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Abstract

Measurement of cognitive bias typically relies on laboratory-based tasks. In order for cognitive bias measures to be useful outside of laboratory settings, a simple measure is required which does not rely on precise measurement tools, e.g., precise reaction time measurement (which can be done only with specialized software typically running through either dedicated hardware or specifically configured computers). The Rough Estimation Task (REsT) is a simple reading task which has been previously shown to be an effective measure of alcohol-related cognitive bias. We conducted an online version of the REsT, so that we could measure cognitive bias away from a laboratory environment. We also measured whether baseline REsT scores could predict future drinking and REsT scores. A sample of undergraduate participants completed the study online. We found that the online REsT was associated with both current and future drinking, as measured in a follow-up online task. The results imply that the online REsT could be used as a simple online measure of cognitive bias for both concurrent and future drinking behavior, and so raises hope for employing this measure outside of laboratory settings and possibly even in clinical applications.

Introduction

Attentional bias is the preferential processing of stimuli, which have developed increased saliency for particular populations (e.g., alcohol-related stimuli for heavy drinkers; Cox, et al., 2002). Substance abusers, for instance, have an attentional bias for substance-related stimuli (Wilcockson & Pothos, 2015). Traditionally, the emotional-Stroop task has been used to measure attentional capture (Cox, et al., 2006). It involves naming the color of words related to a thematic category, which may have attentional holding properties (e.g., alcohol-related stimuli for heavy drinkers). If the word is salient for a participant, the meaning of the word will capture the person's attention and cause a delay in naming the color of the word. Therefore, longer reaction times reflect longer cognitive processing and may reflect a cognitive or attentional bias. Performance on this task has been found to predict relapse and treatment outcome for substance abusers (Cox, et al., 2002). However, such tasks typically require precise reaction time measurement, e.g., using computer-controlled presentation of the stimuli, so that their use outside the laboratory conditions can be problematic.

Wilcockson and Pothos (2016) developed a novel cognitive bias paradigm, which distinguishes heavy from light alcohol drinkers. The task, called the Rough Estimation Task (REsT), involves simply presenting participants with a list of words, which can be in one of three categories: appetitive words (e.g. alcohol, food, etc, depending on which behavior is being studied), neutral words belonging to a common category (e.g., clothing, furniture, office equipment, etc.), and a category of neutral unrelated words. Participants read the words and are then asked to estimate the percentage of words in each category. Individual differences in the propensity to overestimate the proportion of appetitive stimuli (e.g., alcohol or food-related words) in a word list were associated with various behavioral measures (i.e. alcohol consumption, hazardous drinking, body mass index, external eating, and restrained eating, respectively), thereby providing evidence for the validity of the task. Further, REsT was also found to be correlated with an alcohol-related eye tracking attentional bias task, thereby further demonstrating an association between the REsT and traditional attentional bias tasks. It would appear that the REsT is able to measure distortions in a person's perceptions of how numerous a particular type of stimulus (e.g., alcohol-related) is in that person's environment. For example, a heavy drinker might perceive their environment as having a greater frequency of alcohol-related stimuli than it actually does. Preferential processing of a stimulus caused by the orienting of attention may lead to an inflation of the importance of that stimulus (cf. Field et al., 2008), which would then increase the salience of the appetitive words during the task. When participants try to recall the number of words in a cognitive task, their cognitive biases may lead to distortions in their working memory, resulting in an overestimation of the number of words (cf. McCusker, 2001).

The REsT has a number of procedural advantages over other cognitive bias tasks. It alleviates the technical obstacles associated with implementing traditional cognitive bias measures. It is easy and simple to use, yet it is sensitive to cognitive distortions without the use of reaction times. Indeed, its main advantage is that unlike other methods it does not require a laboratory. This is an important

consideration for making data collection easier and if cognitive and attentional bias tasks are to be useful in clinical settings, e.g., alcohol abuse treatment centers. The availability of a task that could be used in clinical settings would enable clinicians to assess the likelihood of relapse to alcohol abuse. This could have important implications for monitoring patients' progress.

The study reported here was aimed at exploring whether the REsT could be administered outside the laboratory in a real-world setting. We aim for a conclusion based upon group-level statistics in this study and do not aim to provide results which could be used for individual analyses on a case-by-case basis. We administered the task online, so that participants could participate in their own homes. We also aimed to see whether performance on the REsT at the start of the study would predict alcohol use and REsT performance in a follow-up assessment either three months or two years after the baseline REsT measure had been completed.

