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From Executive Control to Self-Control: Predicting Problem Drinking Among College Students

PAUL WHITNEY[1]*, JOHN M. HINSON[1] and TINA L. JAMESON[2]

[1]*Washington State University, USA*
[2]*Bridgewater State College, USA*

SUMMARY

This study tested whether individual differences in executive control can be used to predict problem drinking among college students. Performance on tests of executive control functions was contrasted in two groups of students. The groups were defined by how often they experienced negative consequences of drinking. The executive control measures included both objective and self-report measures from neuropsychological batteries, and a novel measure of working memory scanning that allowed us to test performance on theoretically dissociable executive functions. The students who experienced high levels of negative consequences of drinking made fast decisions, but they displayed high levels of interference from prepotent responses. In addition, the self-report measure of executive function was a very strong predictor of group membership. Copyright © 2006 John Wiley & Sons, Ltd.

Failures of control over cognitive processes are characteristic of a wide range of neuropsychiatric disorders (e.g. Royall et al., 2002), and in the general population problems with cognitive control are related to risky behaviour and potentially damaging behaviour problems (e.g. Swann, Bjork, Moeller, & Dougherty, 2002). The concept of control is also a major focus of theory and research in personality research on impulsiveness, and several investigators have claimed that deficits in the executive control of working memory (WM) may help explain impulsivity (e.g. Finn, Justus, Mazas, & Steinmetz, 1999; Villemarette-Pittman, Stanford, & Greve, 2003; Whitney, Jameson, & Hinson, 2004).

The purpose of the present study was to test whether a theoretical framework based on characterising individual differences in executive function can serve as a useful approach to understanding problems in control over behaviour. Our framework is based on the idea that there are different types of executive control problems that are related to the abilities involved in moving information into and out of WM. Recently, we demonstrated that executive function abilities derived from our framework predict impulsiveness as measured by personality indices (Whitney et al., 2004). Here, we extend this line of research by examining the relationship between executive functions and self-reported problems in behavioural control that can have major consequences for everyday functioning.

*Correspondence to: Paul Whitney, Department of Psychology, Washington State University, Pullman, WA 99164-4820, USA. E-mail: pwhitney@wsu.edu

The domain of behavioural control we investigated was the control of drinking behaviour by college students. It is widely recognised that college students are at risk for drinking-related problems, though variability in patterns of drinking in this population is very high (e.g. Baer, 2002). A range of personal, social, and biological factors may be responsible for alcohol use patterns, but the concept of self-regulation has been found to be particularly important in two senses. First, one of the motivations for adolescent and young adult drinking is related to attempts to regulate both mood and behaviour (e.g. Hull & Slone, 2004; Simons, Gaher, Correia, Hansen, & Christopher, 2005). Second, although many adolescents assume that negative effect and sociability can be positively influenced by drinking, it is also clear that alcohol use problems in adolescents and young adults are predicted by problems in self-regulation of behaviour (Baer, 2002; Brennan, Walfish, & AuBuchon, 1986; Colder & O'Conner, 2002). For example, researchers working from a personality perspective have shown that trait impulsiveness predicts problems with alcohol use (e.g. Camatta & Nagoshi, 1995; Stanford, Greve, Boudreaux, Mathias, & Brumbelow, 1996). Researchers using a motivational framework have found that risk for alcohol problems is associated with a biased attentional allocation strategy in which information relevant to rewards is given much higher priority than information relevant to punishments (e.g. Colder & O'Conner, 2002; Finn, Kessler, & Hussong, 1994). From within the motivational framework, this bias in attentional processing is typically referred to as a problem of disinhibition.

