.94, CI = 0.88–1.00; reward dependence: OR = 1.10, CI = 1.04–1.17; persistence: OR = 0.91, CI = 0.86–0.96) indicating that the present associations were largely independent of those reported in our previous study (Jokela et al., 2009). Adjusting for education had no influence on the estimated odds ratios (data not shown). Models predicting separately the birth of the first, second, third and fourth child indicated that temperament traits became stronger predictors of childbearing with the order of children (Table 3).

To test potential confounding due to parenthood influencing temperament, we assessed whether temperament predicted childbearing differently before and after temperament assessment in 1997 in the multispell model. None of the interaction effects between temperament traits and the period indicator were statistically significant (all p-values > 0.21) suggesting no differences in the predictions before and after temperament assessment. The possibility of parenthood confounding was then excluded completely by fitting the survival analysis models by including only the time period after 1997 (Table 3, lower part). These models closely replicated the main results, although not all the associations were statistically significant, possibly because of the decreased number of participants included in the analysis.

In a multilevel logistic regression predicting marital status over the life course, novelty seeking (OR = 0.88, CI = 0.77–1.01), harm avoidance (OR = 0.86, CI = 0.75–0.98) and

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Table 3. Predicting childbearing by temperament traits

	Childbearing over the life course					
	Novelty seeking	Harm avoidance	Reward dependence	Persistence	Births	*n*
Total childbearing	0.92 (0.88–0.97)	0.90 (0.85–0.95)	1.09 (1.03–1.15)	0.91 (0.87–0.96)	2135	1535
First child	0.97 (0.90–1.04)	0.90 (0.84–0.97)	1.13 (1.05–1.21)	0.91 (0.85–0.98)	982	1535
Second child	0.91 (0.84–0.99)	0.89 (0.82–0.97)	1.17 (1.08–1.27)	0.89 (0.82–0.96)	732	1535
Third child	0.80 (0.70–0.90)	0.83 (0.72–0.94)	1.18 (1.04–1.34)	0.82 (0.73–0.93)	305	1535
Fourth child	0.82 (0.64–1.06)	0.91 (0.71–1.17)	1.20 (0.94–1.53)	0.71 (0.56–0.89)	83	1535
	Childbearing after temperament assessment in 1997					
	Novelty seeking	Harm avoidance	Reward dependence	Persistence		
Total childbearing	0.92 (0.86–0.99)	0.88 (0.81–0.95)	1.07 (0.99–1.14)	0.95 (0.89–1.02)	1158	1535
First child	0.95 (0.86–1.06)	0.86 (0.77–0.96)	1.10 (0.99–1.21)	0.96 (0.87–1.06)	471	1024
Second child	0.92 (0.82–1.03)	0.85 (0.75–0.96)	1.16 (1.04–1.30)	0.89 (0.80–0.99)	404	1207
Third child	0.81 (0.70–0.95)	0.81 (0.69–0.96)	1.16 (0.99–1.35)	0.87 (0.75–1.02)	201	1431
Fourth child	0.75 (0.56–1.01)	0.95 (0.71–1.28)	1.22 (0.91–1.63)	0.73 (0.55–0.96)	58	1510

Note: Values are odds ratios (and 95% confidence intervals) of discrete-time survival analysis models in which all temperament traits were mutually adjusted. Total childbearing is modelled using multispell survival analysis, parity-specific analyses are modelled with separate survival analysis models. The two right-most columns show the number of births and the number of participants included in the analysis.

persistence (OR = 0.86, CI = 0.76–0.99) decreased the probability of marriage/cohabitation while reward dependence increased it (OR = 1.28, CI = 1.12–1.47), indicating that the results for marital status paralleled the results for childbearing. To examine the role of marital status in explaining the personality–fertility association, we fitted the multiple-spell survival analysis separately by person-observations for those who were married/cohabiting and for those who were not (Table 4). In married/cohabiting participants, the associations between temperament and having children were very similar to those observed in the main analyses (Table 3). Of the total 2060 children born, 228 (11.0%) were born to participants not living with a partner at the time. Among these participants, harm avoidance and persistence were not associated with childbearing while reward dependence showed a positive tendency similar to that observed for married/cohabiting participants. Novelty seeking exhibited a differing pattern by marital status; it was negatively associated with childbearing in married/cohabiting participants but positively associated with childbearing among participants who were not living with a partner in the year their child was born. The latter association was the same in women (OR = 1.29, CI = 1.08–1.53) and men (OR = 1.27, CI = 0.96–1.67).

