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Spatial anticipatory attentional bias for alcohol: A preliminary report on reliability and associations with risky drinking

Przestrzenna antycypacyjna tendencyjność uwagi dotycząca alkoholu. Wstępne doniesienie na temat rzetelności pomiaru i związku z ryzykownym piciem

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Abstract

Introduction: Although risky drinking and alcohol dependence have been associated with spatial attentional biases, concerns have been raised about the reliability of the frequently-used dot-probe task. A form of anticipatory bias related to predictive cues has been found to be related to alcohol-related processes, and to have high reliability in the context of threat stimuli. It remains to be determined whether this anticipatory attentional bias also has good reliability for alcohol stimuli. Further, correlations with drinking-related individual differences need to be replicated.

Material and methods: Eighty three healthy adult participants were included, who completed the cued Visual Probe Task (cVPT) and questionnaires on risky drinking (AUDIT-C), drinking motives (DMQ-R), reasons to abstain from drink-

Streszczenie

Wprowadzenie: Chociaż badania potwierdzają związek ryzykownego picia i uzależnienia z przestrzenną tendencyjnością uwagi, to jednak pojawiły się obawy co do rzetelności często stosowanego zadania na lokalizację punktu (*dot-probe task*). Stwierdzono, że antycypacyjna tendencyjność uwagi w odpowiedzi na bodźce predyktywne wiąże się z procesami alkoholowymi i odznacza wysoką rzetelnością w przypadku sygnałów o charakterze zagrażającym. Trzeba jednak ustalić, czy antycypacyjna tendencyjność uwagi charakteryzuje się dobrą rzetelnością również w odniesieniu do bodźców alkoholowych. W tym kontekście istnieje potrzeba ponownego zbadania korelacji antycypacyjnej tendencyjności uwagi z indywidualnymi różnicami w charakterystykach picia.

Materiał i metody: Do badania włączono 83 zdrowych dorosłych uczestników, którzy wykonali zmo-

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ing (RALD) and alcohol craving (ACQ). The task (cVPT) used a 400 ms Cue-Stimulus Interval based on previous work. The Spearman-Brown split-half reliability of reaction time-based bias scores was calculated. The within-subject effect of probe location (predicted-alcohol versus predicted-non-alcohol) was tested using a paired-sample t-test. Correlations were calculated between bias scores and questionnaire scales; tests were one-sided for predicted effects and two-sided for exploratory effects.

Results: The reliability was 0.81 (0.74 after outlier removal). There was no overall bias. While a predicted correlation between risky drinking and anticipatory bias towards alcohol was found, there were no other predicted or exploratory effects.

Discussion: The anticipatory attentional bias for alcohol is a reliably measurable individual difference, with some evidence that it is associated with risky drinking.

Conclusions: Implicit behavioural measures of spatial attentional bias can, in principle, achieve high reliability. Further study of attentional biases using predictive cues would appear to be promising.

Keywords: Dot-probe task, Attentional bias, Anticipatory attentional bias, Alcohol, Reliability, Risky alcohol use

dyfikowaną wersję zadania na lokalizację punktu (cVPT) i wypełnili kwestionariusze dotyczące ryzykownego picia (AUDIT-C), motywów picia (DMQ-R), przyczyn utrzymywania abstynencji (RALD) oraz na temat głodu alkoholowego (ACQ). W cVPT zastosowano 400 ms interwał w prezentacji bodźców. Obliczono rzetelność połówkową Spearmana-Browna dla wyników tendencyjności uwagi opartych na czasie reakcji. Wewnątrzobiektowy efekt lokalizacji bodźca (alkoholowego i niealkoholowego) badano za pomocą testu *t* dla prób zależnych. Obliczono korelacje między wartościami testu tendencyjności a skalami kwestionariuszowymi; zastosowano testy jednostronne dla przewidywanych efektów i dwustronne dla efektów eksploracyjnych.

Wyniki: Rzetelność wyniosła 0,81 (0,74 po usunięciu wartości skrajnych). Nie stwierdzono tendencyjności całkowitej. Potwierdzono natomiast korelację między ryzykownym piciem a tendencyjnością antycypacyjną na bodźce alkoholowe. Nie uzyskano żadnych innych istotnych efektów.

Omówienie: Antycypacyjna tendencyjność uwagi wobec bodźców alkoholowych jest rzetelnie mierzalną indywidualną różnicą; niektóre badania wskazują na jej związek z ryzykownym piciem.