In our assessment of the utility of an executive control framework for understanding impulsivity and disinhibition in drinking behaviour, we wanted to limit the possibility that executive function scores would represent a combination of potentially dissociable abilities. There are a number of standard tests of executive control functions in neuropsychological test batteries. These tests are often very complex and they typically involve both executive and non-executive abilities (e.g. Lamar, Zonderman, & Resnick, 2002). Consequently, we chose tasks from the neuropsychology literature that appear to have relatively clear interpretation of their scores. These included the trail making test, which requires the ability to control behaviour by switching task sets in a speeded processing context, both forward and backward digit span, which are classic measures of short-term storage and manipulation, and the Dysexecutive Questionnaire (DEX), which is a self-report measure of problems with executive functions in everyday life (Burgess, Evans, Emslie, & Wilson, 1998). We also assessed executive functioning with a novel measure from our prior research on executive control and impulsiveness (Whitney et al., 2004). This task, the continuous memory-scanning (CMS) task, allows us to look for deficits in theoretically distinct aspects of executive control functions.

We administered these measures to college students who had experienced a substantial number of problems associated with drinking alcohol and to a control group that had experienced few alcohol-related problems. Our hypothesis was that if deficits in executive control functions are at the core of problems with impulsive or disinhibited processing styles, then the two groups of students should differ on measures of executive function. It is important to note that in the present study we were not looking for cognitive deficits caused by alcohol abuse. Thus, we did not look for differences in executive control between groups that were defined by diagnosis of clinical alcoholism. Instead, our groups were defined using the Rutger's alcohol problem index (RAPI; White & Labouvie, 1989) because we were most interested in predicting repeated problems associated with drinking. The RAPI asks how often in the past 3 years one has experienced 23 alcohol-related consequences such as: 'Had a fight, argument, or bad feelings with a friend'; 'Not able to do homework or study for a test'; 'Caused shame or embarrassment to someone'. Our logic in focusing on consequences of drinking was that a group of students who experienced numerous problems related to drinking would have received sufficient feedback on the negative effects of drinking that would be expected to control this behaviour if they could. In other words, a group of college students who score high on the RAPI are likely to have problems in self-control that are associated with deficits in executive control. The RAPI is moderately related to amount of alcohol use and it has high internal consistency (Thombs & Beck, 1994; White & Labouvie, 1989).

EXECUTIVE CONTROL AND WORKING MEMORY MANAGEMENT

Since the introduction of the theoretical concept of WM by Baddeley and Hitch (1974), the concept of executive control has been closely tied to the study of WM. Baddeley, Chincotta, and Adlam, (2001) linked the two concepts by claiming that a system for managing the allocation of attention is tied to various buffers for maintaining critical information during complex task performance (e.g. Baddeley, 1986). Some theorists have further linked the concepts of WM and executive control by claiming that individual differences in executive control ability are a reflection of a single ability: WM capacity for sustained attention in the face of interference (e.g. Kane & Engle, 2002). However, there is increasing evidence from neuroscience that there may be multiple types of executive functions (Royall et al., 2002; Stuss & Levine, 2002). Though there is no consensus as to a taxonomy of executive functions, it is common to draw a conceptual distinction between the capacity for manipulation of information in WM and the ability to regulate the updating of WM (e.g. Braver, Barch, & Cohen, 1999; Dreher, Guigon, & Burnod, 2002). The ability to maintain task relevant information in WM is strongly tied to the dorsolateral prefrontal cortex, but the ability to control attention to update the contents of WM has been tied to several other regions, and appears to depend critically on dopaminergic circuits between the basal ganglia and the frontal cortex (Dreher et al., 2002; Miller & Cohen, 2001).

If WM capacity and the processes that update the contents of WM are based on dissociable abilities, then two people who obtain the same low score on existing measures of executive function could have different deficits. For example, assume that people who make impulsive decisions score lower than their peers on a standard test of general executive function. One possibility is that low overall attentional capacity makes it difficult to evaluate contingencies, which leads to impulsive choices (cf. Finn et al., 1999; Hinson, Jameson, & Whitney, 2002). Another possibility is that the impulsive person may have adequate attentional capacity, but this capacity is not used effectively because of problems with updating the contents of WM. For example, WM capacity may be consumed by task irrelevant information, so that choice options are not properly compared. In short, failures of executive control could result from insufficient attentional capacity, but they could also result from the failure to restrict access to WM or the failure to delete irrelevant information from WM (cf. Chiappe, Hasher, & Siegel, 2000). From an applied perspective, these potential dissociations are important because if people can show a deficit in a general measure of executive control, but they do so for different reasons, there may be considerable noise in data that attempt to relate executive control to actual life decisions.

