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# Associations between the Brief Assessment of Alcohol Demand (BAAD) questionnaire and alcohol use disorder severity in UK samples of student and community drinkers

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ABSTRACT

Value based choice and compulsion theories of addiction offer distinct explanations for the persistence of alcohol use despite harms. Choice theory argues that problematic drinkers ascribe such high value to alcohol that costs are outweighed, whereas compulsion theory argues that problematic drinkers discount costs in decision making. The current study evaluated these predictions by testing whether alcohol use disorder (AUD) symptom severity (indexed by the AUDIT) was more strongly associated with the intensity item (maximum alcohol consumption if free, indexing alcohol value) compared to the breakpoint item (maximum expenditure on a single drink, indexing sensitivity to monetary costs) of the Brief Assessment of Alcohol Demand (BAAD) questionnaire, in student (n = 579) and community (n = 120) drinkers. The community sample showed greater AUD than the student sample ($p = .004$). In both samples, AUD severity correlated with intensity (students, $r = 0.63$; community, $r = 0.47$), but not with breakpoint (students, $r = -0.01$; community, $r = 0.12$). Similarly, multiple regression analyses indicated that AUD severity was independently associated with intensity (student, $\Delta R^2 < 0.20$, $p < .001$; community, $\Delta R^2 = 0.09$, $p = .001$) but not breakpoint (student, $\Delta R^2 = 0.003$, $p = .118$; community $\Delta R^2 = 0.01$, $p = .294$). There was no difference between samples in the strength of these associations. The value ascribed to alcohol may play a more important role in AUD severity than discounting of alcohol-associated costs (compulsivity), and there is no apparent difference between student and community drinkers in the contribution of these two mechanisms.

## 1. Introduction

Modern learning accounts of addiction emphasise two overlapping mechanisms that may underpin individual vulnerability to dependence and explain why drug use persists despite harms. Value-based choice theories emphasise a mechanism whereby dependent individuals ascribe an abnormally high value to the drug such that any drug-associated costs are exceeded, and so drug use persists (Augier et al., 2018; Berkman, Hutcherson, Livingston, Kahn, & Inzlicht, 2017; Field et al., 2019; Hardy, Parker, Hartley, & Hogarth, 2018; Heyman, 2009; Hogarth & Field, 2020; MacKillop, 2016; Rachlin, 1997; Vuchinich and Tucker, 1983). In contrast, certain compulsion-based accounts emphasise a mechanism whereby dependent individuals fail to incorporate drug-associated costs into decision making (i.e. they discount or are insensitive to costs) and thus drug use persists (Belin, Mar, Dalley, Robbins, & Everitt, 2008; Bickel, Johnson, Koffarnus, MacKillop, & Murphy, 2014; Mitchell, 2003). These two mechanisms are hard to fully dissociate experimentally. The purpose of the current study was to evaluate these two positions by testing whether alcohol use disorder (AUD) symptom severity in UK samples of student and community drinkers was more strongly related to alcohol value or cost insensitivity, as indexed by the Brief Assessment of Alcohol Demand (BAAD) questionnaire (Murphy et al., 2019; Owens et al., 2015).

Demand tasks have quantified the relative contribution of drug value

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versus cost insensitivity to dependence. In these tasks, participants report hypothetical consumption of a drug across a range of prices. Three main values are extracted: intensity (maximum consumption at zero or low price), $O_{max}$ (maximum expenditure), and breakpoint (price at which consumption is completely suppressed) (MacKillop, 2016; Zvorsky et al., 2019). Principal component analyses have shown that demand tasks capture a two-factor latent structure, with one factor providing a relatively pure index of drug value under conditions of no or minimal cost and the other factor indexing sensitivity to escalating drug price. The intensity demand metric loads on the value factor, breakpoint on the cost sensitivity factor, and $O_{max}$ partially on both factors (Aston, Farris, MacKillop, & Metrik, 2017; Bidwell, MacKillop, Murphy, Tidey, & Colby, 2012; Higgins et al., 2020; MacKillop et al., 2009).

