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The Mini Alcohol Craving Experience questionnaire: Development and clinical application

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ABSTRACT

Background: Standardised alcohol craving scales are rarely used outside of research environments despite recognised clinical utility. Scale length is a key barrier to more widespread application. A brief measure of alcohol craving is needed to improve research and treatment of Alcohol Use Disorders (AUDs). Grounded in the Elaborated Intrusion Theory of Desire, the Alcohol Craving Experience (ACE) questionnaire comprises two 11-item self-report scales which assess past-week frequency and maximum strength of alcohol craving. This study aimed to create a brief version of the ACE while maintaining psychometric integrity and clinical utility.

Methods: Patients attending a university hospital alcohol and drug out-patient service for treatment of AUD completed the ACE as part of a questionnaire battery. Three patient samples were utilised: 519 patients with pre-treatment and outcome data; 228 patients with pre-treatment data; and 66 patients who completed the ACE at treatment sessions one and two.

Results: The Frequency scale of the ACE possessed greater clinical utility and predictive validity than the Strength scale. Revision of the Frequency measure produced a 5-item 'Mini Alcohol Craving Experience' (MACE) questionnaire. Satisfactory validity (construct, predictive, concurrent, convergent, and incremental) and reliability (internal and test-retest) was maintained. A one standard deviation increase in pre-treatment MACE score was associated with a 54 percent increase in the odds of patient lapse or dropout.

Conclusions: The MACE provides a brief, theoretically and psychometrically robust measure of alcohol craving suitable for use with AUD populations in time-limited clinical and research settings.

Keywords: Alcohol Use Disorder, Craving, Urge, Measurement, Scale development

INTRODUCTION

Craving is a robust marker of substance dependence severity and is implicated in treatment relapse (Flannery et al. 2003; Law et al. 2016; Yoshimura et al. 2016). The Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5) recently included 'craving, or a strong desire or urge to use a substance' as a diagnostic criterion for Substance Use Disorders (American Psychiatric Association, 2013). Craving was defined as a strong desire to consume a substance that makes it difficult to think of anything else (American Psychiatric Association, 2013; Hasin et al. 2013). Craving interventions feature prominently in psychological treatments, and pharmacotherapies have been developed to target specific craving neuromechanisms (Addolorato et al. 2005; Haass-Koffler et al. 2014). After decades of experimental, clinical, and epidemiological research, accurate measurement of substance craving remains a research priority (Tiffany and Wray 2012; Kavanagh et al. 2013). Historically, craving has been measured by conceptually weak and often unstandardised methods, limiting generalisability and clinical utility (Sayette et al. 2000; Pavlick et al. 2009; Kavanagh et al. 2013). Some standardised scales have been introduced, although uptake within clinical settings has been poor (Pavlick et al. 2009; Tiffany and Wray 2012).

A national survey of U.S. addiction services found 99% considered craving in treatment planning, yet only 5% employed standardised self-report craving measures (Pavlick et al. 2009). The majority opted for single-item or non-standard open ended questions, despite well documented limitations to the reliability of these approaches (Cortina 1993; Hruschka et al. 2004). This may reflect the psychometric and theoretical weaknesses in self-report craving scales (Sayette et al. 2000; Kavanagh et al. 2013) and time burden imposed by scale administration and analysis in busy clinical environments. Alcohol Use Disorders (AUDs) are among the most prevalent Substance Use Disorders, placing a substantial burden upon global

mortality and disease (Connor and Hall 2015; Gowing et al. 2015; Connor et al. 2016). A brief, psychometrically sound measure of alcohol craving is needed to improve assessment, diagnosis, and treatment of AUDs.

Measures vary considerably in their definition of craving. In a recent review of alcohol craving scales, based on 47 papers published between 1990 and 2012, we argued that the majority contain constructs extraneous to widely applied diagnostic definitions of craving (e.g. DSM-5, ICD-10; Kavanagh 2013). These often include items measuring allied constructs, such as expectancies, intentions, and refusal self-efficacy (Kavanagh et al. 2013). Though such constructs are important within models of substance use and craving, the presence of these allied phenomena may influence accurate diagnosis of AUD and bias conclusions drawn from subsequent research. For example, the inclusion of items assessing self-efficacy (Bandura 1977) may artificially inflate the predictive utility of a scale, as self-efficacy about drinking control reliably predicts drinking behaviour (Connor et al. 2007).