Method

Participants

Since the REsT has never been employed before in a longitudinal way, sampling considerations were exploratory and partly guided by immediate availability of participants. An indicative power analysis is possible using the previous results of Wilcockson and Pothos (2016), who reported an effect size of r = .374 for the association between REsT and alcohol use. Based on this effect size and a target power of .90, we estimate a sample of approximately 55, using G*Power (Erdfelder, Faul, & Buchner, 1996). We recruited 66 undergraduate psychology students (59 females, 7 males) who participated in the study for course credit [mean age: 18.7 years old (*SD* = 1.6); mean weekly alcohol consumption at baseline (Typical and Atypical Drinking Questionnaire: TAAD: Hogan, et al., 2005): 8.6 units (*SD* = 11.8); mean score on the Alcohol Use Disorders Identification Test (AUDIT: Babor, de la Fuente, Saunders, & Grant, 1992): 8.3 (*SD* = 5.9)]. There were no eligibility or inclusion criteria, and participants were recruited irrespective of whether they were light or heavy drinkers or nondrinkers. Of the 66 participants tested at baseline, a subsample of 19 completed the follow-up assessment either three months [*N*: 10; mean age: 18.9 years (*SD* = .57); TAAD: 5.8 (*SD* = 5.2); AUDIT: 7.9 (*SD* = 6.9)] or two years [N: 9; mean age: 20.3 years (*SD* = .71); TAAD: 5.1 (*SD* = 6.4); AUDIT: 6.4 (*SD* = 5.8)] after completing the initial phase of the study. The remaining participants either did not respond to our request to complete the follow-up assessment, or they indicated during the baseline assessment that they did not wish to be involved in the follow-up. To avoid accidentally priming participants about the study's hypotheses, recruitment was conducted without knowledge of everyone's alcohol usage. Only after the REsT were participants required to report their alcohol usage. Participants were led to believe that they were taking part in a reading task; however, they were fully debriefed at the end of the study. Nevertheless, participants who took part in the follow-up may have been more aware of the alcohol-related nature of the study.

Materials and procedure

All materials were presented to the participants using Qualtrics (www.qualtrics.com). They were instructed to use a computer and not a smart phone or a tablet. A list of 60 words was created (from Fadardi, 2003), and each word appeared on the computer screen for four seconds. The timing of stimulus presentation has typically been found to be accurate (see Semmelmann & Weigelt, 2017) with different hardware used by the different participants having little-to-no effect (see Reimers & Stewart, 2015). Semmelmann and Weigelt (2017) observed that presentation timing accuracy may vary between different web users by approximately 6ms, so the presentation time of 4 seconds used in our study should be relatively consistent between participants and any variation due to hardware/ web browsers should not have any notable influence on results. Three word categories (20 words each) were used: alcohol-related words (e.g., beer, vodka); neutral words, each of which belonged to a particular category (clothing, e.g., necktie, shirt); and neutral unrelated words (e.g., carpet, invitation). The category of clothing-related words was included in order to have a category of control words that were semantically related to one another, like the alcohol words were (because semantic relatedness can increase the degree of cognitive bias, e.g., Warren, 1972). The unrelated control stimuli were included as a filler category in order to increase the perceived *randomness* of the words in the list. Most of the stimuli in the three categories were commonly used, concrete nouns. The words in each category were matched in terms of mean word length and mean number of syllables. The order in which the words were presented was randomized. Participants were simply asked to read each word aloud, without any other instructions being given. After the word lists had been presented, participants were asked to indicate the percentage of words that were alcohol-related, clothing-related, or neutral. Finally, participants completed the Alcohol Use Disorders Identification Test (AUDIT: Babor, de la Fuente, Saunders, & Grant, 1992) and the Typical and Atypical Drinking Questionnaire (TAAD: Hogan, et al., 2005). Total scores on the AUDIT indicate the likelihood that the respondent is an excessive drinker. Scores on the TAAD indicate the amount of alcohol that respondents drink on typical and atypical drinking occasions.

At the end of the testing session, participants were asked to indicate whether they would be willing to participate in a follow-up assessment at a later date. Of the participants who indicated that they would like to participate, half were invited via email to complete the same online procedure again after three months, whereas the other half were invited by email to participate in the follow-up two years later. These delay periods were chosen as we were unsure whether knowledge of the task (i.e. the percentage estimation) would influence the results. Plausibly, participants tested after three months delay may recall that they would be required to estimate percentages of word categories, so they may have approached the task differently. However, we felt that after two years the participants may have forgotten the key percentage estimation aspect of the study. Therefore, these time delays were chosen because we thought they represented the minimum delay which might be necessary to avoid repetition effects and the maximum delay possible where we still could contact the student participants before they graduated. The follow-up participants completed the full procedure on a second occasion, including taking the REsT, AUDIT, and TAAD.