These three indices of demand correlate with various proxies for AUD, including drinks consumed per week, episodes of heavy drinking, and alcohol-related problems (MacKillop & Murphy, 2007; Murphy & MacKillop, 2006; Murphy, MacKillop, Skidmore, & Pederson, 2009). Although breakpoint sometimes correlates significantly with AUD severity (in support of the compulsion account, e.g. Murphy and MacKillop (2006)), this relationship is not found reliably (MacKillop et al., 2010). Indeed, several reviews of the drug demand literature show that intensity is the strongest correlate of dependence severity, followed by $O_{max}$. Breakpoint is typically the weakest correlate of AUD and is often not significant (Kiselica, Webber, & Bornovalova, 2016; MacKillop, 2016; MacKillop, Jackson, Murphy, & Amlung, 2015; Zvorsky et al., 2019). These findings support the value-based choice theory of addiction over compulsion accounts.

By contrast, the strongest evidence for a compulsion account of addiction comes from animal models. Specifically, rodents that are vulnerable to dependence (i.e. show impulsive behaviour in another assay or have received extended drug access) show weaker suppression of drug self-administration by shock punishment compared to controls (Belin et al., 2008; Economidou, Pelloux, Robbins, Dalley, & Everitt, 2009; Pelloux, Everitt, & Dickinson, 2007; Pelloux, Murray, & Everitt, 2015; Vanderschuren & Everitt, 2004). One interpretation is that vulnerable rats discount (are insensitive to) drug-associated costs, and so persist with self-administration in a compulsive manner. However, weaker suppression might also be due to supernormal drug value exceeding costs. This value-based interpretation could be rejected if animals show weaker shock suppression but not greater drug value in a separate assay (i.e. if suppression and valuation assays are dissociated). However, a review by Hogarth (2020) found that, of 15 studies which tested the association between suppression and drug valuation, only four reported such a dissociation. The remaining 11 studies reported associations suggesting that insensitivity to shock suppression can be explained by greater drug valuation, rather than a specific propensity to discount costs.

Human concurrent choice studies have also quantified the relative contribution of drug valuation and insensitivity to costs to dependence severity. One study (Hogarth & Hardy, 2018) found that while students with greater severity of AUD symptoms showed greater valuation of alcohol (indexed by preferential alcohol versus food choice in a concurrent choice task), they were not any less sensitive to delay or opportunity costs imposed on alcohol compared to individuals with lesser severity of symptoms. Three other human concurrent choice studies have confirmed that dependence severity is associated with greater drug choice, but not with reduced sensitivity to the suppressive effects of costs imposed on the drug (Cassidy, Tidey, Kahler, Wray, & Colby, 2015; Hogarth & Chase, 2012; Strickland et al., 2018).

By contrast, two studies have used imagined next-day responsibilities to test the impact of more ecologically valid future costs on alcohol demand. Murphy et al. (2014) found no difference between individuals with and without a family history of AUD in alcohol demand at baseline, i.e. no group difference in alcohol value. However, the family history group were less sensitive to the suppressive effects of imagined next day responsibilities on alcohol demand, suggesting selective insensitivity to costs and supporting the compulsion account. Relatedly, Joyner et al. (2019) found that, in undergraduate drinkers, alcohol-related problems were uniquely associated with greater alcohol demand in a next-day responsibility condition when controlling for demand in a no-responsibility condition, again suggesting a selective insensitivity to costs. In sum, both choice and demand tasks, using different cost manipulations, have found consistent evidence for alcohol value as a correlate of dependence severity. By contrast, evidence for cost insensitivity has been mixed.

