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Research Brief: No evidence that substance use causes ADHD symptoms in adolescence

Abstract

There is a robust association between ADHD symptoms and elevated substance use. Several plausible causal pathways from ADHD to substance use have been articulated and supported empirically. In this study, we tested the recent suggestion that substance use could also influences levels of ADHD symptoms. Using the three most recent waves of data from the Zurich Project on the Social Development of Children and Youth (z-proso) we found significant and strong cross-lagged effects of ADHD symptoms on substance use but no significant effects in the opposite direction. This suggests that individual differences in substance use are not related to increases in ADHD symptoms in adolescence. Adolescent onset symptoms of ADHD are thus unlikely to be caused by substance use and targeting substance use problems is unlikely to reduce ADHD symptoms.

Attention-deficit hyperactivity disorder is defined by impairing levels of hyperactivity/impulsivity and/or inattention (APA, 2013). There is a well-established association between ADHD symptoms and substance use (e.g. Lee et al., 2011) and various pathways have been identified by which ADHD symptoms can lead to increased substance use (e.g. Molina & Pelham, 2014). For example, ADHD symptoms with an onset in early childhood may transact with environmental risk factors leading to the emergence and escalation of behavioural problems over development, including substance use in adolescence and adulthood (e.g. Beauchaine & McNulty, 2013). Much less attention has been paid to the idea that substance use could create risk for later ADHD symptoms; however, with the increasing recognition that ADHD symptoms may not reach clinically significant levels until adolescence and beyond, a search for precipitating factors occurring beyond childhood has been initiated (e.g. see Castellanos, 2015). Substance use during adolescence may represent such a candidate (e.g. Crean et al., 2011; Squeglia et al., 2009). Substance use often first begins in adolescence where in many cultures it is considered a 'rite of passage' (e.g. Masten et al., 2009). However, Beauchaine & McNulty (2013) and others have noted that the relative immaturity of the prefrontal cortex during this period may make adolescents especially vulnerable to long term adverse effects of substance use (e.g. Casey & Jones, 2010). For example, substance use may be associated with disruptions to structure and function in the prefrontal and orbitofrontal regions associated with the behaviour regulation deficits characteristic of the hyperactive/impulsive and comorbid subtypes of ADHD (see Beauchaine & McNulty, 2013; Schoenbauma & Shamand, 2008). On this basis, a pathway from adolescent-onset substance use to later ADHD symptoms may be expected in addition to the widely-accepted ADHD-to-substance use pathway.

Others have speculated about such a pathway. In one recent study, based on their results from a longitudinal study of smoking patterns, Brook et al. (2015) suggested that

'smoking cessation in adolescence may lessen the likelihood of ADHD symptoms in adulthood' (abstract; p.1). However, as ADHD with onset in late adolescence and adulthood has until recently received little attention and is not currently acknowledged within current diagnostic systems (e.g. APA, 2013) there is a paucity of longitudinal evidence on this potential relation. In this study we, therefore, aimed to test the hypothesis that there are bi-directional links between ADHD symptoms and substance use (e.g. Beauchaine & McNulty, 2013).

Method

Ethics

Given the minimally intrusive nature of the study design, questions and interventions, as well as the focus on social science research questions, the relevant Ethics Committee of the Canton of Zurich issued, based on the Swiss Human Research Act, a "declaration of no objection" for the z-proso project. It states that the project falls outside the remit of the Ethics Committee of the Canton of Zurich, and furthermore declared z-proso as ethically unproblematic. Informed consent from the participants were obtained in accordance with the relevant national regulations and all data were processed and stored according to data protection regulations.

Participants and Measures

Data were from the most recent three waves of the Zurich project on the social development of children and youths (z-proso; http://www.cru.ethz.ch/en/projects/z-proso.html). Z-proso is a normative sample longitudinal study of child and adolescent development that began in 2004 when the children entered school (aged 7). In the last three waves of data when the participants were aged 13, 15 and 17 respectively, n=1483 (51% male)provided data on their levels of substance use and ADHD symptomology.