Data scoring

The correct percentage of responses for each word category was 33%. The REsT score was the reported percentage for alcohol words minus those for the two other word categories. For example, if a participant reported that there were 30% clothing words, 40% alcohol words and 30% neutral words, then their REsT score would be 40-(30+30)=-20. Therefore, participants who were able to process the frequency the information accurately would have REsT scores of -33; in addition, the more positive the REsT score, the more the bias to overestimate the frequency of alcohol-related words in the list. This is an appropriate dependent variable, as opposed, for example, to only the estimate produced for the alcohol stimuli, because it correctly controls for situations in which participants systematically underestimate or overestimate the percentage of words in all categories.

Results

We aimed to investigate whether scores on the online REsT were associated with participants' alcohol use in order to determine whether the online REsT is a suitable measure of cognitive bias, at least as far as group level conclusions are concerned. A significant positive correlation was found between participants' word-frequency estimates on the REsT and their self-reported alcohol use on the TAAD, $r(64) = .428$, $p < .0005$, and a significant positive correlation was found between REsT scores and AUDIT scores, $r(64) = .426$, $p < .0005$. This outcome confirms the utility of the online REsT as a group-level measure of cognitive bias.

Our second aim was to determine whether the REsT would predict future alcohol use. Because we used two different lengths of delay, we next determined whether there were significant differences between the two length-of-delay groups in their REsT scores. A 2 (REsT: baseline, follow-up) x 2 (follow-up duration: 3 months, 2 years) mixed-measures ANOVA was conducted, with follow-up duration as the between-participants factor and REsT (baseline, follow-up) as the within-participants factor. There was no significant main effect for the two points in time at which the REsT was administered, $F(1,17) = .367$, $p = .553$), nor a main effect for the duration of the follow-up assessment, $F(1,17) = 1.85$, $p = .192$. Neither was there a significant interaction, $F(1,17) = 2.22$, $p = .154$. Therefore, the two follow-up conditions are collapsed in order to determine whether a follow-up effect would be obtained with the increase in power (see *post-hoc* power analysis below regarding the follow-up).

We next determined whether the baseline scores on the REsT were correlated with the follow-up REsT scores collapsed across the two follow-ups. Baseline REsT scores were found to be associated with future alcohol consumption as measured by the TAAD, $r(17) = .537$, $p = .018$; see Figure 1. Note, there has been criticism of the use of power analysis in a *post hoc* manner as presently, e.g., O'Keefe (2007), so the present power analyses are included only for illustration. A *post-hoc* power analysis of the effect size based on the observed sample effect size for the association between REsT and TAAD ($r = .537$) using G*Power with a target power of .90 indicated that the current sample size (N=19) was sufficient (actual power = .91), but with 95% confidence intervals of .18 - .76. However, within the

entire sample, alcohol use did not differ between baseline and follow-up, $t(18) = 1.281$, $p = .217$. Further, baseline REsT scores correlated with the REsT score after the delay, $r(17) = .611$, $p = .005$; see Figure 2. Note again that a *post-hoc* power analysis indicated that the sample size was adequate (actual power = .90), but with 95% confidence intervals of .31 - .85. These findings demonstrate, therefore, that group-level performance on the REsT predicts both future alcohol consumption and future performance on the REsT.

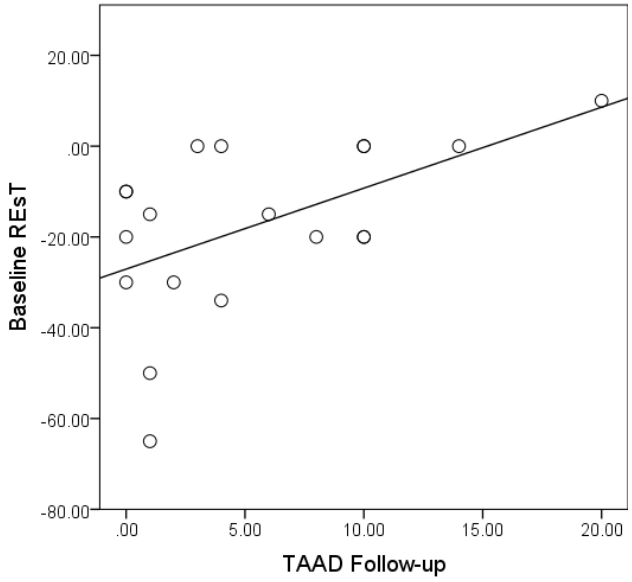

Figure 1. The relationship between baseline REsT scores and self-reported alcohol use (TAAD) at follow-up. A subset of 19 participants completed the follow-up either three months later ($N = 10$) or two years later ($N = 9$).