As noted, demand tasks can distinguish between choice and compulsion accounts of addiction. However, such tasks are limited in being time-consuming and effortful for participants, and requiring complex statistical analysis to extract component scores (Owens et al., 2015). Area under the curve analysis (Amlung et al., 2015) simplifies the pre-processing steps thus increasing accessibility, but produces a single metric which does not distinguish between value and cost insensitivity factors. The Brief Assessment of Alcohol Demand (BAAD) questionnaire solves both completion time and analytical complexity problems by containing just three items. Participants report their maximum alcohol consumption when free (intensity), maximum expenditure in a session ($O_{max}$), and maximum price for a single drink (breakpoint), arguably capturing the same value and cost insensitivity constructs as in a full demand task (Owens et al., 2015). The BAAD, or variants thereof, have been validated in two studies. Owens et al. (2015) demonstrated that scores on each of the three items of the BAAD increased following the presentation of alcohol cues, and correlated with alcohol craving in 84 heavy drinkers. Murphy et al. (2019) adapted the BAAD for cigarette use (the Brief Assessment of Cigarette Demand: BACD) and demonstrated that scores on the three items correlated with metrics from the full cigarette demand task, and with nicotine dependence severity, in both adolescent and adult smokers. Intensity items from both the BACD and full demand task were the strongest correlates of nicotine dependence. However, no study to our knowledge has examined relationships between items of the alcohol BAAD questionnaire and alcohol dependence severity, to test predictions of the value based choice account of addiction.

The aim of the present study was to test choice and compulsion theories of AUD using the BAAD questionnaire. If the intensity item is the strongest independent associate of AUD, this would corroborate the full demand measures reviewed above. We recruited two samples: a UK sample of students who reported drinking in the last month ($n = 579$) and a more dependent sample of adult community drinkers recruited from pubs during the daytime ($n = 120$). Cost insensitivity might underpin alcohol use only in greater AUD severity (Luijten, 2020), and so these samples were recruited to test the possibility that breakpoint (cost insensitivity) might be more strongly associated with AUD in a more dependent community sample. The two samples were first compared on the BAAD to determine differences in intensity, $O_{max}$, and breakpoint scores. Choice theory predicts the samples should be differentiated by intensity (alcohol value), whereas compulsion theory predicts they should be differentiated by breakpoint (insensitivity to costs imposed on alcohol). Second, the continuous measure of AUD symptom severity indexed by the Alcohol Use Disorders Identification Test (AUDIT) (Babor, Higgins-Biddle, Saunders, & Monteiro, 2001) was correlated with BAAD items within each sample, and the individual contribution of each BAAD item quantified via multiple regression. Choice theory predicts that dependence severity should be most strongly correlated with intensity, whereas compulsion theory predicts dependence severity should be most strongly associated with breakpoint. Finally, the strength of these associations was compared between the student and community samples to test whether choice and compulsion mechanisms differentially contribute to dependence in these two samples. The finding that dependence is most strongly associated with intensity relative to breakpoint would be consistent with findings using the BACD (Murphy et al., 2019) and full demand tasks (Kiselica et al., 2016; MacKillop, 2016; Zvorsky et al., 2019) and would support value-based choice over

compulsion accounts of addiction. In Supplementary materials, analyses are replicated with the two subscales of the AUDIT (AUDIT consumption and AUDIT consequences) (Doyle, Donovan, & Kivlahan, 2007), since these subscales may be differentially associated with choice versus compulsion mechanisms underpinning AUD.

## 2. Method

### 2.1. Participants

The student sample included 579 students (42.3% male), all of whom reported drinking in the last month, recruited at the University of Exeter in the UK. All procedures were undertaken in a lab setting at the university. The community sample included 120 adults (60% male) recruited from Exeter pubs between the hours of 1 and 8 pm. Participants who reported being 'very intoxicated' were not invited to participate. Participants were tested at an individual table in the pub with the laptop screen facing the wall to preserve privacy and confidentiality. Ethical approval was obtained from the University of Exeter research ethics committee and all participants provided written informed consent.