ADHD symptom levels were measured using the 4-item ADHD subscale of the Social Behavior Questionnaire (Tremblay et al., 1991). Previous analyses have supported the longitudinal invariance and reliability of this subscale (Murray et al., 2017). This comprises four items measuring inattention, hyperactivity and impulsivity. Responses were provided on a 5-point Likert scale from *never* to *very often.*

Substance use items were preceded by the instruction 'Listed below are some drugs, intoxicants and other substances. Have you ever taken any of them and if yes, how many times in the last 12 months (i.e. since [DATE])?'. Participants then indicated tobacco, alcohol (beer/alcopops), alcohol (spirits) and cannabis use over the previous 12 months . Each was measured with a single item and responses provided on a 6-point scale from *never* to *daily*, specifically: ('never', 'once', '2 to 5 times', '6 to 12-times (monthly)', '13 to 52 times (weekly)' and '53 to 365 times (daily)'. All measures were administered in German (the official language of the study location) in the context of a broader questionnaire measuring problem behaviour and related attitudes, experiences, risk factors and outcomes.

Statistical procedure

Cross-lagged panel models with latent ADHD variables defined by the four SBQ items and substance use were fit separately for each substance. Latent variable scaling and identification were achieved by fixing the mean and variance of the ADHD factor at baseline to 1 and fixing the loading of the first item equal across time. Covariances between unique factors for corresponding items over time were freely estimated. Strict longitudinal invariance has previously been established for this measure in the current sample, therefore, metric invariance could be assumed (Murray et al., 2017). All first-order autoregressive and cross-lagged effects and concurrent effects were included in the model. Concurrent effects i.e. (residual) covariances between substance use and ADHD symptoms within each time-point

were also included. Models were estimated in *Mplus 7.13* using maximum likelihood estimation (Muthen & Muthen, 2014).

Results

The cross-lagged models for all substances provided good fit to the data (tobacco: RMSEA=.04, CFI=.97, TLI=.96, SRMR=.03; alcohol (beer/alcopops): RMSEA=.05, CFI=.96, TLI=.94, SRMR=.04; alcohol (spirits): RMSEA=0.04, CFI=.97, TLI=.95, SRMR=.03; cannabis: RMSEA=.05, CFI=.96, TLI=.94, SRMR=.04). Cross-lagged and autoregressive parameters from the models are provided in Table 1-4. With the exception of the age 11 to 13 lag, ADHD had significant cross-lagged effects on all forms of substance use at all waves. There was, however, no evidence of any effect of substance use on ADHD across any lag.

Discussion

There has been some recent speculation that substance use in adolescence could play a role in ADHD symptoms. High levels of substance use can adversely affect brain development and neuropsychological function during adolescence, thus, substance use may be a candidate causal factor in ADHD symptoms with onset in adolescence and adulthood.

In this study, while we found evidence that individual differences in ADHD symptoms are related to future tobacco, alcohol and cannabis use controlling for past levels, there was no evidence that substance use affects ADHD symptom levels. This suggests that substance use is not an important risk factor for increases in ADHD symptoms in normative populations. It is unlikely that substance use explains the symptom increases from childhood that occur in around 5% of individuals (e.g. Murray et al., 2016). There are several alternative explanations that may contribute to explaining ‘adolescent onset’ ADHD symptoms. One is

that individuals these carry the same underlying neurocognitive impairment as those with earlier onset symptoms but this does not manifest in detectable behaviours until social and academic demands become intensified and/or reliance on compensatory support within the school and family becomes less readily available (e.g. Caye et al., 2016). Alternatively, there may be a genuine change in underlying neurocognitive function in these individuals with concurrent changes in ADHD symptoms resulting from exposure to pathogenic factors. Finally, individuals with 'adolescent onset' symptoms may be expressing a qualitatively different underlying neurocognitive deficit than those with earlier onset symptoms. For example, Murray et al. (2016) hypothesised that those with an earlier onset symptoms are more likely to be expressing difficulties in 'top down' executive control processes while those with later onset symptoms are expressing difficulties relative to 'bottom up' executive control processes (e.g. Sonuga-Barke, 2003). Further longitudinal research tracking the course of ADHD symptoms and candidate risk factors over time will be required to disentangle these possibilities. Finally, our results also imply that while reducing substance use is an important aim, such interventions would not be expected to prevent later increases in ADHD symptoms.