The presence of allied addiction constructs does not necessarily compromise the validity of a craving scale. If the outcomes are interpreted in the context of a prescribed definition or with regard to a theoretical model then construct validity may be maintained. However, craving scales infrequently report a definition to which they adhere and are often developed atheoretically (Flannery et al. 1999; Rojewski et al. 2015; McHugh et al. 2016). We developed the Alcohol Craving Experience (ACE) Questionnaire to be consistent with common definitions of craving while adhering to a specified theory (Statham et al. 2011). However, administration of the 22-item ACE is likely to be too time consuming for practical use. It is proposed that reduction of the ACE would result in a theoretically and psychometrically sound measure of craving which may be easily integrated in time-limited environments.

Reflecting the Elaborated Intrusion (EI) Theory of Desire (Kavanagh et al. 2005; May et al. 2014b), the ACE measures three aspects of craving: the intensity of the drive to drink (Intensity), the presence of associated imagery (Imagery), and intrusiveness of desire cognitions (Intrusion; Statham et al. 2011). EI theory defines craving as an affectively laden cognitive event, where an object or activity and its associated pleasure or relief is in focal attention (Kavanagh et al. 2005). Consistent with neurobiological models of craving, addictive substances are believed to recruit the same physiological mechanisms that drive appetitive behaviours required for survival (Robinson and Berridge 1993). EI theory proposes that biological, environmental, and affective cues trigger intrusive desire-related cognitions which occupy attention and prompt elaboration. The subsequent elaboration process—in particular imagery—provides momentary pleasure or relief of physical and emotional discomfort (Connor et al. 2014). However, pleasure or relief from elaborative cognitions quickly dissipates. Instead, awareness is drawn to any emotional or physical deprivation and to potential actions to acquire the target. Further elaboration and intensification of the desire ensues, unless the target is acquired or attention is captured elsewhere.

EI theory aligns with treatment approaches such as motivational enhancement, mindfulness, acceptance-based therapies, and retraining attentional biases (Witkiewitz et al. 2013; May et al. 2014b; Witkiewitz et al. 2014). Recent research has directly employed EI theory in the development of promising new craving management strategies and novel treatment approaches (Kemps and Tiggemann 2007; Knäuper et al. 2011; Kemps and Tiggemann 2013; Hsu et al. 2014; Skorka-Brown et al. 2014; Littel et al. 2016). These approaches employ non-substance imagery and sensory tasks designed to compete with craving-based imagery within the limited capacity of working memory. The information provided by the ACE may facilitate more detailed formulation, treatment planning, and monitoring of craving.

The ACE was originally developed in an AUD sample (Statham et al. 2011), to measure the frequency (ACE-F) and peak strength (ACE-S) of alcohol craving over the previous week. Exploratory and confirmatory factor analysis showed that the items in both forms of the ACE cluster into three distinct factors consistent with EI theory: Intensity, Imagery, and Intrusion of craving-related cognitions. The ACE has high internal reliability and significantly correlates with the Obsessive Compulsive Drinking Scale (OCDS), Alcohol Use Disorders Identification Test (AUDIT), as well as measures of psychological distress highly comorbid with AUDs. The ACE has further been demonstrated to discriminate non-clinical from clinical samples (Statham et al. 2011). May and colleagues (2014) pooled 12 studies using modified forms of the ACE to assess craving across a range of substances, including alcohol (May et al. 2014a). The original factor structure was replicated across all substances.

The ACE provides a theoretically grounded, psychometrically robust measure, with strong rationale for more effectively targeting alcohol craving interventions, and has shown its value in research settings. For clinical settings, however, the full ACE is repetitive (with each item appearing in both the Strength and Frequency forms) and time consuming. A shorter version of the ACE is likely to result in higher uptake, especially where repeated administration is required. The aim of this study is to develop a short form of the ACE for use in treatment planning and outcome assessment without compromising its theoretical foundation or psychometric integrity.

