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Adolescent Self-control Predicts Midlife Hallucinatory Experiences: 40-Year Follow-up of a National Birth Cohort

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Introduction

Self-control is defined as “the capacity to override natural and automatic tendencies, desires, or behaviors”; “to pursue long-term goals, even at the expense of short-term attractions”; and “to follow socially prescribed norms and rules.” In other words, self-control is the capacity to alter the self’s responses to achieve a desired state or outcome that otherwise would not arise naturally.1 Self-control pertains to the ability to wilfully or voluntarily inhibit, activate, or modulate attention and behaviors, as well as executive functioning tasks of planning, detecting errors, and integrating information relevant to selecting behavior.2

Recent reports from birth cohort studies have indicated that self-control in childhood and adolescence might be a significant developmental precursor that could predict a broad range of later outcomes including educational and occupational underachievement, poor physical health, and trouble with the criminal justice system.3,4 However, these studies did not identify clear associations between self-control and mental health outcomes. This is an important issue given the impact of these outcomes. For example, common mental disorders are a leading cause of years of health lost to disease in middle- and high-income countries, and its economic costs can be huge.5 Based on the longitudinal data of the Dunedin Multidisciplinary Health and Developmental Study, Moffitt et al6 found a significant inverse association between self-control in childhood and adolescence and substance dependence but found no such association with recurrent depression at age 32 years. In contrast, Fergusson et al4 found that self-control in childhood and adolescence was associated with later anxiety disorder and suicidal ideation (although not major depressive disorder) at age 30 years after controlling for sex, IQ, and socioeconomic status. However, these associations were explained by childhood conduct problems, which are well known to predict adverse life outcomes, including mental health problems.6–8
other hand, studies have reported continuity between emotional problems in adolescence and later depression and other mental health outcomes, yet emotional problems in early years were not taken into account in these studies as a potential confounder. Analyses that consider the effects of both conduct and emotional problems in adolescence as confounders are therefore needed when examining associations between self-control in adolescence and mental health outcomes in adulthood.

Moreover, these longitudinal studies, so far, have not considered psychotic experiences as a mental health outcome. Self-control is thought to have developmental roots in a neural system subserving executive attention, the pivotal brain regions of which are focused on the orbitofrontal cortex, the anterior cingulate, and the paralimbic. Structural abnormalities in these regions involving deficits in attention, executive functioning, and behavior regulation have been reported in individuals with schizophrenia and first-episode psychosis. This overlap of neurobiological bases between self-control and psychotic phenomena suggests that there might be possible association and common underlying mechanisms between them. This has potential implications for intervention, because a focus on developing behavioral regulation in children is likely to be more effective for a range of outcomes than a narrow focus on schooling.

Psychotic-like experiences (PLEs), which are attenuated hallucinatory and delusional symptoms, are experienced not only by patients with psychotic disorders but also by patients with nonpsychotic disorders and by a substantial part of general population. Population-based studies have shown that PLEs are quite common in the community through childhood and adolescence to adulthood and midlife. A recent meta-analysis reported that around 8% of the general adult population experienced psychotic phenomena. PLEs in the general population are generally transient and only a small proportion (8–10%) evolve into psychotic and nonpsychotic disorders each year, but they may share an etiological portion (8–10%) evolve into psychotic and nonpsychotic disorders. Population-based studies have shown that PLEs are quite common in the community through childhood and adolescence to adulthood and midlife. A recent meta-analysis reported that around 8% of the general adult population experienced psychotic phenomena.

Methods

The NSHD is a prospective cohort study, originally consisting of 5362 individuals born in England, Scotland, and Wales in 1 week in March 1946. The cohort was stratified for social class such that all births to the wives of agricultural and nonmanual workers in that week were included, along with 1 in 4 births to the wives of manual workers, the majority occupational group in postwar Britain. This cohort has been prospectively studied 23 times, most recently at ages 60–64 years. At age 53 years, 3035 study members were successfully contacted. Major reasons for nonresponse included death (n = 469), temporary or permanent refusal (n = 948), participants who were temporarily or permanently abroad (n = 580), and participants who could not be traced (n = 330). Ethical approval for this study was granted by the North Thames Multicentre Research Ethics Committee, and all participants provided written informed consent.