In order to avoid confounding dissociable indices in a single score, we have adapted a classic tool for studying WM, the Sternberg memory-scanning task (Sternberg, 1969), to allow us to separate WM capacity from WM updating processes. In the standard Sternberg task, the participant holds a memory set, typically two to five letters or digits, in WM, and then responds to a probe item to indicate whether the probe was in the memory set. Response times increase as memory set size increases, and the slope of the line is the rate of search of WM, a useful index of WM capacity (Cowan, 1999). Other components of performance, such as encoding and response speed, are reflected in the intercept of the function relating memory set size to RT.

As in standard versions of the Sternberg task, in our CMS task each trial starts with a memory set of two or four letters to retain in WM. Instead of following the memory set with a single probe, we present a series of probe items on each trial. The time to decide whether that item is in the memory set is recorded for each probe item. With its novel multi-probe procedure, the task we have developed is a hybrid of the Sternberg task and a 'continuous performance test' that has been used to study WM updating (cf. Braver et al., 1999).

As in the Sternberg task, we use the slope of the function relating memory set size to RT to assess the capacity for WM manipulation. However, in the CMS task we can also manipulate the sequence of probe items and the relationships among trials in order to assess WM updating. For example, we can use foil repetition to determine if an individual has difficulty restricting access to WM. If a particular foil item is repeated on a given trial, then the second occurrence of the foil may cause confusion over whether a foil was an earlier probe item or was an item in the memory set. Similarly, we can script a block of trials to test whether irrelevant information is maintained in WM. Responses to a particular letter are biased by having the letter serve as a positive probe for two consecutive trials. If that probe letter remains active in WM, on a subsequent trial when the letter serves as a foil, response time will be increased (cf. Bunge, Ochsner, Desmond, Glover, & Gabrieli, 2001). Over trials, we can thus obtain measures of WM capacity, restriction of access, and deletion. Example trials and the executive control constructs they measure are shown in Table 1. Whitney et al. (2004) showed that the indices derived from the CMS were dissociable from one another, and the indices differed in the degree to which they predicted trait impulsivity as defined by personality measures.

EXECUTIVE CONTROL AND PROBLEM DRINKING

A variety of measures from personality theory and from motivational psychology have been used to support the idea that poor control of response tendencies is a risk factor for alcohol problems in adolescents and young adults (cf. Baer, 2002). Our interest was in whether this general pattern might be understood as dysfunctional executive control. If impulsive processing is related to a general executive control ability, then high scorers on the RAPI should show deficits in executive processing across most or all of the executive function measures used in this study. In contrast, if there are dissociable executive functions, only some of which are related to impulsive processing, then we may only find deficits in processing on some aspects of executive control.

METHODS

Participants

Eighty Washington State University undergraduate students were screened using the RAPI. People scoring in the highest and lowest quartiles were selected for inclusion in the full

Table 1. Examples of trials from the CMS task used to measure dissociable executive control functions

STANDARD CONDITION (Low load example):

Memory Set	Probe Items	
S N	S V N L G Q N	

Construct: Capacity. The greater the load effect, the lower the WM capacity

REPEATED FOIL CONDITION (High load example):

Memory Set	Probe Items	
J P K W	S X J W M X P	(X is the repeated foil)

Construct: Access. The larger the interference effect, the greater the difficulty restricting access to WM.

BIASED FOIL CONDITION (High load example):

Trial No.	Memory Set	Probe Items	
1	G K P S	K L G X T G P	(G is biased as a positive probe)
2	J G	B C J P G Z T	(G is biased as a positive probe)
3	V H W T	D M Q L G H N	(G now occurs as a foil)

Construct: Deletion. The larger the interference effect, the greater the difficulty with deleting irrelevant information from WM

Note: High- and low-load memory sets were used in all three conditions. Each index of executive control is based on the increase in RT as WM memory load increases.

study. All participants earned partial credit toward a research involvement requirement in their introductory psychology course. In the highest RAPI (HR) group, there were 11 males and 9 females. In the lowest RAPI (LR) group, there were 10 males and 10 females. The participants ranged in age from 18 to 24 years.