MATERIALS AND METHODS

Participants

Three samples of data were drawn from patients attending a metropolitan university hospital alcohol and drug out-patient service. The service comprises eight sessions of

Cognitive Behaviour Therapy (CBT) conducted over 12 weeks. Treatment may be supplemented by pharmacotherapy (naltrexone, acamprosate, or both). The assessment battery is completed in a separate consultation prior to the first treatment session and again at the completion of treatment. All patients were over 18 years of age and met DSM-IV (American Psychiatric Association 2000) criteria for alcohol dependence. Human ethics approval was obtained (2008/125, HREC/12/QPAH/022 HREC/14/QPAH/664) and participants provided informed written consent. Sample characteristics are presented in Table 1.

Scale Reduction Sample. This sample comprised 519 alcohol dependent patients (Table 1). All patients were over 18 years of age and met DSM-IV(American Psychiatric Association 2000) criteria for alcohol dependence. These data have been used previously in the original development of the ACE (Statham et al. 2011) and in examining craving as a mediator of change (Law et al. 2016), but have not been used to directly predict treatment outcome.

Validation Sample. The validation sample comprised pre-treatment data from 228 consecutively treated alcohol dependent patients (Table 1). These data were employed to assess the factor structure of the ACE scales and cross-sectional relationships between variables.

Test-Retest (TRT) Sample. The ACE-F was administered to 66 patients at treatment sessions one and two, in-order to assess test-retest reliability of the ACE-F. Mean time between sessions was 8.40 days (*SD* = 2.86).

Insert Table 1

Measures

The Alcohol Craving Experience (ACE) questionnaire. The ACE comprises two 11-item scales that assess the frequency (ACE-F) and peak strength (ACE-S) of desire-related cognitions over the previous week. Items load onto three classes of cognition, 'Intensity' (items 1-3), 'Imagery' (items 4-8), and 'Intrusion' (items 9-11). Participants respond via an 11-point visual analogue scale with anchors 0 (*not at all*) and 10 (*constantly/extremely*). The ACE-F and ACE-S have good internal reliability and concurrent validity, and can discriminate between problem and non-problem drinkers (Statham et al. 2011).

The Obsessive Compulsive Drinking Scale (OCDS). The OCDS is a 14-item self-report measure intended to reflect drinking-related obsessive and compulsive craving and behaviour (Anton et al. 1995). The OCDS has received extensive research attention and is currently the most widely used measure of alcohol craving. The OCDS has acceptable test-retest reliability, internal reliability, and concurrent validity (Anton et al. 1995; Kranzler et al. 1999; Roberts et al. 1999). The OCDS cannot be considered a 'pure' measure of craving as extraneous constructs such as consumption, effort to resist drinking, functional interference and distress from drinking, as well as perceived control of drinking are all assessed within the scale. The first six items, comprising the Obsessions Subscale are most consistent with the clinical definitions of craving. OCDS-Obsessions is intended to assess drinking obsession related cognitions, for example, "How much of your time when you're not drinking is occupied by ideas, thoughts, impulses, or images related to drinking?". While less confounded than the full OCDS, OCDS-Obsessions does contain extraneous phenomena, assessing functional interference and distress caused by obsessive cognitions. OCDS-

Obsessions has been demonstrated to improve prediction of drinking behaviour (Flannery et al. 2003) and likelihood of relapse post treatment (Soyka et al. 2010). As OCDS-Obsessions is a widely used measure of craving and considered among the better performing craving scales (Kavanagh et al. 2013) it was employed as a concurrent measure of alcohol craving.

The Alcohol Use Disorders Identification Test (AUDIT). The AUDIT is a 10-item, self-report measure assessing recent alcohol use, symptoms of alcohol dependence, and alcohol related problems (Saunders et al. 1993). The AUDIT has sound internal reliability, sensitivity and specificity, and discriminant validity (Saunders et al. 1993). Higher scores indicate increased risk of harmful or hazardous drinking.

The Beck Depression Inventory - Second Edition (BDI-II). The BDI-II is a 21-item self-report measure assessing attitudes and behaviours symptomatic of depression (Beck et al. 1996). The BDI-II is a well validated measure demonstrating strong test-retest and internal reliability, as well as good concurrent, content, discriminant, and construct validity (Beck et al. 1988; Beck et al. 1996).

The State Anxiety Scale (S-Anxiety). The S-Anxiety Scale of the State Trait Anxiety Inventory (STAI) comprises 20 self-report items assessing the respondent's current state of anxiety (Spielberger 1983). The S-Anxiety has acceptable internal and test-retest reliability, as well as content, discriminant, and construct validity (Spielberger 1983; Oei et al. 1990; Barnes et al. 2002).