## 3. Assessments

Data were collated across a number of experiments and in all cases questionnaires were delivered at baseline and followed the same order. Demographic measures (age and gender) were collected. AUD severity was assessed using the ten-item Alcohol Use Disorders Identification Test (AUDIT) (Babor et al., 2001). The AUDIT total score ranges from 0 to 40, and can be divided into categories: low-risk (0–7), hazardous (8–15), harmful (16–19) and possibly dependent (20–40). Cronbach's alpha for the AUDIT was 0.78 in the student and 0.81 in the community sample. The AUDIT has two subscales, measuring alcohol consumption and alcohol-related consequences (Doyle et al., 2007). Value and cost insensitivity constructs were measured with the Brief Assessment of Alcohol Demand (BAAD) questionnaire (Owens et al., 2015). The BAAD has three items. The first item indexes intensity of demand ('If drinks were free, how many would you have in a single session?'), with possible responses ranging from 0 to 10 + drinks in increments of 1. The second item indexes $O_{max}$ ('What is the maximum total amount you would spend on drinks for yourself in a single session?'), with responses ranging from £0 to £40 in £4 increments. The final item indexes breakpoint ('What is the maximum you would pay for a single drink?') with responses ranging from £0 to £20 in £2 increments.

## 4. Results

### 4.1. Participant characteristics

Following Murphy et al. (2019), participants who demonstrated low effort on the BAAD (reporting a higher spend on a single drink than all drinks in total) were excluded. This excluded 13 student and 3 community drinkers. Cases with values 1.5 times the interquartile range on the four measures (AUDIT score, and the three BAAD items) were also excluded (student sample: AUDIT n = 3, BAAD breakpoint n = 5; community sample: AUDIT n = 2, BAAD breakpoint n = 5) leaving respective samples of 558 and 110 for analysis (Draper & John, 1981). Of the community sample, 83.6% were tested between 3 pm and 7 pm. There was no significant correlation between the time of data collection and AUDIT total score ($r = -0.15$, $p = .131$) or AUDIT consequences subscale ($r = -0.09$, $p = .351$), but there was a significant negative correlation with the AUDIT consumption subscale ($r = -0.28, p = .003$), indicating lower alcohol consumption scores in those tested later in the day. Table 1 shows characteristics for the two samples. Compared to the student sample, the community sample had a significantly higher mean total AUDIT score (and a greater proportion reached the threshold for possible dependence), were older, reported greater BAAD intensity, and $O_{max}$, and reported lower scores on BAAD breakpoint. The community sample also had significantly higher scores on the consumption subscale of the AUDIT.

**Table 1**
Participant characteristics and statistics contrasting the two samples. Scores are means (SD and range), contrasted between samples by a Welch's T test to accommodate unequal variance. The exception is the four percentage scores, which describe the proportion of each sample that fall into each of the AUDIT severity categories. The proportion falling into each category (versus falling into any other category) were compared between samples using chi-square, and p values reported. Significant test statistics are highlighted in bold.

| | *M* (SD, range) | | $t/\chi^2; p$ |
|---|---|---|---|
| | Student (n = 558) | Community (n = 110) | |
| Age (years) | 21.26 (3.45, 18–54) | 29.15 (11.82, 18–78) | **48.22; <0.001** |
| BAAD Intensity | 5.63 (2.51, 0–10) | 6.32 (2.46, 0–10) | **7.15; 0.008** |
| BAAD $O_{max}$ | 20.03 (8.89, 0–40) | 25.96 (9.75, 0–40) | **35.05; <0.001** |
| BAAD Breakpoint | 6.87 (3.36, 0–20) | 6.07 (3.10, 0–20) | **5.97; 0.016** |
| AUDIT total | 11.00 (5.84, 0–29) | 13.10 (6.97, 0–29) | **8.80; 0.004** |
| Low-risk | 29% | 25% | 1.06; 0.304 |
| Hazardous | 48% | 39% | 3.19; 0.074 |
| Harmful | 15% | 13% | 0.24; 0.623 |
| Possible dependence | 8% | 24% | **25.18; <0.001** |
| AUDIT consumption subscale | 5.75 (2.38, 0–11) | 6.82 (2.28, 0–12) | **19.91; <0.001** |
| AUDIT consequences subscale | 5.25 (4.20, 0–21) | 6.28 (5.42, 0–21) | 3.59; 0.060 |