Table 4. Predicting childbearing by temperament traits and marital status

	Married/Cohabiting	Not living with a partner	*p* for interaction effect
Novelty seeking	0.90 (0.85–0.95)	1.29 (1.12–1.49)	<0.001
Harm avoidance	0.90 (0.85–0.96)	1.02 (0.88–1.18)	0.05
Reward dependence	1.05 (0.99–1.12)	1.09 (0.94–1.26)	0.43
Persistence	0.90 (0.85–0.95)	1.04 (0.90–1.19)	0.03

Note: Values are odds ratios (and 95% confidence intervals) of multispell discrete-time survival analysis models predicting total childbearing, with all temperament traits mutually adjusted. *P* for interaction effect gives the *p*-value for the interaction effect between marital status and temperament trait.

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Table 5. Model-predicted percentage probabilities of having children by age 45 by different levels of temperament traits

	Novelty seeking		Harm avoidance		Reward dependence		Persistence	
	Low	High	Low	High	Low	High	Low	High
First child	72.5	70.1	74.7	67.8	67.2	75.3	74.4	68.1
Second child	58.5	51.7	59.2	51.1	49.6	60.7	59.2	51.0
Third child	29.6	20.0	28.7	20.7	21.1	28.1	28.8	20.6
Fourth child	7.9	5.5	7.2	6.0	5.5	7.8	9.2	4.7
Averaged relative % difference*	−19.6%		−16.8%		+27.4%		−24.9%	

Note: Values are model-predicted percentage probabilities (percentage × 100) of having children by levels of temperament traits (Low = 1*SD* below the mean, High = 1*SD* above the mean).

*Values are relative percentages of High versus Low group probabilities averaged over the four births. See Table 2 for statistical details.

The results of the main survival analysis models (Table 3) were illustrated by calculating the predicted probability of having the first, second, third and fourth child by age 45 by different levels of temperament traits (Table 5; Low = 1*SD* below the mean, High = 1*SD* above the mean). To summarize these differences, we calculated the relative probability differences between High versus Low groups for each birth (e.g. 70.1/72.5 = 0.97 for the first birth in the case of novelty seeking) and then averaged these relative probabilities over the four births, yielding an average difference in childbearing probability comparing high versus low temperament level in terms of relative percentages. Childbearing probability was decreased by 19.6% by novelty seeking, 16.8% by harm avoidance, and 24.9% by persistence and increased by 27.4% by reward dependence.

A linear regression analysis model predicting the number of children in the last follow-up year (when the participants were aged 30–45) indicated that higher number of children was predicted by low novelty seeking ($B = -0.08$, SE = 0.03, $p = 0.02$, $\beta = -0.06$), low harm avoidance ($B = -0.12$, SE = 0.03, $p < 0.001$, $\beta = -0.10$), high reward dependence ($B = 0.12$, SE = 0.03, $p < 0.001$, $\beta = 0.10$) and low persistence ($B = -0.11$, SE = 0.03, $p = 0.001$, $\beta = -0.09$). Quadratic effects of temperament traits were not statistically significant (all p-values$>$0.24). The associations were similar, albeit slightly weaker, when only children born after temperament assessment were included and the model was further adjusted for the number of children in 1997 (Novelty seeking: $B = -0.05$, SE = 0.03, $p = 0.06$, $\beta = -0.05$; harm avoidance: $B = -0.09$, SE = 0.03, $p < 0.001$, $\beta = -0.10$; reward dependence: $B = 0.07$, SE = 0.03, $p = 0.009$, $\beta = 0.07$; persistence: $B = -0.03$, SE = 0.02, $p = 0.17$, $\beta = -0.04$). The attenuation of the associations may have reflected (a) the exclusion of the influence of parenthood on temperament and/or (b) the effect of range restriction which is known to attenuate correlations between two variables; the variance of number of children was lower in the latter model ($SD = 0.94$) than in the former ($SD = 1.25$).