Midlife Symptom Assessment

Symptoms of anxiety and depression were self-rated at age 53 years using the 28-item version of the General Health Questionnaire (GHQ-28). Study members rated their experience over the previous few weeks (eg, “Have you recently lost much sleep over worry?”). Each individual item was scored using a 1–4 point Likert scale, and a total score was calculated (range 29–109; mean: 45.3, SD = 9.6). To test whether any association was confined to severe symptoms, we also repeated the analysis with the GHQ-28 Severe Depression (D) subscale only, which contains items about worthlessness, hopelessness, and suicidality. Of those contacted at age 53 (n = 3035), 2902 participants successfully completed the GHQ-28. Study members without GHQ-28 data at age 53 years for any reason were more likely to be male, lower social class assessed by occupational group of father in childhood, to have lower cognitive ability at age 8 years, and to score lower on self-control, and higher on conduct and emotional problems in adolescence (all P < .001).

At age 53 years, study members also rated possible PLEs over the previous 12 months using 5 screening-level
items from the Psychosis Screening Questionnaire (PSQ). These questions have been used in previous studies of the British adult population to establish the prevalence of broadly defined PLEs. As in previous surveys, more than half of respondents gave a positive response to the hypomania item “Have there been times when you felt very happy without a break for days on end?” Further, 643 respondents (22.0%) rated themselves as “unsure” on this item. As a result of this apparent lack of specificity, this item was eliminated from this analysis. Responses to the 4 remaining PSQ items referring to symptoms of thought interference (Have you felt that your thoughts were directly interfered with or controlled by some outside force or person?), persecution (Have there been times when you felt people were against you?), strange experiences (Have there been times when you heard or saw things that other people couldn’t?) and hallucinations (Have there been times when you heard or saw things that other people couldn’t?) were coded as positive if the study member definitely reported that item and negative if the symptom was absent or was rated as unsure. Of those contacted at age 53 (n = 3035), 2918 participants successfully completed PSQ questions. As for those without GHQ-28 data, study members without PSQ data at age 53 years for any reason were more likely to be male, lower social class assessed by occupational group of father in childhood, to have lower cognitive ability at age 8 years, and to score lower on self-control and higher on conduct and emotional problems in adolescence (all P < .001).

### Table 1. Associations Between GHQ-28 Aged 53 y and Scores of Self-control, Conduct, and Emotional Problems Aged 13 + 15 y

<table>
<thead>
<tr>
<th>Scores Derived From Teacher Rating</th>
<th>GHQ-28 Age 53</th>
<th>Unadjusted Association</th>
<th>Adjusted Associationa</th>
<th>Adjusted Associationb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Latent Factors</td>
<td></td>
<td>Regression Coefficient</td>
<td>95% CI</td>
<td>p value</td>
</tr>
<tr>
<td>Male</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Self-control problem 13 + 15</td>
<td>0.108</td>
<td>0.378 0.593 .664</td>
<td>0.393 −1.144 0.357 .304</td>
<td>0.414 −1.117 0.290 .249</td>
</tr>
<tr>
<td>Conduct problem 13 + 15</td>
<td>0.080</td>
<td>0.424 0.585 .755</td>
<td>0.438 −0.273 1.149 .227</td>
<td>0.398 −0.270 1.065 .243</td>
</tr>
<tr>
<td>Emotional problem 13 + 15</td>
<td>0.534</td>
<td>0.020 1.047 .042</td>
<td>0.734 0.114 1.354 .020</td>
<td>0.772 0.192 1.353 .009</td>
</tr>
<tr>
<td>Female</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Self-control problem 13 + 15</td>
<td>1.058</td>
<td>0.439 1.678 .001</td>
<td>0.535 −0.379 1.448 .251</td>
<td>0.411 −0.431 1.253 .339</td>
</tr>
<tr>
<td>Conduct problem 13 + 15</td>
<td>0.622</td>
<td>0.038 1.207 .037</td>
<td>0.283 −0.522 1.088 .490</td>
<td>0.129 −0.612 0.871 .733</td>
</tr>
<tr>
<td>Emotional problem 13 + 15</td>
<td>0.711</td>
<td>0.137 1.284 .015</td>
<td>0.404 −0.285 1.094 .250</td>
<td>0.338 −0.299 0.975 .298</td>
</tr>
</tbody>
</table>

Note: aRegression coefficient adjusted for each mutually adjusted score derived from teacher ratings at age 13 + 15 y, social class in childhood, and childhood cognitive function at age 8.

bRegression coefficient adjusted for each mutually adjusted score derived from teacher ratings at age 13 + 15 y, social class in childhood, childhood cognitive function at age 8, and the sum of PSQ symptoms.
new combined scales were then standardized to form z scores.