### 4.2. Data analysis

Spearman's rank order correlations tested the relationship between BAAD items and AUD severity (AUDIT) as these variables were non-normally distributed. Multiple linear regression was used to identify independent associations between BAAD items and AUDIT, and general linear models (GLM) to compare the strength of these associations between samples. These methods are considered robust to non-normality (Blanca, Alarcón, Arnau, Bono, & Bendayan, 2017; Schmidt & Finan, 2018). Tests of homoscedasticity and collinearity confirmed that assumptions of GLM were met.

## 5. Correlations between BAAD items and AUDIT scores

The correlation matrix relating total AUDIT score to BAAD items for both samples is shown in Table 2, and key scatterplots in Fig. 1. AUDIT score was most strongly correlated with BAAD intensity, followed by $O_{max}$, and was not correlated significantly with breakpoint in either sample. Within the BAAD items, intensity did not correlate with breakpoint, supporting the claim that these two items index dissociable constructs (value and cost insensitivity, respectively). However, $O_{max}$ correlated with the intensity measure in both samples and breakpoint in the student sample, supporting the claim that $O_{max}$ measures both drug value and cost insensitivity.

## 6. Multiple regression

Multiple regression was used to determine the extent to which each of the three BAAD items were independently associated with AUDIT scores. Partial $R^2$ was calculated to quantify the unique variance accounted for by each predictor in the overall model. In the student sample, 37% of the AUDIT score was predicted by the three BAAD items,

**Table 2**
Spearman's rank order correlation matrix between BAAD items and AUD severity indexed by total AUDIT score, in student (n = 558) and community (n = 110) samples. ** Significant at 0.01 * significant at 0.05.

| | AUDIT score | | BAAD Intensity | | BAAD $O_{max}$ | |
|---|---|---|---|---|---|---|
| | Student | Community | Student | Community | Student | Community |
| BAAD intensity | 0.63** | 0.47** | | | | |
| BAAD $O_{max}$ | 0.39** | 0.37** | 0.46** | 0.53** | | |
| BAAD breakpoint | −0.01 | 0.12 | −0.04 | 0.03 | 0.40** | 0.17 |