DISCUSSION

The present findings provide novel evidence of the importance of temperament in predicting reproductive behaviour in contemporary humans. High childbearing probability was predicted by low novelty seeking, low harm avoidance, high reward dependence and

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low persistence. On average, having a high versus low level of a particular trait was associated with a 17–27% relative difference in the probability of having children, the association being somewhat stronger for reward dependence and persistence than for novelty seeking and harm avoidance. There were no sex differences or nonlinear (quadratic) effects in these associations. The associations between temperament traits and marriage/cohabitation were in parallel to those between temperament and childbearing. However, temperament was associated with childbearing even when the sample was restricted to those who were currently married or cohabiting, indicating that the temperament–childbearing associations were not explained by differences in marriage/cohabitation probability. And although the overall association between novelty seeking and childbearing was negative, high novelty seeking increased the probability of having children among participants who were not living with a partner.

Temperament and fertility

Reward dependence predicted higher probability of having children, which is to be expected given that people with high reward dependence are characterized as tender-hearted, socially dependent, caring and affectionate. It seems plausible that individuals with high reward dependence feel that having children is more rewarding and fulfilling than those with low reward dependence. Supporting this hypothesis, Miller (1992) reported a positive correlation between affiliation, a trait related to reward dependence, and positive childbearing motivation, a scale assessing the perceived joys and rewards of having children, in a sample of American couples. Our finding demonstrates that such temperament dispositions may not only influence people's perceptions of parenthood but also predict actualized fertility behaviour.

As hypothesized, individuals with high harm avoidance were less likely to have children. This observation is in agreement with our previous finding of negative emotionality, a trait related to harm avoidance, and decreased fertility (Jokela et al., 2009). Moreover, studies of childhood shyness have reported delayed transition to marriage and parenthood in shy individuals, men in particular (Caspi, Elder, & Bem, 1988; Kerr, Lambert, & Bern, 1996). Together these findings indicate that temperament and personality traits related to avoidant behaviour and sensitivity to negative emotions predict postponed and lower likelihood of family formation. This fits to the more general pattern of postponed life transitions associated with an avoidant temperament disposition (Asendorpf, Denissen, & van Aken, 2008; Caspi et al., 1988; Dennissen, Asendorpf, & van Aken, 2008; Kerr et al., 1996).

Based on the model of positive and negative childbearing motivations (Miller, 1992, 1994), we hypothesized that individuals with high novelty seeking would be more inclined to have children because novelty seeking reflects approach behaviour and sensitivity to rewards. The results yielded empirical evidence to the contrary; married/cohabiting individuals with high novelty seeking were less rather than more likely to have children. *Post hoc*, the observation suggests that novelty seekers do not perceive having children as more rewarding. Rather, they may prefer a more care-free life and therefore shun away from the responsibilities of raising children. Novelty seekers might also hold less traditional values and attitudes regarding marriage and having children, which could help to explain their lower fertility.

While the overall association between novelty seeking and childbearing was negative, high novelty seeking increased the probability of having children among women and men who were not living with a partner, i.e. who were not married or cohabiting. There are at

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least two possible explanations for this. First, high novelty seekers may be more likely to have an 'unconventional' approach to family formation, e.g. they may be more willing to have children without a partner or to have children with a partner with whom they are not sharing a household. Second, they may be more prone to having unintended children as a result of casual sex and lack of family planning (Hoyle, Fejfar, & Miller, 2000; McCoul & Haslam, 2001). From the perspective of behavioural ecology, and for men in particular, it is tempting to interpret this pattern as a reproductive strategy involving little or no parental investment (Gangestad & Simpson, 2000; Van Oers, Drent, Dingemanse, & Kempenaers, 2008) and perhaps higher mating effort (*cf.* Nettle, 2005). More detailed data of the mediating mechanisms are needed before such an interpretation is warranted.

