

ORIGINAL ARTICLE

A New Test to Measure Attentional Bias and Cognitive Disinhibition in Drinkers, Based on the Hayling Task

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Abstract — **Aims:** To generate and pilot unfinished sentences, based on the Hayling Task of disinhibition, which could be completed with alcohol or non-alcohol words. To determine whether drinking habits influenced responses on the new sentences, which may advance understanding of the cognitive processes underlying alcohol-related behaviours. **Methods:** Three phases: I—Generation of appropriate sentences (via email correspondence); II—Sentence completion to establish proportion of alcohol-related and non-alcohol-related responses; III—A Hayling-style task using the sentences (laboratory-based). During the Hayling task, sentences were completed with the first word that came to mind (initiation task), and with a word that did not make semantic sense (inhibition task). In Phase III, the alcohol use disorder identification test (AUDIT) was also completed to determine whether drinking habits were related to responses. **Results:** Fifteen sentences were generated and tested. Compared with low hazardous drinkers, higher hazardous drinkers gave more alcohol-related responses; persisted in giving alcohol responses in the inhibition task; and were slower to make non-alcohol-related responses. A positive correlation was found between AUDIT score and number of alcohol-related responses. **Conclusions:** A new alcohol-related sentence-completion tool, based upon the Hayling disinhibition task, was developed and piloted. Responses on the task were associated with measures of alcohol use disorders. The task can be used in research investigating the processes underlying the acute and chronic effects of alcohol, such as attentional bias and disinhibition. In future, the task could be used in conjunction with non-alcohol-related sentence completion tasks to investigate general and alcohol-specific processes of disinhibition.

INTRODUCTION

Given the significant negative consequences of excessive alcohol consumption and the continuing high rates of binge drinking and alcohol use disorders, there is a real need to understand why some people drink in hazardous ways. A growing body of animal and human evidence suggests that impulsivity may be related to alcohol use disorders. Impulsivity can be understood as responding with a lack of reflectiveness (Magid *et al.*, 2007) or when behaviour is stimulus-driven (Lubman *et al.*, 2004). Individuals scoring high on measures of impulsivity and disinhibition are more likely to have an alcohol use disorder (Trull *et al.*, 2004). In addition, acute and chronic alcohol consumption can attenuate control processes, leading to disinhibited and impulsive behaviour, which may relate to risky and/or excessive drinking, e.g. binge drinking (Fillmore, 2003; Poulos *et al.*, 1998; Rose and Duka, 2007; Rose and Grunsell, 2008; Volkow *et al.*, 2004).

There are a number of tasks used to assess the relationship between inhibitory control and alcohol use and which reflect different dimensions of disinhibition. Behavioural inhibition tasks, such as the go/no-go, are associated with the anterior cingulate cortex and assess pre-potent responding (Bechara and Martin, 2004; Ramaekers and Kuypers, 2006). In comparison, cognitive tasks, such as the Stroop, require intact inhibitory mechanisms associated with the ventromedial portion of the frontal lobes, and reflect interference inhibition (Bechara and Martin, 2004; Fillmore, 2003; Fillmore and Rush, 2001; Ramaekers and Kuypers, 2006; Rose and Duka, 2007, 2008). Although such tasks have proved useful in understanding the relationship between alcohol use and disinhibition, the participant remains somewhat 'passive' during

such tasks. That is, the stimuli used within these tasks are determined in isolation from the participant.