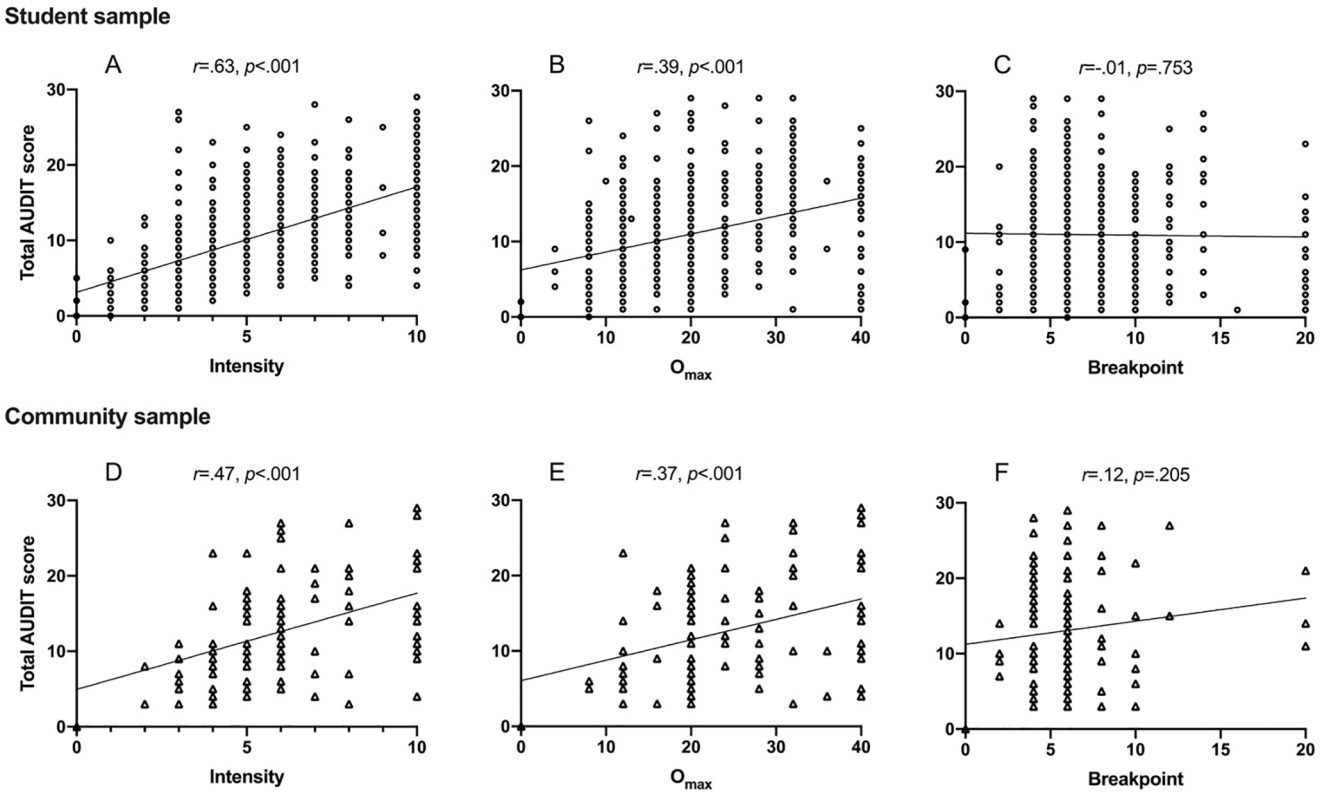


**Fig. 1.** Scatterplots and regression slopes relating AUDIT scores with the three BAAD items (intensity, $O_{max}$ and breakpoint) in the student (A–C) and community (D–F) samples. Spearman's rank order correlation statistics are shown. GLMs indicated that the slopes did not differ between student and community samples.

$R^2 = 0.37$, $F(3,554) = 109.15$. $p < .001$. Intensity emerged as the strongest independent predictor, $\Delta R^2 = 0.20$, $t(554) = 13.30$, $\beta = 0.53$, $p < .001$, followed by $O_{max}$, $\Delta R^2 = 0.01$, $t(554) = 3.09$, $\beta = 0.14$, $p = .002$. Breakpoint was not a significant predictor, $\Delta R^2 = 0.003$, $t(554) = -1.57$, $\beta = -0.06$, $p = .118$. In the community sample, 24% of the AUDIT score was predicted by the three BAAD items, $R^2 = 0.24$, $F(3,105) = 10.74$. $p < .001$. Again, intensity emerged as the strongest independent predictor, $\Delta R^2 = 0.09$, $t(105) = 3.49$, $\beta = 0.36$, $p = .001$), but AUDIT score was not predicted by either $O_{max}$, $\Delta R^2 = 0.02$, $t(105) = 1.58$, $\beta = 0.16$, $p = .118$, or breakpoint, $\Delta R^2 = 0.01$, $t(105) = 1.06$, $\beta = 0.09$, $p = .294$.

## 7. Comparison of correlations between the student and community sample

General linear models (GLMs) were undertaken to test whether student and community samples differed with respect to the correlations (slopes) relating AUDIT score to the three BAAD items (see Fig. 1). AUDIT score was entered as the dependent variable, group (student/community) as a between subjects variable, and one of the three BAAD items as a continuous predictor variable. In all three GLMs, there was no significant two-way interaction, indicating that the relationship between AUDIT score (indexing AUD severity) and the BAAD items did not differ between student and community samples: intensity, $F(1,663) = 0.33$, $p = .567$, $\eta_p^2 < 0.001$; $O_{max}$, $F(1,664) = 0.29$, $p = .589$, $\eta_p^2 < 0.001$; breakpoint, $F(1,664) = 2.70$, $p = .101$, $\eta_p^2 = 0.004$. Value-based choice and compulsion therefore do not appear to contribute to dependence differentially between the two samples. Supplementary materials provide a breakdown of these associations with the consumption and consequences subscales of the AUDIT, which mirror the results above with total AUDIT score.