**Childhood Cognitive Assessment**

Childhood cognitive ability predicts midlife affective symptoms in NSHD, although this was explained by psychotic-like symptoms. These tests were of verbal and nonverbal ability devised by the National Foundation for Education Research. These tests were (1) reading comprehension (selecting appropriate words to complete 35 sentences); (2) word reading (ability to read and pronounce 50 words); (3) vocabulary (ability to explain the meaning of 50 words); and (4) picture intelligence, consisting of a 60-item nonverbal reasoning test. We used confirmatory factor analysis to construct a scale summarizing these data. Model fit indices were chi-square = 63.145 with 1 degree of freedom, RMSEA = 0.121, CFI = 0.994, and TLI = 0.966. Factor scores were computed and then standardized to a mean of 0 with a SD of 1.

**Early-Life Socioeconomic Factors**

Early-life socioeconomic factors, as assessed by occupational social class of the father when study members were aged 11 years, or if this was unknown, at 4 or 15 years, were considered possible confounders for any association between adolescent self-control, conduct, and emotional problems and adult psychopathologic symptoms.

**Statistical Analysis**

Associations between total score for each of adolescent self-control, conduct, and emotional problems and total GHQ-28 score and the GHQ-28 Severe Depression subscale score were tested using multivariable regression models. Because the self-control × sex interaction terms for GHQ-28 total score and GHQ-28 Severe Depression subscale score were significant ($P = .018$, $P = .006$, respectively), these models were stratified by sex. The first model tested unadjusted associations between these variables. The second model adjusted for father’s social class and childhood cognitive ability. In the third model, we additionally adjusted for total number of PSQ symptoms, because they are associated with GHQ score in NSHD.

We then used logistic regression to test associations between adolescent self-control, conduct, and emotional problems and each PSQ symptom (thought interference, persecution, strange experiences, and hallucinations), using those without these symptoms as reference groups. We then adjusted for sex (self-control × sex interaction terms for each PSQ symptom: thought interference, $P = .276$; persecution, $P = .377$; strange experiences, $P = .361$; hallucination, $P = .083$), father’s social class and childhood cognitive ability (as in the model for the GHQ-28 outcome), and additionally the GHQ-28 score. All models were estimated using IBM SPSS version 21.0 for Windows (New York).

**Results**

The GHQ-28 at age 53 was completed by 1423 men (mean score [SD]: 43.7 [8.6]) and 1479 women (mean score [SD]: 46.9 [10.3]), $P < .001$. Corresponding values for manual vs nonmanual social class of origin were 45.3 (9.7) and 45.4 (9.6), $P = .75$. The PSQ at age 53 was completed by 1430 men and 1488 women. The 4 PLEs were positively endorsed with the following prevalence: thought interference, $n = 302$ (10.3%); persecution, $n = 397$ (13.6%); strange experiences, $n = 216$ (7.4%); hallucinations, $n = 107$ (3.7%). Less than 1% of study members endorsed all 4 symptoms. Symptom frequencies were equal in men and women ($\chi^2 = 2.94$, $df = 4$, $P = .57$), and endorsement of one or more symptoms was unrelated to manual vs nonmanual social class of origin ($\chi^2 = 0.87$, $df = 1$, $P = .35$).

**Adolescent Self-control and Midlife Symptoms of Anxiety/Depression**

When unadjusted associations were examined using multivariable regression, adolescent self-control problems were associated at 5% significance with higher total GHQ-28 score in females (regression coefficient = 1.06, 95% CI = 0.44–1.68, $P = .001$); this was also the case for conduct problems (regression coefficient = 0.62, 95% CI = 0.04–1.21, $P = .037$). After mutually adjusting the adolescent teacher ratings, and additionally adjusting for social class in childhood, childhood cognitive ability, and the total number of PSQ symptoms at age 53 years, adolescent self-control problems in females did not remain significantly associated with symptoms of anxiety and depression at age 53 years (regression coefficient = 0.41, 95% CI = −0.43 to 1.25, $P = .339$) (table 1).