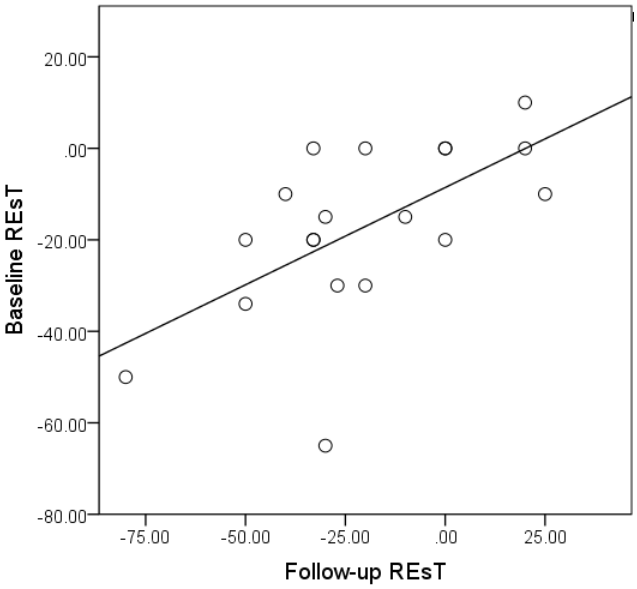

Figure 2. Relationship between baseline and follow-up REsT scores. A subset of 19 participants completed the follow-up either three months later ($N = 10$) or two years later ($N = 9$).

Discussion

Tasks that measure attentional and other kinds of cognitive bias have been shown to predict relapse (e.g., Cox, et al., 2006). Our aims in the present study were to determine (a) the feasibility of using an online administration a cognitive bias task and (b) whether this task would predict future alcohol use.

First, we confirmed that the online REsT could be used as a measure of alcohol-related cognitive bias. This has important implications in that the online REsT is much easier to administer than traditional attentional bias tasks. The REsT, therefore, has considerable potential for measuring cognitive biases for research purposes.

Second, the results indicate that the REsT is a useful measure for predicting group-level future alcohol use. The REsT scores predicted both future performance on the REsT and alcohol use, regardless of the length of the follow-up period. The results suggest that a simple reading exercise could potentially be used in any setting, where it might have the potential for predicting future drinking behavior and perhaps even the likelihood of relapse (cf. Cox, et al., 2006).

Third, this study has in general implications for substance abuse and cognitive bias. It would appear that sustained high alcohol use can lead to an impression of an environment becoming increasingly populated with alcohol-related stimuli (cf. Tiffany, 1990). Cognitive biases have been found to contribute to subjective craving and substance-seeking behavior (see Field & Cox, 2008). People who have developed a cognitive bias for substance-related stimuli are likely at increased risk of experiencing craving and subsequent substance seeking when they are confronted with substance-related stimuli (Field & Cox, 2008). Therefore, if an environment becomes increasingly associated with alcohol, and attentional bias can lead to substance seeking, then, as alcohol use continues, there will be an increasing number of automatic cues which could lead to drinking (see Wilcockson & Pothos, 2016). The results of the current study underscore the robust and intransient nature of substance-related attentional bias (cf. Wilcockson, Pothos, & Parrott, 2019). In this case, alcohol users who develop an alcohol-related attentional bias might be at risk of developing alcohol problems in the future. However, further research is needed to test this hypothesis.

This research has demonstrated that the REsT is a useful tool for measuring cognitive bias in a research capacity because of its ease of administration in terms of both simplicity and the demonstration of its online utility. The ability to measure cognitive biases online would be of great benefit to researchers as it allows a greater scope for data collection. Further, it was shown that the REsT appears to be stable over time. Therefore, it might eventually be used as a clinical tool for monitoring treatment-seeking substance abusers' progress. However, the present study is the first step in demonstrating the

potential utility of the REsT as a clinical tool and an important next step will be to repeat this study on a clinical sample and see whether REsT performance is potentially able to predict treatment adherence.

The utility of the REsT as a research tool is hampered by some important potential limitations. Indeed, although we have demonstrated that REsT performance is stable over time, there are potential issues regarding its ability to be used as a repeated measure. If patients/participants become aware that the proportion of alcohol terms is always the same, the test will have limited utility. Further, the task has been demonstrated online, which we feel demonstrates the task can be utilized outside of the laboratory, however, an actual test of this assertion would be to compare results in and out of the laboratory to see if the scores are consistent. Also relevant is the issue of whether the results are the same when participants have recently consumed alcohol versus when they are abstinent. These are important considerations which will need to be taken into account when using the REsT in future research studies.

In summary, the present study suggests the REsT could be administered over the Internet. This useful finding may now enable researchers to examine cognitive biases without the need for time-consuming laboratory-based testing. In short, the results reported here would seem to have implications for the assessment of alcohol-related cognitive biases in research and also eventually in clinical settings. However, more research is required to truly ascertain whether the REsT can be utilized in clinical settings.

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