The negative association between persistence and childbearing was somewhat unexpected. People with high persistence tend to be industrious, ambitious and achievement-oriented, so persistent individuals might pursue a career and therefore be less likely to have children. Adjusting for educational achievement did not explain any of the association between persistence and fertility, but achievement striving might become expressed in other ways besides high socioeconomic status. Perhaps persistence is relevant on a more psychological level. Highly persistent individuals may tend to postpone childbearing because they set high standards for themselves in preparing for parenthood (e.g. having stable income, a proper house and safe neighbourhood). However, at present the specific role of persistence in childbearing remains unclear, especially as it seems to contradict previous studies showing that childbearing is positively associated with achievement motivation (Elder & Macinnis, 1983) and conscientiousness (Roberts & Bogg, 2004).

In a previous study with the same sample as here, Jokela et al. (2009) found evidence to suggest that sociability may be more important in determining whether a person will have children at all and less important in determining family size beyond the first child. Negative emotionality, in turn, was not associated with the probability of becoming a parent but predicted a smaller family size after having the first child. In the present study, all the associations between temperament traits and childbearing became progressively stronger with increase in number of children. The strengthening associations with birth order may result from an accumulating effect; in order to have the third child one must already have the first and the second child. Sociability appears to function differently in this respect (Jokela et al., 2009).

Evolutionary considerations

Traits related to reproductive differences are of interest to evolutionary sciences. Obviously, some of the specific associations between temperament and childbearing are likely to reflect responses to modern environments and therefore to differ from those present in our ancestral past. Such modern factors might include conflicts between family and career, perceptions of parenthood in modern societies and lifestyle choices. On the other hand, research in evolutionary psychology suggests that mating behaviour may still be guided by evolved psychological mechanisms (Gangestad & Simpson, 2000; see also Laland & Brown, 2006), implying that contemporary populations may provide evidence with which to evaluate evolutionary theories of personality. At least the general association between temperament and reproductive behaviour is not unique to modern humans, as temperament has been associated with reproductive behaviour in non-human animals (Both et al., 2005; Reale et al., 2009; Smith & Blumstein, 2008).

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Given that heritable temperament traits are associated with reproductive differentials, they may be under directional natural or sexual selection, and these processes may bring about quantitative changes in relatively short periods of time, evolutionarily speaking (Kingsolver et al., 2001). In the present sample, the standardized beta coefficients measuring the strength of selection were $\beta = -0.06$ for novelty seeking, $\beta = -0.10$ for harm avoidance, $\beta = +0.10$ for reward dependence and $\beta = -0.09$ for persistence. The absence of quadratic effects indicated that there was no evidence for stabilizing selection i.e. reproductive advantage associated with both high and low ends of temperament traits. Interestingly, the selection differentials estimated here are quite similar to those recently reported for physical attractiveness (Jokela, 2009) and male economic success (Nettle & Pollet, 2008) in contemporary humans. A meta-analysis of 63 studies with a broad range of species, on the other hand, estimated the median selection differential to be $\beta = 0.16$ (Kingsolver et al., 2001) which is somewhat higher than that observed here. Measurement error in temperament assessment may have attenuated the present associations, particularly for persistence which had the lowest reliability ($\alpha = 0.63$) of the four traits.