Procedure

Scale Reduction. To best maintain consistency of the measured construct, an initial step involved selection of a form of the ACE for further refinement (ACE-F or ACE-S). Each form was evaluated based on perceived clinical utility and predictive validity. Decisions guiding subsequent item reduction were informed by the following rationale: (a) to enhance construct validity, items with the greatest face validity and theoretical importance within EI theory were prioritised; (b) to maximise the sensitivity and clinical utility of a reduced scale, the most highly endorsed items were also prioritised for retention; (c) to enhance predictive validity, the capacity of items to discriminate between patients who lapsed or withdrew from treatment and those who were abstinent throughout treatment was also considered. Data analyses within this step utilised the Scale Reduction Sample.

Scale Evaluation. Reduced models were further evaluated based on construct, predictive, concurrent, and convergent validity, as well as internal and test-retest reliability. Predictive validity of OCDS-Obsessions was also assessed for concurrent comparison. Data analysis within this step utilised the Validation and Test-Retest samples.

Scale Selection. The shortest scale maintaining psychometric integrity would be selected as the final reduced version.

Data Analysis

Analyses were conducted in SPSS version 22. Confirmatory factor analyses (CFA) were conducted in R version 3.2.1 (R Core Team 2015), package extension *lavaan* .5-18 (Rosseel 2012). As the distributions of all ACE item and scale scores were significantly negatively skewed, statistical procedures robust to non-normal distributions were utilised. CFA Models were compared using changes in χ^2 /df ratios (smaller values indicating

improved fit; Carmines and McIver 1981), Comparative Fit Indices (CFI, values >.93 indicating good fit; Hu and Bentler 1999) , Standardised Root Mean Square Residual (SRMR; Values <.07 indicating good fit; Hu and Bentler 1999), Root Mean Square Error of Approximation (RMSEA; values <.07 indicating good fit; Hu and Bentler 1999), and Akaike Information Criterion (AIC; smaller values indicating improved fit; Bozdogan 1987).

RESULTS

Scale Reduction

Subscale-Selection. As the ACE-S asks the respondent to report on only the most severe episode of past week craving, it is influenced by contextual factors such as situational cues and novel stressors. Clinical value of this method is drawn from the isolation of a specific time-period where the patient may be most vulnerable to lapse. Alternatively, the ACE-F assesses the perceived frequency of craving symptoms over the past week, providing a more general overview of the patients craving experience. The ACE-F was subsequently identified as the preferred scale for reduction, based on its perceived benefit as a measure more sensitive to change in the patient's typical craving experience.

Using the Scale Reduction Sample, separate logistic regression analyses were employed to assess the capacity of pre-treatment ACE scale scores to predict the likelihood of treatment lapse relative to patients who were abstinent throughout treatment. Patients who discontinued treatment without record of lapse were conservatively included within the lapse group. All scale scores were standardised to facilitate the comparison of effects. AUDIT scores and medication status were included as covariates, but did not significantly improve upon the intercepts-only model (χ^2 (2) = 0.26, p = .877, *Nagelkerke* R^2 = .001; Table 2, Baseline Model). Inclusion of either the ACE-S ($\Delta\chi^2$ (1) = 18.71, Δp = <.001, *Nagelkerke* ΔR^2 = .054, Table 2, Model 1) or ACE-F ($\Delta\chi^2$ (1) = 21.68, Δp = <.001, *Nagelkerke* ΔR^2 =

.062, Table 2, Model 2) significantly improved the predictive power of the model. As Model 2 appeared to explain more variance than Model 1, the ACE-F was added to Model 1 in an additional step to examine if it would account for significantly more variance than the ACE-S. The addition of the ACE-F to Model 1, saw the ACE-F become the dominant predictor within the model, though predictive power was not significantly improved ($\Delta\chi^2$ (1) = 3.63, Δp = .057, *Nagelkerke* ΔR^2 = .011, Table 2, Model 3). The ACE-F was subsequently selected for further refinement.