**Adolescent Self-control and Midlife Severe Depression**

When unadjusted associations were examined using multivariable regression, adolescent self-control problems were associated at 5% significance with severe depression in females only (regression coefficient = 0.33, 95% CI = 0.17–0.50, $P < .001$). After mutually adjusting the adolescent teacher ratings, and additionally adjusting for social class in childhood, childhood cognitive ability, and the total number of PSQ symptoms at age 53 years, adolescent self-control problems in female did not remain significantly associated with severe depression at age 53 years (regression coefficient = 0.09, 95% CI = −0.14 to 0.31, $P = .434$) (table 2). This was also the case when the self-control score was split into tertiles, and the highest tertile compared to the lowest on the GHQ-28 ($P = .148$).
Adolescent Self-control and Midlife Hallucination

The 4 PLEs had the following prevalence: thought interference, \( n = 302 \) (10.3%); persecution, \( n = 397 \) (13.6%); strange experiences, \( n = 216 \) (7.4%); and hallucinations, \( n = 107 \) (3.7%). Less than 1% of participants experienced all 4 symptoms. A significant unadjusted association was found only between adolescent self-control problems and midlife hallucinations (OR = 1.54, 95% CI = 1.24–1.91, \( P < .001 \)) (table 3). The strength of this association was unchanged after adjusting for sex, social class in childhood, childhood cognitive ability, adolescent conduct and emotional problems, and GHQ-28 score (OR = 1.55, 95% CI = 1.09–2.18, \( P = .013 \)) (table 3).

Discussion

Using data from a national birth cohort, we showed that self-control problems in adolescence predicted hallucinatory experiences in midlife after controlling for the effects of adolescent conduct and emotional problems, symptoms of anxiety and depression in midlife, sex, social class of origin, and childhood cognition. We did not find any significant independent association between adolescent self-control and midlife symptoms of anxiety and depression, even when severe symptoms only were used as an outcome. The prevalence of PLEs in this study was 22.3%, which was higher than that reported by a recent meta-analysis,\(^{25}\) but similar to the results by studies using same instrument.\(^{39,44}\) In particular, the British National Morbidity Survey, which was nationwide adult population survey, reported similar prevalence of each PSQ item (thought insertion: 9.0%; strange experiences: 8.9%; hallucinations: 4.2%), except for the higher prevalence of persecution (21.2%),\(^{39}\) to those in our current study (thought interference \( n = 10.3\% \); persecution: 13.6%; strange experiences: 7.4%; hallucinations: 3.7%).

Strengths of our study include the use of a national population-based sample and independently and prospectively rated adolescent mental health, as well as availability of a range of potential confounders. Limitations are that our main analyses stemmed from self-reported responses from a small number of broad questions about PLEs. It is possible that individuals with lower cognitive scores might be more likely to misinterpret or misunderstand questions about such experiences in self-reported questionnaires. However, this explanation seems unlikely given that childhood cognition, which correlates with adult,\(^{46}\) midlife\(^{46}\) and later life\(^{47}\) cognition, was controlled in the present study. Another limitation is that the information about illicit drug use in adolescence and adulthood, which might be considered as a confounder,\(^1\) was not available in the present study.

A further limitation of the present study is that individuals may have had PLEs at times outside of the PSQ assessment window. In the NSHD, the PSQ was only administered at age 53 years; prior to that only clinical diagnoses\(^{48}\) or more narrowly defined clinical symptoms\(^{49}\) were elicited. Thus, the no-symptom group may contain...
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Table 3. Associations Between Each Psychotic Experience Aged 53 y and Scores of Self-control, Conduct, and Emotional Problems Aged 13 + 15 y