Stacy *et al.* (1997) selected words which could be associated with different behaviours, for example, 'shot' and 'pitcher' may be associated with alcohol, whereas 'program' and 'screen' may be associated with computers. Participants were provided with a list of words and asked to pair each one with the first word that came to mind, for example, 'doctor' may result in a pairing with 'nurse'. A positive relationship was found between participants' typical drinking and computer activities and the frequency of alcohol- and computer-related responses, respectively. In a separate study, providing participants with alcohol-related scripts and words increased alcohol responding on the subsequent word association task, and frequency of self-generated alcohol responses was positively related to drinking behaviour (Stacy *et al.*, 1994). Such findings indicate that personal behaviour influences cognitive processes and that ambiguous situations are interpreted within a framework of previous experience. In turn, this may help explain why heavier drinkers (Field *et al.*, 2004) and priming doses of alcohol (Rose and Duka, 2008) are related to alcohol attentional bias. Heavier drinkers are likely to have stronger and/or more elaborate alcohol-related associative networks and concepts, due to more alcohol-related experiences (Stacy *et al.*, 1997). In addition, heavier drinking is associated with higher perceived reward value of alcohol and, therefore, alcohol cues will have greater incentive salience and may exert more control over behaviour (Berridge and Robinson, 2003; Leventhal and Schmitz, 2006; Spada *et al.*, 2007). Taken together, these factors may result in an alcohol-related attentional bias which could be exacerbated by the act of drinking and the acute effects of alcohol (Schoenmakers *et al.*, 2008). Indeed, attentional bias for drugs has been linked with disinhibited

and excessive drug-related behaviour (Field *et al.*, 2008). It would, therefore, be useful to have a task in which responses are self-generated (Stacy *et al.*, 1994, 1997) to look at cognitive biases, but which could also assess other important factors, such as disinhibition.

The Hayling task is a theory-driven test of inhibition, employing sentence completion methods (Burgess and Shallice, 1996; Shallice and Burgess, 1996). The participant is given a list of sentences and asked to complete each sentence with the first word which comes to mind. This is called the 'initiation task' and measures general response type. Subsequently, the participant is asked to inhibit a semantically correct word and complete the sentences with an unrelated word. This is called the 'inhibition task' and measures response disinhibition and perseveration. This task differs from the work of Stacy *et al.* (1994, 1997), which was more based on word association, in that there are clear correct and incorrect responses and participants must, in some instances, inhibit their automatic response.

Research indicates that impairment of the anterior frontal lobe is associated with greater error rates on both the initiation and inhibition phases of the task (Burgess and Shallice, 1996). Alcohol dependence is associated with impaired frontal lobe function (Chen *et al.*, 2007; Tekin and Cummings, 2002) and detoxified alcoholics, compared with control participants, are likely to respond to the Hayling inhibition measure with words that are related to the expected word (Noel *et al.*, 2001). A subsequent study demonstrated a relationship between relapse after detoxification and poor performance on the Hayling task but not on measures of abstract reasoning or episodic memory. Detoxified alcoholics who had relapsed after 3 months showed the greatest perseveration of semantically appropriate responses during the inhibition phase. In addition, imaging data revealed lower ^{99m}Tc -Bicisate SPECT uptake in the bilateral middle frontal gyrus (BA47) within the relapsed participants (Noel *et al.*, 2002). The abstaining and relapsed participants did not differ on a range of other factors, including alcohol behaviour prior to detoxification, number of prior detoxifications, anxiety or depression.

The current work sought to develop an alcohol-related tool, based on the original Hayling task, which may be used in conjunction with the Hayling task in future research. The tool was developed so that, although sentences could be completed with alcohol words, there was no priming of alcohol responses as in Stacy *et al.*'s (1994, 1997) work. We were interested in several factors: the natural tendency to complete sentences with alcohol-related words; the ability to suppress pre-potent responding and whether this ability differs between alcohol- and non-alcohol-related words; and how such effects are influenced by the individual's typical drinking habits.

MATERIALS AND METHODS

The research was approved by the King's College, London Central Ethics Committee and participants provided informed consent.

Participants

One hundred and twenty students and associates of Southampton Solent University and King's College London

took part in the research: 37 males and 83 females aged 18–64 years (mean = 24.1; SD = 8.7). Ten participants did not give their age.