Procedures and measures

The executive measures were administered to the HR and LR participants in group sessions of 5–15 participants using the procedures described below for each measure. In the initial session, participants were run through the CMS task. Each participant was directed to a small room containing a desk, chair, and computer. Upon completion of the CMS, the participants were scheduled for a second session in which they were run through the remaining tasks. The order of the DEX, Trails A and B, and digit spans were counterbalanced during the second session. Each of the two sessions lasted slightly less than an hour.

The CMS task

All stimulus presentation and data collection in this task was computer-controlled using the Micro Experiment Lab (MEL) software. Participants were shown a set of either two (low load) or four (high load) letters for 4000 ms in the centre of the computer screen, and were asked to maintain those letters in memory. Following this memory set, a prompt reading, 'Get ready to respond' appeared on the screen for 750 ms. After the ready signal, each of seven probe letters was presented individually for either 4000 ms or until the participant made a response, whichever came first. A fixation point, which consisted of three asterisks placed in the same location as the letters, was presented between each letter for 500 ms. Participants were required to make a 'yes' or 'no' key press response to each letter as quickly as possible while still being accurate. Four memory sets and their associated probe items constituted a block of trials, and the sequence of presentation within a block of trials was fixed, but the presentation order of the blocks was randomised.

Initially, the memory sets and probe sequences were constructed by generating a series of random letters taken from all consonants and then forming sets of 2, 4 (for memory sets) and 7 (for probe sequences). There was a total of 64 high-load memory sets, and 64 low-load memory sets each with their attendant probe sequences. These initial sets of randomly constructed sets of letters were then manipulated in order to fit the parameters of the task. The probe sequences were constructed so that there were 32 trials with repeated foils in which the foils were at least two letters apart. To avoid having the participants adopt specific strategies related to probe repetition, we also added 32 occurrences of adjacent repeated foils and an equal proportion of spaced and adjacent repeated targets. Repeated targets could occur in any of the trial types. Thus, while we were interested in the interfering effects of repeated (spaced) foils, probe repetition gave the participant no clues as to the correct answer for a particular probe.

In addition to a manipulation of the probe sequences, the memory sets were also manipulated to create 16 blocks of four memory sets and probe sequences in which a particular target was 'biased'. To bias a block of trials, a particular letter appeared in the first two trials as an item in the memory set and was probed at least once on each trial. The interfering effect of bias was measured by having the biased target occur as a foil probe item on one of the last two trials in the block. To avoid special response strategies, the biased probes occurred as valid targets on half of the biased blocks. The trials within each block were in a fixed order, but each participant received a randomised ordering of biased and unbiased blocks of trials. High- and low-load memory sets occurred in random order, and set size was equally represented across probe types.

Digit spans

The stimuli for both digit span forward and backward consisted of sets of digits presented by the experimenter at a rate of approximately one item per second. The set sizes increase as the task progresses. Digit span forward, where the participant must recall the items in their original order of presentation, begins with three digits in a set and progresses up to nine digits. Digit span backward begins with two digits and progresses up to eight digits in a set. For digit span backward participants must recall the digits in the reverse order of presentation. There are two trials at each set size, and the task is discontinued when the participant fails both trials in a set (Wechsler, 1981).

Trails A and B

For Trails A, participants must connect, in order, 25 digits that are randomly placed on an 8½ by 11 sheet of paper. The amount of time it takes them to complete the task is recorded in seconds. For Trails B, the participants must connect both letters and digits, in order. However, they must alternate digits with letters. For example, 1 then A, then 2, then B and so on. The time it takes to complete the task is recorded in seconds (Reitan & Wolfson, 1985).

The DEX

The DEX is a 20-item questionnaire that was designed to measure problems of executive functioning in daily living (Wilson, Alderman, Burgess, Emslie, & Evans, 1996). Questions on the DEX come from four areas in which change can occur: (1) emotional or personality changes (e.g. 'I have difficulty showing emotion'); (2) motivational changes (e.g. 'I have difficulty thinking ahead or planning for the future'); (3) behavioural changes (e.g. 'I do or say embarrassing things when in the company of others'); and (4) cognitive changes (e.g. 'I have problems understanding what other people mean unless they keep things simple and straightforward'). Participants must rate each of the 20 questions on a scale of 0–4 ranging from 'never' to 'very often'. For the sample used in this study, the DEX had adequate reliability (Cronbach's alpha = 0.79).