## 8. Discussion

The present study sought to test the relative contribution of value-based choice versus compulsion processes to addiction by examining whether AUD severity in student and community samples was more strongly associated with the intensity versus breakpoint item of the Brief Assessment of Alcohol Demand (BAAD) questionnaire. Results showed that, compared to the student sample, the more dependent community sample reported greater intensity and lower breakpoint scores, suggesting that alcohol value may represent a more important process in AUD than cost insensitivity. Continuous variation in AUD severity indexed by AUDIT scores was independently associated with intensity but not with breakpoint in multiple regression in both samples, and there was no difference in these slopes between the two samples. These

findings reaffirm the importance of alcohol value to AUD compared to cost insensitivity, and suggest that the relative contribution of these two mechanisms may not vary across samples of differing dependence severity. Finally, the $O_{max}$ score of the BAAD showed intermediate associations with AUDIT, falling between intensity and breakpoint items, consistent with $O_{max}$ indexing both alcohol value and cost insensitivity.

The superiority of drug value over cost insensitivity in its association with dependence severity, demonstrated here using the BAAD measure, has also been reliably obtained with full demand and concurrent choice measures, confirming the generality of these relationships. First, four reviews of full demand tasks have shown that intensity and $O_{max}$ emerge as the stronger correlates of drinking behaviour compared to breakpoint (Kiselica et al., 2016; MacKillop, 2016; MacKillop et al., 2015; Zvorsky et al., 2019), with intensity typically superior to $O_{max}$, as was the case in our findings (Kiselica et al., 2016; Zvorsky et al., 2019). Similarly, in a smoking version of the BAAD (the BACD) completed by community smokers, Murphy et al. (2019) found a significant association between nicotine dependence and intensity, but not $O_{max}$ or breakpoint. Secondly, in concurrent choice tasks, dependence severity has been found to be associated with percent choice of the drug reward (indexing relative drug value) (Hardy & Hogarth, 2017; Hardy et al., 2018) but not with insensitivity to costs imposed on the drug choice (Cassidy et al., 2015; Hogarth & Chase, 2012; Hogarth & Hardy, 2018; Strickland et al., 2018). Finally, in animal models, persistence of drug self-administration under shock punishment can be explained by excessive valuation of the drug rather than a specific propensity to cost discounting (Hogarth, 2020). This converging evidence bolsters support for the choice over compulsion account of addiction. On this view, addiction is primarily due to excessive value ascribed to the drug (Bickel et al., 2014; MacKillop, 2016), outweighing associated costs such that drug use persists despite harms (Heyman, 2013).