Eighty of these participants completed Phase II (19 males, 18–64 years [mean = 25.5; SD = 9.9]) whereas the remaining 40 (18 male, 18–28 years [mean = 20.6; SD = 2.8]) completed Phase III. Phase III participants also completed the Alcohol Use Disorders Identification Test (AUDIT: Babor *et al.*, 2001) and were classed as 'higher hazardous' or 'lower hazardous' drinkers determined by a median split of AUDIT scores. The lower hazardous drinkers scored between one and 11 on the AUDIT (mean = 5.6; SD = 3.1) and therefore met the criteria of low risk/hazardous drinkers. The higher hazardous drinkers scored between 12 and 30 (mean = 19.5; SD = 4.8), meeting the criteria for harmful drinking, or possible dependence.

Procedures

Phase I: Sentence generation

Emails were sent out at several UK-based universities asking for sentences that the respondents felt could be completed by alcohol- or non-alcohol-related words. The emails were sent using a 'viral' strategy; recipients were asked to forward on the email to friends and colleagues. From the responses received (~55 sentences which made grammatical sense), sentences were placed into matching categories and a title given to each group. The research team generated 15 sentences which represented these categories.

Phase II: Proportion of alcohol- and non-alcohol-related words

Participants were presented with the 15 incomplete sentences (Table 1). Sentences were completed via email. Participants were instructed to complete the sentence quickly, i.e. not to think too much about their answer, with the first word that came to mind. The data yielded counts for the number of alcohol-related and non-alcohol-related words given for each sentence. One data point was missing for the sentences.

Table 1. Percentage of alcohol-related words provided to complete sentences (Phase II and III)

Sentence	<i>n</i>	% Alcohol-related responses
1. The man bought a pint of ...	120	72.5
2. She drank a glass of ...	120	57.5
3. The woman ordered an orange juice and ...	120	35.8
4. The man asked the waiter for a ...	120	16.7
5. In the UK, 18 is the legal age to ...	120	68.3
6. When he went to the beach on a hot summer's day he always made sure to bring the ...	120	9.2
7. She asked if he wanted a can of ...	120	33.3
8. France is well know for its ...	119	42.5
9. After going out with friends last week she was so ...	120	51.7
10. Duty free is good for buying cheap ...	120	54.2
11. Supermarkets stock cans of ...	120	20.8
12. Ice goes well with ...	120	40.0
13. A famous American drink is ...	120	40.0
14. With dinner most people drink ...	120	53.3
15. On a hot day nothing is quite as refreshing as a cold ...	120	40.0

Phase III: Impact of drinking habits on response type

Emulated the Hayling task using the same 15 sentences in a laboratory setting. Participants completed the AUDIT before the two versions of the sentence completion exercise. In the Initiation Version, participants were required to complete the sentences with the first word that came to mind that made semantic sense (e.g. She drank a glass of 'wine/water'). In the Inhibition Version, participants were asked to provide a word that did not make semantic sense (She drank a glass of 'elephant'). The sentences were read aloud by the researcher at Southampton Solent University. The researcher wrote down the participant's response (word) and recorded response latency using a stopwatch for each sentence. Participants were instructed not to think too much about their answers and to respond as quickly as possible. There was no reaction time data for six participants in Phase III.

Analysis

The number of alcohol-related responses provided in Phases II ($n = 80$) and III ($n = 40$) were counted to yield the percentage of alcohol-related responses for each question.

In Phase III, the mean number of alcohol-related words and mean response times were calculated for each AUDIT group (lower/higher hazardous drinker) for both the initiation and inhibition versions of the task. Between group effects were tested for significance using *t*-tests except where the data were not normally distributed (test of skewness >1). When this occurred, a Mann–Whitney *U* test was utilized, as log transforming the data failed to improve skewness sufficiently to warrant parametric tests.

Correlational analysis was used to test the strength of the association between AUDIT scores and responses on the sentence completion responses (Phase III).