Wnioski: Pośrednie, behawioralne miary przestrzennej tendencyjności uwagi mogą zasadniczo osiągnąć wysoką rzetelność. Dalsze badania tendencyjności uwagi z użyciem bodźców predyktywnych wydają się bardzo obiecujące.

Słowa kluczowe: zadanie na lokalizację punktu, tendencyjność uwagi, antycypacyjna tendencyjność uwagi, alkohol, rzetelność, ryzykowne picie alkoholu

Introduction

The dot-probe task [1, 2] is often used to measure spatial attentional biases. In trials of this task, first two cues are shown from two different categories, such as alcohol versus soft drink, and subsequently probe stimuli are presented at the cue locations. Differences in responses to the probes that depend on cue category at their location suggest that the cues caused a bias in processing; e.g., if one of the cue types tends to capture attention, then responses to probes at its location should be faster. Alcohol-related stimulus have been found to affect spatial attention [3-6]. In individuals reporting heavy social drinking, attention appears to be drawn towards alcohol cues [4, 5], as would be expected given theory on incentive salience [7, 8]. However, complex, time-dependent patterns have been found in dependence, with a shift from initial orienting to attentional disengagement [6, 9, 10].

Further, a problem with the dot-probe task is that it has been found to have low reliability in a number of studies [11-19]. This would seem to pose a serious threat to at least some forms of attentional bias research using behavioural measures. If the current literature is taken to imply that any behavioural measure of attentional bias is unacceptably likely to be noisy, this could lead to

a shift to interesting but expensive and less widely accessible psychophysiological methods. It is essential to ask whether this shift is truly necessary and whether it is justified to consider behavioural measures as inherently problematic [20].

One alternative approach is to explore novel versions of the dot-probe task: perhaps a reliable behavioural measure is possible but not yet known. One such task variant was suggested by the R3 model – the Reprocessing and Reinforcement model of Reflectivity [21, 22]. In this model, automatic attentional biases can occur due to the predicted outcomes of attentional shifts (note that "prediction" here is conceived of as a low-level, underlying process caused by prior reinforcement learning rather than an effortful attempt to make a prediction about the future). For example, if an individual believes that something scary is lurking behind a door, the anticipation of what could happen on opening the door will affect their attention towards it. Or, if there might be something tasty out of sight in a cupboard, the predicted outcome of finding a treat might involuntarily affect attention. It thus seems that attentional biases could occur in response to information on what is likely to happen if attention is directed to one location or another: will something attractive or aversive appear at that location? And could that kind of prediction of outcome automatically affect attentional shifts? A cued version of the dot-probe task, termed the cued Visual Probe Task, cVPT [23], was developed to measure such anticipatory or outcome-related effects. In this task, instead of presenting emotional cues intended to evoke an automatic stimulus-driven response, two visually neutral predictive cues are presented at the start of each trial. On one half of the trials, the predictive cues are replaced by affective stimuli, one cue always being replaced by a stimulus from one category (e.g., alcohol or threat) and the other by a stimulus from another category (e.g., water or safe). On the other half of the trials, probe stimuli are presented requiring a response; on these trials, no affective stimuli are presented at all. Thus, performance on probes is never influenced by the direct presentation of an emotional stimulus, only by the location of visually neutral cues predicting stimulus categories. Further, it has been found that performing a training version of the cVPT induces an attentional bias to stimuli belonging to the trained predicted categories [24]. This supports the interpretation of effects on the cVPT being due to anticipatory processes. It could be expected that performing the cVPT only involves the visually neutral cues acquiring salience, rather than outcome-related processes. However, this would not be expected to lead to the predicted stimulus categories acquiring a bias following the cVPT-training, rather than just the predictive cues.

In the context of threat-related attentional bias, reliability was found to be improved in the cVPT relative to a usual VPT in which emotional cues were presented before probes [25]. The improved reliability was suggested to be due to the removal or mitigation of noisy influences that could play a role when actually presenting emotional stimuli, such as varying responses to particular exemplars, or potentially complex patterns of multiple cognitive responses to actually presented emotional stimuli. While the anticipatory attentional bias was previously used to study alcohol-related attentional bias and bias variability [23, 26], its reliability has not yet been evaluated for alcohol-related stimuli. Further, the validity of the bias as a reflection of processes related to alcohol and risky drinking requires additional support.