RESULTS

Description of the groups

For the entire sample of 80 students who took the RAPI, the mean score was 23.82 ($SD = 12.53$). The internal reliability of the RAPI for this sample was acceptable (Cronbach's alpha = 0.82). RAPI scores for the LR group ($n = 20$) ranged from 4 to 17 with a mean of 10.70 ($SD = 4.22$). For the HR group ($n = 20$), the scores ranged from 32 to 64 with a mean of 39.90 ($SD = 9.33$). All of the students in the HR group were in the range of scores considered to represent 'high consequence drinkers' in previous studies using the RAPI (e.g. Thombs & Beck, 1994).

Derivation of the CMS indices

As indicated in Table 1, we derived several different indices from the CMS task that allowed us to examine whether there are relationships among executive functions and impulsive behaviour that were not revealed by the more global executive control measures. Using RTs from correctly answered trials, we calculated, for each participant, the slope and the intercept of the RT–WM load function for each of the conditions of interest: standard memory scanning, repeated foils, and biased foils. Figure 1 shows that the overall performance on the CMS task was consistent with our interpretation of the task manipulations. WM scanning rates were slower under the two interference conditions,

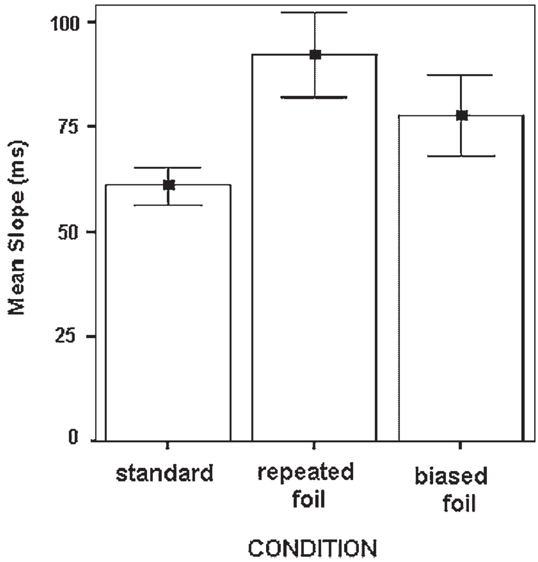

Figure 1. Mean performance on the standard and interference conditions of the CMS task. Bars indicate plus or minus one standard error of the mean

repeated foil and biased foil, compared to the standard condition. A repeated measures ANOVA on slopes across the three conditions was significant, $F(2,78) = 5.87$, $p < 0.01$. The intercept values, which measure overall speed of encoding, deciding, and responding, did not vary significantly by condition, $F < 1$. The mean intercept values (in ms) for the standard, repeated foil, and biased foil conditions, respectively, were 487, 455, and 484. Therefore, we averaged the intercept values for each participant as a general speed of processing index. These data closely replicate the CMS data obtained by Whitney et al. (2004).

Group performance on the executive control measures

As shown in Table 2, we performed planned contrasts on the mean executive function scores of the two groups, defined by high and low RAPI quartiles. The results clearly show that there is *not* a general deficit in executive functioning that is associated with high RAPI scores, but rather, there appears to be a qualitative *pattern* of executive control abilities that may lead to impulsive decision making.

The self-report measure, the DEX, revealed significant problems with executive control issues in everyday life among the high consequence drinkers. In fact, the mean score obtained by the HR group is only about two points less than scores obtained for executive control problems in a sample of neurological patients with mixed aetiology (Burgess et al., 1998). In contrast to typical results obtained with neurological populations, however, the other tests revealed some areas of superior performance by the HR group. The HR group was somewhat better than the LR group on the backward digit span (HR mean = 7.5; LR mean = 6.2). In addition, the HR group was significantly faster than the LR group on some of the more basic aspects of information processing as assessed by the Trails B and the intercept measure of the CMS.