RESULTS

Sentence generation and response proportion

The sentences generated in Phase I were placed into categories: Buying drinks (S1, S10, S11); Consumption (S2); Countries (S8, S13); Legal (S5); Ordering drinks (S3, S4, S7); Socializing (S14, S9); Weather/refreshment (S6, S12, S15) (Table 1).

Analysis was run to determine whether completion of the AUDIT in Phase III predisposed participants to complete sentences with alcohol-related words. There was no difference in the number of alcohol-related responses generated between Phases II and III ($P = 0.31$). Therefore, responses from Phases II and III (Initiation task only) were combined to look at the proportion of response types.

Table 1 shows the sentences generated from Phase I and the percentage of alcohol-related responses given by participants in Phases II and III. No participants completed a sentence with a word that did not make semantic sense.

Part III: Hayling-style pilot

Table 2 shows the mean number of words and reaction times for the heavy and light drinkers for the initiation and inhibition versions.

Table 2. Mean (\pm SD) number of alcohol-related words and response latency (s) for lower and higher hazardous drinkers

	Lower hazardous ($n = 20$)	Higher hazardous ($n = 20$)
Initiation task		
Mean no. alcohol words	4.7 (2.3)	8.8 (2.7)
Response latency (s) alcohol words	0.78 (0.24)	0.76 (0.17)
Response latency (s) non-alcohol words	1.32 (1.76)	0.94 (0.2)
Inhibition task		
Mean no. alcohol words	0.1 (0.45)	1.7 (1.56)
Response latency (s) alcohol words	1.84 ($n = 1$)	1.48 (0.6)
Response latency (s) non-alcohol words	1.48 (1.0)	1.87 (0.4)

Initiation responses

There was a significant positive correlation ($r = 0.76$, $P < 0.01$) between scores on the AUDIT and total number of alcohol-related words given across all sentences. This transferred to a significant difference between heavy and light drinkers; heavy drinkers were more likely to complete sentences with alcohol-related words relative to light drinkers ($t[38] = 5.19$, $P < 0.01$). No participant gave a response that did not make semantic sense within the context of the sentence.

Initiation response latency

There was no significant difference in latency between heavy and light drinkers when alcohol-related ($U = 137$, $P = 0.93$) and non-alcohol-related ($U = 131.5$, $P = 0.77$) responses were given.

Inhibition responses

Heavy, relative to light, drinkers persisted in responding with alcohol-related words even when instructed to respond with words that did not make semantic sense (i.e. error responses; $t[38] = 4.41$, $P < 0.01$).

Inhibition response latency

An analysis of the latency between heavy and light drinkers for alcohol-related words was not conducted as only one light drinker gave an alcohol-related word in the inhibition phase. Light drinkers were quicker to respond with non-alcohol-related words compared with heavy drinkers ($U = 54$ $P = 0.002$).

DISCUSSION

The current paper represents initial pilot work in the development of a sentence-completion task which can contribute to the understanding of the cognitive processes, especially those involved in inhibitory control and attention, underlying hazardous drinking and alcohol use disorders. The pilot work generated 15 sentences which could be completed with alcohol- or non-alcohol-related words (Phase I). The research tested the proportion of alcohol- and non-alcohol-related responses (Phase II and III) before conducting a Hayling-style task with the 15 sentences (Phase III). During

Phase III, participants were split into two categories, lower or higher hazardous drinkers (based on AUDIT scores) to determine whether drinking habits influenced response type and response latency.

Participants who scored higher on the AUDIT were more likely to complete sentences with alcohol-related words. This finding may reflect stronger alcohol-related (neural-based) associations and concepts based on previous experience (Stacy *et al.*, 1994, 1997). The greater incentive salience of alcohol-related cues in heavy drinkers, and the relative ease with which alcohol-related associations may be activated, may result in ambiguous stimuli being interpreted in an alcohol-related way. This may explain why heavier drinkers show alcohol-related attentional biases even in the absence of alcohol consumption (Townshend and Duka, 2001). Future research needs to take more detailed data on participant drinking habits (e.g. frequency of binge drinking, number of alcohol units per week) to test this possibility.