The current study therefore aimed first, to determine the reliability of the anticipatory attentional bias for alcohol and, second, to explore correlations between the anticipatory bias and alcohol-related individual differences.

Material and methods

Participants

The experiment was completed online by an analytical sample of 83 healthy adult participants (75 female, 8 male; age 19.7, *SD* = 2.95). A further 15 participants performed the experiment but were excluded due to inadequate performance (mean accuracy below 0.90) indicating, given the simplicity of the tasks and usual accuracy levels, that these participants were not performing the task as required. Participants gave informed consent, and the study was approved by the institutional ethics committee.

Questionnaires

The following questionnaires were used to assess individual differences related to alcohol use. The 3-item Alcohol Use Disorders Identification

Test – Consumption, AUDIT-C was used to measure hazardous drinking [27-30]. The Drinking Motives Questionnaire Revised, DMQ-R [31] provided measures of Enhancement, Social, Coping, and Conformity motives. The Reasons for Abstaining or Limiting Drinking questionnaire, RALD [32, 33] was used to measure motives to refrain from drinking: Loss of Control, Adverse Consequences, and Convictions. Finally, aspects of craving for alcohol were measured with the Alcohol Craving Questionnaire – Short Form, ACQ [34, 35]: Compulsivity, Expectancy, Purposefulness and Emotionality.

Tasks

The cued Visual Probe Task consisted of 9 blocks of 40 trials, preceded by a training phase of 8 blocks of 40 trials. Trials were divided into Picture and Probe trials.

Probe trials started with the presentation of a central fixation cross for 300, 400 or 500 ms, followed by the presentation of two visually neutral cues: the symbols O O O O O and | | | | |, presented in yellow versus blue. The cues were onscreen for a Cue-Stimulus Interval of 400 ms. The cues were located on alternating diagonals per trial: either on the top-left and bottom-right of the screen, or on the bottom-left and top-right of the screen. Following the cue period, a probe stimulus, >><<, was presented at one of the cue locations, and a distractor stimulus, /\/\ or \/\/, at the other location. The probe stimulus was presented for 1000 ms, or until a response was given if faster than 1000 ms. The task was to quickly and accurately press a key (R, F, I or J) corresponding to the probe location. Errors were followed by a red –1 for incorrect responses, and a red "Too late!" if no response was given, for 200 ms.

On Picture trials, the cues were replaced by pictures presented at the cue locations. One of the cues was always replaced by an alcoholic stimulus (a colour picture of a glass or bottle of an alcoholic beverage) centred on the cue location. The other cue was always replaced by a non-alcoholic stimulus (a colour picture of a non-alcoholic beverage). The mapping of cues to stimulus category was randomized over subjects. The pictures remained onscreen for 1000 ms, followed by 200 ms of empty screen.

Procedure

Participants performed the experiment fully online. They first filled in the questionnaires and subsequently completed the training and assessment phase of the task. For the sake of transparency, we note that participants performed additional tasks and sessions unrelated to the current study.

Preprocessing and statistical analyses

Trials that were likely not to reflect normal task performance were removed and included the first four task trials, trials following an error and the first trial of each block. Of the remaining probe trials, the median reaction time was calculated for the Probe-on-Alcohol and Probe-on-Non-alcohol predictive cue locations. The reliability of the bias, i.e., the median RT for the Alcohol minus Non-alcohol locations, was tested using Spearman-Brown formula for the split-half reliability of the task, which was divided in sets of even and odd numbered blocks. The effect of probe location was tested using paired-sample t-tests, and correlations were tested between questionnaire scores and the individual bias scores. Based on previous results involving the same Cue-Stimulus Interval of 400 ms [26], we could hypothesize an increasing bias towards alcohol (i.e., more negative bias scores) with increasing scores on the AUDIT, ACQ-Compulsivity, ACQ-Expectancy, and RALD-Convictions and therefore used one-sided tests ($p < 0.1$ criterion) for these scales.

Data and software will be made available upon request.

Results

The mean sample scores on the questionnaires are given in Table I. Using cut-offs for risky drinking in a student population [36], the percentage of female participants with an AUDIT-C score of at least 5 was 35%, and the percentage of male participants with an AUDIT-C score of at least 7 was 25%.

The reliability of bias scores was 0.84. Removal of extreme points (z-score > 3 on either the "even" or "odd" bias, $n = 2$) resulted in a reliability of 0.74.

