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Weaknesses in executive functioning predict the initiating of adolescents' alcohol use

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ABSTRACT

Recently, it has been suggested that impairments in executive functioning might be risk factors for the onset of alcohol use rather than a result of heavy alcohol use. In the present study, we examined whether two aspects of executive functioning, working memory and response inhibition, predicted the first alcoholic drink and first binge drinking episode in young adolescents using discrete survival analyses. Adolescents were selected from several Dutch secondary schools including both mainstream and special education (externalizing behavioral problems). Participants were 534 adolescents between 12 and 14 years at baseline. Executive functioning and alcohol use were assessed four times over a period of two years. Working memory uniquely predicted the onset of first drink ($p = .01$) and first binge drinking episode ($p = .04$) while response inhibition only uniquely predicted the initiating of the first drink ($p = .01$). These results suggest that the association of executive functioning and alcohol consumption found in former studies cannot simply be interpreted as an effect of alcohol consumption, as weaknesses in executive functioning, found in alcohol naïve adolescents, predict the initiating of (binge) drinking. Though, prolonged and heavy alcohol use might further weaken already existing deficiencies.

1. Introduction

Recent studies have demonstrated associations between cognitive deficits and (heavy) drinking in adolescents (Fernie et al., 2013; Hanson et al., 2011; Khurana et al., 2012; Nigg et al., 2006; Squeglia et al., 2009; Tapert et al., 2002). Especially binge drinking seems to be associated with cognitive deficits in adolescents and young adults (Hermens et al., 2013; Peeters et al., 2014). An important question that arises from these findings is whether these deficits are present prior to and predict the onset of drinking or whether the (heavy) use of alcohol induces these deficits. Although this relationship has been investigated in several studies (Fernie et al., 2013; Hanson et al., 2011; Khurana et al., 2012; Nigg et al., 2006; Squeglia et al., 2009; Tapert et al., 2002), none of these studies have included alcohol-naïve adolescents at baseline, which clearly limits the interpretation of the associations found. In the present study we therefore examined whether the relative weaknesses in executive functions (i.e., working memory and response inhibition) predict the initiation of the first alcoholic drink and the first binge drinking episode in young adolescents.

1.1. Cognitive development in adolescence

During adolescence several important cognitive functions mature and develop. Executive functions such as working memory, attention and response inhibition, continue to mature until late adolescence (Blakemore and Choudhury, 2006; Casey et al., 2008). These functions are important for the planning, organization and coordination of other cognitive processes (Baddeley, 1983; Miyake et al., 2000), and involve neural networks including different areas in the prefrontal cortex. In contrast to other brain regions (e.g., the visual cortex), the prefrontal cortex undergoes changes until late adolescence (Blakemore and Choudhury, 2006). Working memory, in particular, continues to mature until late adolescence (18–21 years; Luna et al., 2004). In addition, basic levels of response inhibition are already present in early childhood; young children already able to inhibit responses, however, improvement of this function continues into adolescence (Luna et al., 2004). Both working memory and response inhibition are important for cognitive control; the

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ability to suppress thoughts and impulses in order to achieve long-term goals (Bunge and Wright, 2007; Luna et al., 2004; Steinberg, 2007). Cognitive control has often been related to risk behavior (Casey et al., 2008; Steinberg, 2007). It has been argued that the slower maturation of the prefrontal cortex, and the accompanying gradual development of cognitive control, might underlie the often observed increases in risky behaviors during adolescence, including binge drinking (Casey et al., 2008; Steinberg, 2007). A different line of research has suggested that the increase in risk-taking behavior is a motivational issue (Crone and Dahl, 2012). It is more rewarding, and thus more motivating, for adolescents than it is for adults to engage in risky behaviors because of factors such as peer acceptance or popularity, which might explain the increased risk-taking behavior during adolescence (Crone and Dahl, 2012). The delayed development of the prefrontal cortex and associated cognitive control skills in adolescents might therefore not represent a "deficit" or immature functioning, but rather a highly flexible and adaptive development, tuned to the social demands adolescents encounter (for a detailed description see Crone and Dahl, 2012). Nevertheless, in both lines of research, the development of cognitive control in late adolescence plays an important role in explaining risk-taking behaviors in adolescents.

1.2. Executive functioning and alcohol use

Working memory (i.e., keeping information active) and response inhibition are two important executive functions often examined in relation to alcohol use (Khurana et al., 2012; Nigg et al., 2006; Verdejo-Garcia et al., 2008; Wiers et al., 2007). Deficits in response inhibition and working memory appear to increase automatic and impulsive response in such a way that behavioral responses in relation to alcohol stimuli are more likely directed by immediate satisfaction of needs than pursuance of long-term goals (Grenard et al., 2008; Thush et al., 2008; Peeters et al., 2012, 2013; Wiers et al., 2007). In other words, deficits in executive functioning limit individuals to respond in a controlled and planned manner to alcohol stimuli, leading to more impulsive and automatic responses which have been associated with increased alcohol use (Grenard et al., 2008; Thush et al., 2008; Peeters et al., 2012).