Noel *et al.* (2002, 2001) have shown that alcohol use disorders and risk of relapse are associated with an inability to suppress pre-potent responding on the original Hayling task. The current work showed a positive relationship between the AUDIT score in non-clinically dependent drinkers and the perseverance of alcohol responding during the inhibition task. A common impairment in cognitive mechanisms involved in suppressing inappropriate responses, may be a pathway to developing alcohol use disorders. Future research which compares a wider range of drinking behaviours, e.g. non-drinkers, social and binge drinkers, and clinically dependent alcoholics, can assess whether alcohol-related responses show a steady continuum alongside drinking habits. Although more research is needed to support this initial evidence, the alcohol sentence completion task may have the potential to measure hazardous drinking and risk for alcohol use disorders. In order to assess this possibility, future research which includes measurements of certain risk factors (e.g. family history of alcohol abuse, age of drinking onset, functional genetic variants) will be needed.

The alcohol theme of the AUDIT may have led to a bias in alcohol-related responding, for example by activating alcohol-related cognitions (Stacy *et al.*, 1997), in Phase III. Although *post hoc* analysis did not show any such bias, this needs to be confirmed in future studies. Our ongoing research combines the new alcohol sentences with the original Hayling task which should help in removing any alcohol-related bias. Ongoing research has omitted sentence 6 (Table 1), which was originally included because sentence generation (Phase I) respondents provided a number of sentences related to alcohol on 'sunny days' and 'day trips'. Although the sentences used in the Hayling task were chosen to be representative of the ideas illustrated by the Phase I generation task, sentence 6 was substantially longer than the other sentences and under 10% of responses were alcohol-related (measured in Phases II and III). Although other sentences showed a fairly low proportion of alcohol-related responses, this is seen as a useful element as it allows investigation of other experimental factors. For example, some sentences which naturally generate a low alcohol response rate are required to avoid a ceiling effect (i.e. all sentences trigger high rates of alcohol responses) when indentifying whether the acute effects of alcohol increase the generation, and decrease the suppression, of alcohol responses.

Rose and Duka (2008) found that social drinkers were more disinhibited during the classic Stroop task and an alcohol-modified Stroop task after a priming dose of alcohol (0.6 g/kg), relative to placebo. However, they did not find this enhanced disinhibition on other, non-alcohol, modified Stroop tasks. It is possible that the acute effects of alcohol may exacerbate processes of alcohol-related attentional bias and disinhibition as measured by this new task. We are currently using the new task in conjunction with validated cognitive tests to investigate alcohol priming and disinhibition. Alcohol priming is the enhanced motivation to drink which can follow initial alcohol consumption (Rose and Duka, 2006) and is believed to play an important role in binge drinking and relapse (de Wit, 1996; Shaham *et al.*, 2003; Stewart *et al.*, 1984). If heavy drinkers show a greater alcohol response rate following priming on the initiation task this may indicate an attentional bias for alcohol, while during the inhibition phase may signal attenuated interference inhibition processes (Rose and Duka, 2007, 2008).

In terms of response latency, no differences were found during the initiation phase and analysis was not possible on alcohol-related words during the inhibition phase due to the low levels of alcohol-related responses. However, during the inhibition phase, heavy drinkers were slower to respond with non-alcohol-related words relative to light drinkers. Given the discussion above, it is possible that heavy drinkers have a natural tendency to make alcohol-related responses. The longer response latencies may reflect the greater cognitive effort it takes to suppress this tendency and/or the longer cognitive search time it takes to activate an alcohol word, suppress this, and then search for a non-alcohol word. Previous work has shown that alcohol-dependent participants are slower on the inhibition subtest of the Hayling task (Noel *et al.*, 2001) which may indicate a general impairment of interference inhibition processes as a result of chronic alcohol intake. These possibilities are being investigated in our current work which has embedded the new sentences into the original Hayling task. It is possible that the inclusion of unambiguous non-alcohol sentences will tease apart differences in response latency based on drinking habits. It may also be useful to include unambiguous alcohol-related sentences in future work to test more conclusively whether drinking habits are positively correlated with impaired ability to suppress alcohol responses. However, this was not appropriate in the current pilot as a key aim was to ensure there were no strong alcohol cues to influence the participant's response. It is important to note, however, that the natural tendency to make alcohol-related responses in ambiguous situations (e.g. during the initiation phase) may have primed alcohol responses in the inhibition phase. However, the key measure in the inhibition phase was the inability to inhibit automatic responses.