Table 2. Comparison of high and low RAPI groups on executive function measures

Measure	RAPI Group				
	Low Mean (*SD*)	High Mean (*SD*)	*p*	Direction	Effect size
DEX	16.75 (6.26)	31.45 (6.00)	*0.001*	HR−	2.45
Digit forward	7.55 (2.11)	8.25 (1.65)	*0.37*		
Digit backward	6.20 (2.16)	7.50 (1.76)	*0.04*	HR+	0.67
Trails A (seconds)	23.25 (7.78)	22.16 (8.45)	*0.77*		
Trails B (seconds)	56.90 (13.75)	45.10 (13.03)	*0.008*	HR+	0.90
CMS:					
Intercept					
RT	535 (110)	421 (127)	0.004	HR+	1.00
Errors	0.01	0.02			
Standard slope					
RT	54 (23)	65 (32)	0.55		
Errors	0.02	0.02			
Repeated foil					
RT	96 (43)	101 (70)	0.63		
Errors	0.01	0.03			
Biased foil					
RT	48 (44)	102 (72)	0.01	HR−	0.86
Errors	0.02	0.01			

Note: HR− denotes inferior performance by high RAPI group; HR+ denotes superior performance by high RAPI group. $N = 20$ per group. Error rates on the CMS were too low to be meaningfully related to conditions, so only the RT data from the CMS were statistically analysed. The effect size measure reported is Cohen's d.

The Trails B involves perceptual encoding, task switching, decision making, and motor responses. The intercept measure from the CMS (like other Sternberg-type tasks) involves perceptual encoding, decision making, and motor responses (Sternberg, 1969). Clearly, the HR group is faster than the LR group in some or all of these processes. Performance on the other tasks used in this study can narrow down the possible interpretations. The two groups were very close in performance on the Trails A, which involves perceptual encoding and motor responses. Thus, it seems likely that faster decision processes, and possibly the ability to switch tasks easily, were the key differences between the groups.

A very notable exception to faster processing by the HR group was obtained with the biased foil measure from the CMS. This result suggests that, in the HR group, once an association was established between a positive response and a particular target letter, the participants had a great deal of trouble inhibiting a positive response to that target even when the information that led to a positive response should have been cleared from WM. Thus, the pattern of abilities that appears to distinguish the HR group from the LR group is that the HR group makes generally rapid decisions, but they maintain information in WM that is no longer relevant, which makes it much harder to inhibit a prepotent response. To provide a further test that it is this qualitative pattern that characterises the HR group, and to examine the magnitude of these effects, we conducted an additional analysis in which the variables that distinguished the HR and LR groups were used as predictors of group membership in a binary logistic regression.

Predicting problem drinking

The logistic regression to predict membership in the HR and LR groups was performed in a hierarchical manner, moving from the 'purest' measure to the most composite measure. Thus, on step 1 the biased foil measure from the CMS task was entered as an index of the ability to avoid interference from prepotent responses. On step 2, two measures on which the HR group performed better, the Trails B and the intercept measure from the CMS were added; these measures appear to capture speed of processing, or at least speed of decision making. On step 3 the DEX was added to the model as a global index of executive control dysfunction. The results are summarised in Table 3.

The overall model does a remarkably good job of predicting group membership, with nearly 93% of the cases classified correctly. Even if we exclude the DEX and rely solely on the objective indices from our battery of tests, 70% of the cases were correctly classified. These data provide strong support for the hypothesis that a suboptimal pattern of executive control predicts which the students repeatedly suffered negative consequences from drinking alcohol. The high consequence drinkers were quick to make decisions, but had difficulty with inhibition of prepotent responses. In addition, a self-report measure designed to provide an ecologically valid index of executive functions was a particularly powerful predictor of problem drinking when it was added to the model.