Several longitudinal studies have examined the direct effect of relatively poor executive functioning on drinking behavior in adolescence. Nigg and colleagues (2006), for instance, found that poor inhibition skills in early adolescents (12–14 years, $N = 498$) predicted later (15–17 years) problematic alcohol use. Likewise, Khurana and colleagues (2012) found that relatively poor working memory predicted growth in the frequency of alcohol use in a community sample of adolescents ($N = 358$). Moreover, the authors found that the effect of working memory on alcohol use was mediated by impulsivity suggesting that poor working memory functioning might increase impulsive behavior which subsequently increases alcohol use among adolescents. In addition, Fernie and colleagues (2013) found that several measures of impulsivity (i.e., delay discounting, risk taking and response inhibition) predicted increase in alcohol use among young adolescents (12–13 years, $N = 287$). The question remains, however, whether these deficits precede and predict the onset of adolescents' drinking, since these studies have examined executive functioning after adolescents already consumed their first drink, thus leaving open the possibility that the impaired executive functioning was already the result of earlier drinking.

1.3. Current study

In the present study we examined the predictive effect of working memory and response inhibition, two executive functions under the heading of cognitive control, and frequently associated with risk behavior, on the initiating of the first alcoholic drink in a sample of young adolescents (12–15 years, before the legal alcohol buying age of 16 – in the Netherlands at the time of the study). Although cognition involves many more aspects than executive functions, we decided to focus on these two cognitions, since particularly these functions are assumed to play a vital role in adolescent alcohol use as they continue to mature in adolescence (Verdejo-Garcia et al., 2008). Binge drinking is a common drinking pattern among young adolescents, and it has been linked to several (health) risk behaviors (Miller et al., 2007). We therefore also examined the predictive effect of executive functioning on the initiating of the first binge drinking episode (i.e., five or more glasses on a day). Both adolescents form mainstream as well as adolescents from special education (SE) were included in the study to ascertain variation in drinking behavior. Adolescents in SE schools have been found to drink more heavily (Kepper et al., 2011) compared to adolescents from mainstream education. Adolescents attend these SE schools when they have behavioral problems (e.g., conduct problems, hyperactivity, attention problems), although they may not necessarily be diagnosed with a behavioral disorder. These externalizing behavioral problems are associated with relatively weak WM functioning (Barkley, 1997; Pihl et al., 1990), and might place adolescents at risk for problematic alcohol use and later alcohol dependence.

We hypothesized that relatively weak working memory and response inhibition would predict the initiating of the first alcoholic drink and the first binge drinking episode in this sample. Discrete-time survival analyses was used to determine the initiating of the first drink and binge drink episode during the two-year follow-up of the study and to evaluate the predictive effect of executive functioning. Moreover, both functions have previously been associated with adolescent alcohol use and problem drinking (Khurana et al., 2012; Nigg et al., 2006), although their unique contribution to the initiating of drinking has not yet been examined simultaneously.

2. Materials and method

2.1. Participants

This study was part of a larger study in which we assessed self-reported and behavioral cognitions, and personality styles related to alcohol use and other risk behaviors. Participants were recruited from several mainstream and 17 SE schools in the Netherlands. Males were slightly overrepresented (69% boys versus 31% girls) because more boys than girls attend SE schools (Oswald et al., 2003). For both samples, informed consent of the child as well as passive parental consent was requested. In the mainstream sample, 37 parents declined participation of their child. For the SE sample, 15 parents and 7 students declined participation in this study. The mainstream sample included 250 adolescents (69% girls), selected from a national survey study, which was part of the International Health Behavior of School-aged Children-survey (HBSC, Zanotti et al., 2012). Adolescents who participated in the Dutch national study were contacted for additional assessments after the completion of the main survey. The SE sample included 374 adolescents (12% girls). For the purpose of this study, adolescents between 12 and 15 years were selected, resulting in a sample of 534 (371 boys, 163 girls) adolescents.

Data were collected at intervals of 6–8 months across four waves. At baseline, 525 adolescents participated in the study (98% of 534, note that some adolescents were absent during the first wave but participated in the following waves). Overall, 415 (78%) adolescents participated in wave 2, 399 (75%) adolescents participated in wave 3, and 425 (80%) adolescents participated in wave 4. Missing cases were imputed using a multiple imputation program