A trait's response to selection depends on its selection differential and additive heritability. Only additive genetic effects are transmitted as 'main effects' from parents to offspring. The formula for response to selection is $R = h^2S$ where $h^2 =$ heritability and $S =$ selection differential. If we use the broad-sense heritability estimates presented in Table 1 and assume that they reflect mostly additive variance, the means of the four traits would be expected to change by $R_{NS} = -0.06 \times 0.39^2 = -0.9\%$ (novelty seeking), $R_{HA} = -0.10 \times 0.44^2 = -1.9\%$ (harm avoidance), $R_{RD} = 0.10 \times 0.38^2 = +1.4\%$ (reward dependence) and $R_P = -0.09 \times 0.26^2 = -0.6\%$ (persistence) of a standard deviation per generation as a result of gradual changes in the gene pool. Depending on temperament trait, changes of small effect sizes (0.1 *SD*) could be expected over a time of approximately 5–15 generations.

These calculations need to be qualified by at least three reservations. First, it is unknown whether the estimates generalize over generations and across different populations, so one must be careful in making evolutionary extrapolations from these data alone. Second, if the additive genetic variance is substantially lower than that estimated by classical twin studies (Table 1) then the above calculations are overestimates. In the absence of additive variance, temperament traits could influence reproductive differences yet be unrelated to natural selection. Non-additive genetic variance is difficult to estimate in classical twin designs because of low statistical power. The only extended twin study carried out to date suggests that most of the genetic variance in TCI traits may be non-additive (Table 1), but it is currently uncertain whether these estimates are robust and how they generalize to other populations. Third, the present estimates were calculated for individuals aged 30–45, which may underestimate the effects of temperament on completed fertility.

Strengths and limitations

The main strengths of the study include a large population-based sample and a detailed fertility history of the participants. However, three methodological limitations need to be acknowledged. First, as already pointed out, we modelled the temperament–fertility association using both prospective and retrospective fertility data in relation to the timing of temperament assessment. The results were substantially the same when only prospective data were used, suggesting that the results were not biased by any influences of parenthood on temperament development. Note that this does not yet imply that personality

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development is unaffected by parenthood and having children (Jokela et al., 2009) but rather that the inclusion of retrospective fertility data did not lead to substantial bias in the estimates for temperament.

Second, the participants were 30–45 years of age at the end of the follow-up period. Although survival analysis allowed us to estimate fertility up to age 45, the predicted absolute probabilities of having children need to be considered with caution. The fertility rates of the present sample were somewhat lower than those estimated from Finnish demographic data. In 2007, 82% of women and 73% of men 45 years of age had at least one child (Statistics of Finland, 2009). In the present sample, the corresponding percentages predicted from the survival analysis model were 74 and 61%. This discrepancy may be due to the selective nature of individuals participating in a longitudinal study. Random sampling variation may also have contributed to the underestimation as the predictions beyond age 30 were based on progressively decreasing number of birth cohorts.

Third, measurement imprecision in the construction of marital history data needs to be acknowledged. These data were partly based on the participants' retrospective reports of changes in their marital status, and people may not recall such changes accurately. In addition, missing values had to be imputed with data from earlier years, which assumes no changes in marital status during the years with missing data. This could have lead to a spurious marital status by novelty seeking interaction effect if high novelty seekers were less likely to correctly recall their marital status between the study phases. Although we cannot exclude this possibility, it seems unlikely that such a specific recall bias would account for the relatively large effect size of novelty seeking observed in participants not living with a partner.

CONCLUSION

In conclusion, these findings add new evidence to previous literature associating temperament and personality traits with reproductive behaviour. On average, low novelty seeking, low harm avoidance, high reward dependence and low persistence increased the probability of living with a partner and, more importantly, having children. Depending on the additive genetic variance of these traits, natural selection may continue to act on temperament differences even in contemporary humans. Studies using other temperament and personality scales should be valuable in gaining a better understanding of the personality dimensions that are most important in the context of reproductive behaviour. Furthermore, there is a need for more detailed data on the psychological and social pathways connecting personality differences to reproductive behaviour. These may involve mate choice, how others evaluate the person as a potential parent, the person's own preferences and desires for children and perceptions of the rewards and difficulties related to parenthood.

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