Our critique of compulsion theory might be challenged on the grounds that breakpoint may perform less well in its association with dependence simply because this item has more error variance than intensity (i.e. it has poorer psychometric properties), rather than because cost insensitivity does not contribute to dependence. For example, error variance in breakpoint (maximum spend on a single drink) might be increased by variation in disposable income between participants, masking differences in cost insensitivity. One limitation of the present study is that participants' disposable income was not recorded, and therefore we could not test this possibility. In the present study, some evidence for the validity of the breakpoint item comes from the intercorrelations between BAAD items (shown in Table 2). Specifically, intensity and breakpoint were not correlated, suggesting they index different constructs, value and cost insensitivity respectively, but $O_{max}$ did correlate with both intensity and breakpoint, suggesting $O_{max}$ measures both constructs. This pattern of correlations supports theoretical claims about the underlying constructs measured by the BAAD (Owens et al., 2015), specifically that breakpoint measures a distinct cost sensitivity trait. However, substantial further work is required to support this claim. Only one study has tested whether the cigarette version of the BAAD (the BACD) is associated with a full demand task (Murphy et al., 2019) and no study has tested correlations between the BAAD itself and a full alcohol demand task. In addition, no study has examined the test re-test reliability of the BAAD to determine whether it indexes stable traits. Finally, no study has tested whether the breakpoint item is associated with another assay of cost insensitivity. For example, breakpoint might correlate with insensitivity to delay, financial, or opportunity costs imposed on alcohol in a concurrent choice task (Hogarth & Hardy, 2018) or insensitivity to next day responsibilities in demand tasks (Murphy et al., 2014). Such work would complement validation of full alcohol demand tasks (Acuff & Murphy, 2017). In sum, to strengthen our current critique of compulsion theory, the BAAD breakpoint item needs to be validated as accurately measuring a stable, cost insensitivity trait.

A more immutable concern with the BAAD is whether self-report is an appropriate method to capture cost insensitivity. It is unclear whether individuals are able to accurately introspect the extent to which they would persist in drug use under rising costs (i.e. breakpoint), especially since this behaviour may be at odds with reported intentions (Bickel et al., 2014). A second related concern is that the only form of cost manipulated in the BAAD (and purchase tasks more generally) is the monetary price of the drug. A number of studies have demonstrated that dependence vulnerability is associated with insensitivity to the effect of imagined future costs (such as failure to fulfil next day responsibilities) on drug demand (Acuff, Soltis, & Murphy, 2020; Joyner et al., 2019; Murphy et al., 2014; Teeters & Murphy, 2015). These studies may have detected an association between cost insensitivity and dependence, where the present study did not, because the cost imposed was more ecologically valid, personalised, or framed in the future, or for the technical reason that demand was measured twice, i.e. once in a neutral condition and once in the cost condition. It remains to be seen whether insensitivity to costs is robustly associated with dependence, and the boundary conditions under which such an association occurs. A final, related limitation with the BAAD is that the range of possible values is restricted. The intensity measure is capped at 10 + drinks, $O_{max}$ is capped at a £40 total spend, and breakpoint is capped at a £20 spend on a single drink. It is possible that an association between AUD and cost insensitivity might have been detected if breakpoint allowed a broader range of values. However, given that breakpoint scores averaged between £6-7 maximum spend on a single drink, it does not appear that variation in breakpoint was compressed by a ceiling effect (examination of the scatterplots in Fig. 1C and F confirm this). Nevertheless, Murphy et al. (2019) extended these caps when adapting the BAAD for cigarette use (BACD), and future work with the BAAD might follow this example.

There is a final limitation which weakens our critique of compulsion theory. Although the study recruited two samples with differing severities of dependence, we cannot exclude the possibility that cost insensitivity (breakpoint) might be more pronounced, and explain more variance in dependence severity, in clinically-diagnosed treatment-seeking samples (Burchi, Makris, Lee, Pallanti, & Hollander, 2019), or in users of different drug classes (Sussman et al., 2011). Although 24% of our community sample reached the threshold for possibly dependent use of alcohol (indexed by the AUDIT), the current study needs to be replicated with a clinically-diagnosed dependent sample to provide a stronger test of the role of cost insensitivity (compulsion) in addiction.

## CRediT authorship contribution statement

**Lorna Hardy:** Conceptualization, Investigation, Formal analysis, Writing - original draft. **Alexandra E. Bakou:** Investigation, Writing - review & editing. **Ruichong Shuai:** Investigation, Writing - review & editing. **Samuel F. Acuff:** Writing - review & editing. **James MacKillop:** Writing - review & editing. **Cara M. Murphy:** Writing - review & editing. **James G. Murphy:** Writing - review & editing. **Lee Hogarth:** Conceptualization, Formal analysis, Writing - review & editing, Supervision.

## Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.addbeh.2020.106724.

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