A flaw in the study with respect to interpretation of the response latency data was the use of stopwatches which have the potential of inaccurate measurement. Future work should use computer-based voice detection software, which could result in more accurate data and enhance identification of response latency differences. Fillmore and Rush (2001) found that a priming dose of alcohol (0.55 g/kg) led to participants selecting a quick response strategy at the cost of making more errors. Our ongoing work will be able to assess whether alcohol's acute effects results in participants responding more quickly while making more errors.

Some research has suggested that the underlying risk factors for hazardous drinking and dependence may differ across gender (King *et al.*, 2003). The current study was not conducted in order to look at gender effects and the unequal numbers of males and females makes analysis inappropriate. Future research which is adequately controlled and powered can investigate whether mechanisms of inhibitory control and attention, as measured by the current task, are more important in male or female drinking practices.

Although the Hayling task is primarily an inhibition task, it also involves aspects of planning, semantic search, manipulation of information, selection and evaluation of the response (Collette *et al.*, 2001). These processes will also be involved in the alcohol-sentence completion task. Although beyond the scope of the current pilot study, future research will include validated measures of these cognitive processes in conjunction with the alcohol-sentence completion task.

Both cognitive-behavioural and imaging research have the potential to increase understanding of the processes involved in the new task and how it may be used in clinical populations to identify risk factors for important phenomena, such as relapse. Collette *et al.*'s (2001) imaging study found that the left superior temporal gyrus and the right inferior parietal were storage areas for semantic content. Response inhibition was associated with activation within the left-side middle and inferior frontal areas, supporting the hypothesis that inhibition processes are linked with the prefrontal cortex (Collette *et al.*, 2001; Johansson and Hansen, 2000; Maguire *et al.*, 2003). In addition, activation of the inferior frontal region appeared important in the selection and evaluation of appropriate responses. This activation was more localized to the anterior region during the inhibition task, which is linked with the findings of Burgess and Shallice (1996) employing the original Hayling task. Both acute and chronic alcohol consumption affect a wide range of brain regions, including the prefrontal cortex which involves the anterior cingulate and orbitofrontal cortices important in executive functions such as inhibitory control (Crews and Boettiger, 2009). Future research can determine how acute alcohol administration affects such activation and how this translates to responding. In addition, given that the current pilot data showed differences in responses between light and heavy social drinkers, it will be important to see how activation differs between individuals with different drinking habits.

One main weakness of the current study was that Phases I and II were conducted by email, therefore, there was no control over what the respondents were doing at the time of participation. The email method was the most practical for obtaining data from a large number of individuals in a relatively short amount of time. Future, laboratory-based research, which takes more detailed measures of participant characteristics and drinking habits, will test the validity and reliability of the new task.

The current pilot data introduces a new set of incomplete sentences which can be completed with alcohol or non-alcohol-related words and which may be used alone or in conjunction with other sentence completion tasks. The task allows measurement of several important processes; how drinking habits, learning, memory and attention influence interpretation of ambiguous contexts (Stacy *et al.*, 1994, 1997) whereas at the same time assessing mechanisms of inhibition and control (Burgess and Shallice, 1996). The

new task should contribute to our understanding of the complex cognitive mechanisms underlying drinking habits and, potentially, highlight individuals at risk of hazardous drinking and alcohol use disorders.

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