Strengths and Limitations

Our study used three waves of data in which both ADHD symptoms and substance use were measured, allowing us to implement a fully cross-lagged design. This allowed us to account for previous levels of ADHD when assessing effects of substance use. However, as our data was drawn from a large longitudinal study, the available measures of ADHD and substance use were brief and did not allow us to examine relations between subtypes of ADHD symptoms or substance use in detail. In addition, our measures of substance use captured frequency of use over a 12 month period but did not capture the extent of intoxication during each episode of substance use. Further, as our sample is drawn from the

general population rather than a high risk sample, the use of hard drugs was infrequent and we, therefore, could not evaluate their effects on ADHD symptoms. Finally, our results do not speak to onset of symptoms beyond age 17 and they do not rule out the possibility that the cumulative effects of chronically high levels of substance use could increase ADHD symptoms later in life. Future studies extending into young adulthood and beyond will be required to test this possibility.

Conclusions

ADHD symptoms influence substance use across adolescence; however, contrary to recent speculation there is no evidence that the opposite is also true. Substance use is, therefore, unlikely to be an important cause of adolescent onset ADHD symptoms.

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Table 1:

Standardised auto-regressive and cross-lagged for tobacco and ADHD model

Path	**β**	**SE**	***p***
$ADHD_{13}$→$ADHD_{15}$	.606	.027	<.001
$ADHD_{15}$→$ADHD_{17}$	.646	.025	<.001
$tobacco_{13}$→$tobacco_{15}$	.490	.021	<.001
$tobacco_{15}$→$tobacco_{17}$	.664	.017	<.001
$ADHD_{13}$→$tobacco_{15}$	.103	.028	<.011
$ADHD_{15}$→$tobacco_{17}$	.045	.026	.086
$tobacco_{13}$→$ADHD_{15}$	-.014	.028	.611
$tobacco_{15}$→$ADHD_{17}$	-.022	.028	.421

Table 2:

Standardised auto-regressive and cross-lagged for alcohol (beer/alcopops) and ADHD model

Path	**β**	**SE**	***p***
$ADHD_{13} \rightarrow ADHD_{15}$	0.604	0.027	<.001
$ADHD_{15} \rightarrow ADHD_{17}$	0.651	0.025	<.001
$alcohol(beer/alcopops)_{13} \rightarrow alcohol(beer/alcopops)_{15}$	0.389	0.023	<.001
$alcohol(beer/alcopops)_{15} \rightarrow alcohol(beer/alcopops)_{17}$	0.579	0.022	<.001
$ADHD_{13} \rightarrow alcohol\ (beer/alcopops)_{15}$	0.154	0.029	<.001
$ADHD_{15} \rightarrow alcohol\ (beer/alcopops)_{17}$	0.121	0.030	<.001
$alcohol(beer/alcopops)_{13} \rightarrow ADHD_{15}$	0.011	0.028	0.682
$alcohol(beer/alcopops)_{15} \rightarrow ADHD_{17}$	-0.043	0.028	0.127

Table 3:

Standardised auto-regressive and cross-lagged for alcohol (spirits) and ADHD model

Path	**β**	**SE**	***p***
$ADHD_{13} \rightarrow ADHD_{15}$	.609	.027	<.001
$ADHD_{15} \rightarrow ADHD_{17}$	.641	.025	<.001
$alcohol(spirits)_{13} \rightarrow alcohol(spirits)_{15}$	.327	.025	<.001
$alcohol(spirits)_{15} \rightarrow alcohol(spirits)_{17}$	.503	.025	<.001
$ADHD_{13} \rightarrow alcohol\ (spirits)_{15}$	.145	.030	<.001
$ADHD_{15} \rightarrow alcohol\ (spirits)_{17}$	.145	.031	<.001
$alcohol(spirits)_{13} \rightarrow ADHD_{15}$	-.024	.028	.219
$alcohol(spirits)_{15} \rightarrow ADHD_{17}$	-.004	.028	.884

Table 3:

Standardised auto-regressive and cross-lagged for alcohol (spirits) and ADHD model

Path	**β**	**SE**	***p***
$ADHD_{13} \rightarrow ADHD_{15}$	.608	.027	<.001
$ADHD_{15} \rightarrow ADHD_{17}$	.642	.025	<.001
$cannabis_{13} \rightarrow cannabis_{15}$	-.016	.028	.561
$cannabis_{15} \rightarrow cannabis_{17}$	-.008	.028	.784
$ADHD_{13} \rightarrow cannabis_{15}$	.139	.030	<.001
$ADHD_{15} \rightarrow cannabis_{17}$	.145	.027	<.001
$cannabis_{13} \rightarrow ADHD_{15}$	-.016	.028	.561
$cannabis_{15} \rightarrow ADHD_{17}$	-.008	.028	.784