<table>
<thead>
<tr>
<th>Latent Factors</th>
<th>Thought Interference</th>
<th>Persecution</th>
<th>Strange Experience</th>
<th>Hallucination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unadjusted associations</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Self-control problem 13 + 15</td>
<td>1.08 0.94–1.23</td>
<td>1.12 0.99–1.26</td>
<td>1.17 1.00–1.38</td>
<td>1.54 1.24–1.91</td>
</tr>
<tr>
<td>Conduct problem 13 + 15</td>
<td>1.07 0.94–1.22</td>
<td>1.12 1.00–1.26</td>
<td>1.15 0.98–1.34</td>
<td>1.22 1.00–1.50</td>
</tr>
<tr>
<td>Emotional problem 13 + 15</td>
<td>0.96 0.84–1.10</td>
<td>1.05 0.93–1.18</td>
<td>1.03 0.88–1.21</td>
<td>1.08 0.87–1.33</td>
</tr>
<tr>
<td>Adjusted associationsa</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Self-control problem 13 + 15</td>
<td>1.02 0.83–1.26</td>
<td>0.99 0.82–1.18</td>
<td>1.02 0.80–1.31</td>
<td>1.53 1.09–2.15</td>
</tr>
<tr>
<td>Conduct problem 13 + 15</td>
<td>1.01 0.83–1.21</td>
<td>1.11 0.94–1.30</td>
<td>1.07 0.85–1.33</td>
<td>0.91 0.67–1.23</td>
</tr>
<tr>
<td>Emotional problem 13 + 15</td>
<td>0.93 0.79–1.10</td>
<td>1.05 0.91–1.21</td>
<td>1.01 0.83–1.23</td>
<td>0.91 0.70–1.19</td>
</tr>
<tr>
<td>Adjusted associationsb</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Self-control problem 13 + 15</td>
<td>1.03 0.82–1.27</td>
<td>0.98 0.81–1.19</td>
<td>1.04 0.80–1.36</td>
<td>1.55 1.09–2.18</td>
</tr>
<tr>
<td>Conduct problem 13 + 15</td>
<td>0.98 0.80–1.19</td>
<td>1.07 0.90–1.28</td>
<td>1.02 0.81–1.30</td>
<td>0.90 0.66–1.22</td>
</tr>
<tr>
<td>Emotional problem 13 + 15</td>
<td>0.88 0.74–1.05</td>
<td>1.00 0.86–1.16</td>
<td>0.95 0.77–1.17</td>
<td>0.90 0.69–1.18</td>
</tr>
</tbody>
</table>

Note: aOR adjusted for each mutually adjusted score derived from teacher ratings at age 13 + 15 years, sex, social class in childhood, and childhood cognitive function at age 8. bOR adjusted for each mutually adjusted score derived from teacher ratings at age 13 + 15 years, sex, social class in childhood, childhood cognitive function at age 8, and GHQ-28 total scores at age 53.

some false-negative findings, which would lead to a conservative bias in the effects. Conversely, as these experiences are more common during adolescence and early adulthood than in later years,26,49 individuals who report them in late adulthood may represent a “poor prognosis” subset whose experiences did not dissipate with age, inflating the association between adolescent self-control and late-life experiences. Sample attrition would be expected to lead to underrepresentation both of individuals with poorer self-control and of individuals with psychotic symptoms, potentially producing a conservative bias. Wadsworth et al conducted an in-depth analysis of factors that predicted nonresponse at age 53 years; these included male gender, low cognitive test score at age 8 years, behavior at age 15 years, and educational, stress, and social factors during early adulthood.36 It is likely that some of these factors may also be related to the likelihood of experiencing psychotic-like symptoms. However, while this may have reduced statistical power, we have no reason to believe that this would have altered the pattern of associations observed here.

Recent neuroimaging studies have investigated the neurobiological basis of self-control. A brain morphological study which examined a large sample of healthy early adolescents revealed that higher self-control was significantly associated with larger volume of the orbitofrontal cortex and hippocampus.50 A number of neuroimaging studies have reported structural and functional abnormalities in the orbitofrontal cortex and hippocampus in patients with schizophrenia and first-episode of psychosis.22,23,51 Furthermore, some longitudinal studies in individuals at high risk of developing psychosis have demonstrated progressive orbitofrontal cortex volume decrease during the transition from subclinical psychotic symptoms to clinical psychosis.52,53 The orbitofrontal cortex is thought to modulate human behavior through a stimulus-reinforcer association learning process, and it is also involved in various cognitive functions such as executive functioning and decision making.54–57 These deficits have been observed in individuals with psychosis and subclinical psychotic symptoms.58–60

Associations between adolescent self-control and midlife psychotic-like symptoms only reached conventional levels of significance for hallucinations, although this was not a matter of power since hallucinations showed the lowest frequency of these PSQ items; and it is also worth noting that associations for all psychotic-like
symptoms were in the positive direction. Our current understanding of the pathophysiology of schizophrenia posits that developmental differences reflect aberrance in early brain development, the full effects of which do not become apparent until late adolescence or adulthood.61 The presence of early low self-control among individuals who will later experience hallucinatory-like experiences suggest that this model can be applied more broadly throughout the spectrum of risk for psychosis.

It is worth commenting on the lack of change in the association between self-control and hallucinations when this was adjusted for childhood cognition, because the latter is frequently associated with adult psychotic experiences. It is possible that the executive component of cognition that is thought to explain this association was better accounted for by the self-control variable.

Conclusions

Lower self-control in adolescence may be a risk factor for hallucinatory experiences in adulthood.

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Declaration of Interests

None declared.

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