DISCUSSION

It is not surprising that the DEX is a good predictor of problem drinking. Previous studies have shown that trait measures of impulsiveness, such as the Barratt impulsiveness scale (BIS), are predictive of problem drinking (e.g. Stanford et al., 1996), and in a previous study we found that the DEX is strongly correlated with the BIS (Hinson, Jameson, & Whitney, 2003). Further, Hinson et al. found that the DEX is predictive of the tendency to choose smaller short-term gains over larger long-term gains in a laboratory test of decision making.

One could argue that the slips of control that result in higher DEX scores could themselves be a direct consequence of problem drinking. However, the performance on the objective measures used in this study was not consistent with impairment caused by alcohol abuse. When neurocognitive impairment due to alcohol use is found among college students (typically students in substance abuse treatment programs), it tends to be fairly general and includes *impaired* performance on tests like the Trails B and backward digit span (Blume, Marlatt, & Schmaling, 2000; Sher, Martin, Rutledge, & Wood, 1997). In contrast, our sample of 'high consequence' drinkers do not show a general pattern of deficits.

Table 3. Results from the binary logistic regression predicting group membership from executive control variables

Step	Variable(s) entered	*B*	Test of the model	% Correct classification
1	Bias foil slope (CMS)	0.03	$\chi^2(1) = 9.61$, $p < 0.01$	62.5
2	Trails B	−0.06		
	Intercept (CMS)	−0.01	$\chi^2(3) = 15.26$, $p < 0.01$	70.0
3	DEX	0.38	$\chi^2(4) = 38.99$, $p < 0.001$	92.5

Note: We repeated this analysis using backward digit span in place of the DEX, but the backward digit span had no predictive utility beyond that of variables on steps 1 and 2.

To some extent, the two paper and pencil measures used in this study could be related to factors inherent in the self-report nature of the measures. The more important result of this study is that a *deficit model*, in which poor executive control equals poor behavioural control, may not be the best way to view the relationship between executive control and problem-drinking behaviour. It may prove more useful to think of a *balance model* in which the pattern of strengths and weaknesses in a set of executive processes influence behavioural control. In particular, the data showed that a particular qualitative pattern of abilities related to executive control characterises the problem-drinking group: fast decision processing coupled with difficulty inhibiting prepotent responses.

It is important to consider the question of whether the group differences that we demonstrated represent a risk factor for problem drinking, or instead represent a consequence of alcohol abuse. The cross-sectional design of this study is an important limitation in addressing this issue. We have characterised dysfunctional executive control as a risk factor for problem drinking, but the antecedent-consequence relationship among the variables can only be conclusively demonstrated with longitudinal designs. It is also important to acknowledge that executive control dysfunction could be both a risk factor for, *and* a consequence of, problem drinking. However, despite the limits of our design, it seems difficult to account for the results obtained here in solely in terms of the effects of alcohol use on executive control.

While it is difficult to argue that the executive control pattern we see in the high RAPI group is the result of their alcohol use, it should be noted that our 'high consequence' drinkers are young college students who volunteered for this study as one of several options available to them for fulfilling a course requirement. They may represent a fairly high functioning group whose executive control abilities might not generalise to other groups of 'high consequence' drinkers.

The causes behind alcohol abuse by adolescents and college students are complex and they exist on several levels from personal to social (e.g. Sobeck, Abbey, Agius, Clinton, & Harrison, 2000). Nevertheless, we were able to demonstrate that control over alcohol misuse is related to executive control. Although measures of WM and executive control have been correlated with general academic success (e.g. Gathercole, Pickering, Knight, & Stegmann, 2004), there is relatively little research that has attempted to relate laboratory or clinical measures of executive control to problems in self-regulation (Banfield, Wyland, Macrea, Munte, & Heatherton, 2004). Even in neuropsychology, where various measures of executive function can be used to distinguish between different groups of brain-injured patients, there is relatively little evidence for the ecological validity of the measures (Gioia & Isquith, 2004; Ready, Stierman, & Paulsen, 2001). As research on the relationship between executive control of WM and self-control of behaviour continues, it is important to bear in mind the salient lesson of the data obtained here. Namely, that progress may be impeded by thinking only in terms of a deficit model. Future studies should explore whether the same qualitative pattern of executive control that characterised our high consequence-drinking group is characteristic of individuals with other types of self-control problems.

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