There was no overall probe location effect, with reaction times of 486 ms (SD = 48 ms) for probes on the non-alcohol location and 489 ms (SD = 44 ms) for probes on the alcohol location. Of the a priori expected one-sided relationships with questionnaires, only higher AUDIT scores

Table I. The mean studied sample scores on the questionnaires

Scale	Mean (*SD*)
AUDIT-C	4.30 (2.23)
DMQ-Social	2.94 (0.97)
DMQ-Coping	1.70 (0.79)
DMQ-Enhancement	2.45 (1.03)
DMQ-Conformity	1.52 (0.71)
ACQ-Compulsivity	1.20 (0.58)
ACQ-Expectancy	1.97 (1.04)
ACQ-Purposefulness	4.57 (1.49)
ACQ-Emotionality	1.85 (1.09)

were associated with a bias towards alcohol, $r = -0.22$, $p = 0.050$. There were no other significant correlations.

Discussion

The current results agree with previous studies in two main ways. First, the anticipatory attentional bias for alcohol revealed good split-half reliability. This is of interest in relation to the concern with reliability for the usual dot-probe task [18]. The current task's reliance on only anticipatory attentional processes may aid reliability. Any interfering processes evoked by actual stimulus presentation do not occur on probe trials, and there is no variability due to the immediate presentation of different specific exemplars (although there could of course still be more complex history effects related to the particular sequence of presented stimuli). Any bias must be due to the learned relationship between the simple, non-varying cues and the overall stimulus categories. The diagonalized form of the task may also contribute as neither responses nor stimulus locations were ever immediately repeated, reducing potential trial-to-trial carryover effects.

The availability of a form of spatial attentional bias with good reliability would be of interest when studying correlations between attentional bias and other individual differences, or when the bias is used as a dependent variable in a training study. Further, this finding indicates that the anticipatory bias is a consistent individual difference as individuals systematically differ in the degree to which their attention is affected by predicted outcomes of attentional shifts towards or away from cued locations. The current findings may thus be useful for research aimed at a better understanding of the nature of attentional biases and automaticity, and of the influences of task variations on psychometric properties.

Second, supporting the interpretation of individual differences in the bias in terms of attention to predicted outcome categories and hence the validity of the bias, hazardous drinking was indeed associated with an anticipatory bias towards predicted alcohol location, as in a previous study [26]. However, as other predicted effects were not found and the effect size of the current result was not large and the test would not survive correction for multiple testing, future research should focus on replicating the specific correlation between risky drinking and anticipatory attentional bias. The relatively weak correlation between bias and risky drinking may have been due to the limitation of a low overall level of risky drinking in the current sample. Further research is now necessary in larger samples with a wider range of risky drinking, and in clinical groups compared to control groups. Another important limitation of the current opportunistic sample is the unequal distribution of male and female participants. Future work should consider moderating effects of gender on the relationships between anticipatory bias and alcohol-related individual differences.

Another limitation is the use of only a single Cue-Stimulus Interval of 400 ms. While this was selected based on previous work, it must be acknowledged that the current results are specific to this interval, and longer or shorter durations could well produce different reliabilities and effects due to the role of temporal dynamics in attentional biases [6, 9, 10].

Conclusions

The current results provide further support for the concept and measurability of an anticipatory attentional bias for alcohol. Risky drinking may be related to enhanced salience of predicted alcohol stimuli. More generally, biases can be due to the selection of cognitive responses, such as attentional shifts, based on their predicted outcome; e.g., whether they are likely to focus attention on upcoming salient stimuli. The results also

add to the evidence suggesting that behavioural measures of attentional bias can, in principle, be both reliable and valid, but it may be necessary to use novel variations of tasks and concepts.

Conflict of interest/Konflikt interesów

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Ethics/Etyka

The work described in this article has been carried out in accordance with the Code of Ethics of the World Medical Association (Declaration of Helsinki) on medical research involving human subjects, EU Directive (210/63/EU) on protection of animals used for scientific purposes, Uniform Requirements for manuscripts submitted to biomedical journals and the ethical principles defined in the Farmington Consensus of 1997.

Treści przedstawione w pracy są zgodne z zasadami Deklaracji Helsińskiej odnoszącymi się do badań z udziałem ludzi, dyrektywami UE dotyczącymi ochrony zwierząt używanych do celów naukowych, ujednoliconymi wymaganiami dla czasopism biomedycznych oraz z zasadami etycznymi określonymi w Porozumieniu z Farmington w 1997 roku.

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