Insert Table 2

Item Importance. Prior to item reduction, the structure and items central to the theoretical foundation of the scale were considered. At least one item from each sub-scale was retained to represent each factor. Items 3 and 9 (Table 3) were prioritized for retention due to high semantic consistency to the Intensity and Intrusion factors respectively. Multiple items of the Imagery factor would be retained to capture potential individual differences in the most prevalent imagery modalities involved in alcohol craving.

Feature Prevalence. Medians and interquartile ranges for all ACE-F items are presented in Table S1 within the online supplementary material. While all items had an interquartile range of at least 4 on the 11-point scale, most also received a large proportion of 'not at all' responses. To identify which items were most representative of common craving symptoms among patients with AUD, the endorsement rates (ERs; proportion of non-zero responses to each item) were also calculated. McNemar's χ^2 was utilised to identify significant differences between items in the prevalence of endorsement rates within each factor. Within the Intensity factor, the endorsement rate of Item 2 (80.2%) was significantly

lower than Item 3 (86.1%, $p < .001$), while Items 1 (87.6%) and 3 could not be distinguished ($p = .169$). Comparisons of endorsement rates of items within the Imagery factor revealed all were significantly different ($p < .001$), with the exception of the most highly endorsed, items 4 (80.9%) and 8 (80.1%, $p = .716$). Within the Intrusion factor, item 11 was the least endorsed factor (75.8%, $p < .001$) while items 9 (84.9%) and 10 (83.8%) could not be differentiated ($p = .291$).

Separate Mann-Whitney *U* tests revealed that the mean rank of patients who lapsed or withdrew from treatment was significantly higher for every item than those who completed treatment abstinent (Table 3). Steiger's *Z* revealed no significant differences in the size of the effects between items.

Insert Table 3

Item Reduction. To maximize sensitivity of the reduced craving measure items with the highest endorsement rates were given greater priority for retention to minimise the number of 'not at all' responses within the reduced scale. Based on feature prevalence and consistency with the overarching factors, items 3 and 9 were retained to represent the Intensity and Intrusion factors respectively. The three imagery items with the highest endorsement rates (4, 5, and 8) were retained to comprise the initial Imagery factor.

A sequential logistic regression was employed to assess the capacity for the selected items to predict alcohol lapse in the Scale Reduction Sample. Addition of the items intended to comprise the reduced ACE (items: 3, 4, 5, 8, 9) to the Baseline Model (Table S2) significantly improved predictive power of the model ($\Delta\chi^2$ (5) = 21.49, $\Delta p < .001$, *Nagelkerke* $\Delta R^2 = .061$, Model 4, Table S2). To assess whether the model could be improved with the inclusion of additional ACE items, the remaining items were included using forward

entry. Sequential inclusion of items 1 ($\Delta\chi^2$ (1) = 7.61, Δp = .006, *Nagelkerke* ΔR^2 = .023, Model 5, Table S2) and 10 ($\Delta\chi^2$ (1) = 9.84, Δp =.002, *Nagelkerke* ΔR^2 = .027, Model 6, Table S2) would significantly improve the final model (χ^2 (9) = 39.20, $p < .001$, *Nagelkerke* R^2 = .111).

Scale Evaluation

Validity. To assess the construct validity of the initial five-item scale, the seven-item scale, and the complete ACE-F, confirmatory factor analyses were performed utilising the Validation Sample. Maximum likelihood estimation with robust standard errors and a Satorra-Bentler scaled test statistic were employed to reduce the effects of non-normality. Model fit statistics are presented in table 4, and parameter estimates are summarised in the supplementary material. For the 11 and 7 item scales, the three-factor solution provided a better fit to the data than a unifactorial model (Table 4). For the five item scale, both solutions showed comparable fit. The CFI, RMSEA, SRMR, and AIC fit statistics all improved through reduction. No covariance between error terms was specified in any of the models. These results support previous studies validating the three-factor structure of the ACE (Statham et al. 2011; May et al. 2014a), though when reduced to a five-item scale, it could equally reflect a global construct of craving within a single factor (Figure 1).

Insert Table 4

Insert Figure 1

Data from the Validation Sample indicated that all scales had significant ($p < 0.001$) large positive correlations with OCDS-Obsessions, indicating an acceptable level of concurrent validity (r = 0.60 to 0.58). Convergent validity was demonstrated by significant (p

< 0.01) small to moderate positive correlations with the AUDIT (r = 0.22 to 0.20) and significant ($p < 0.001$) moderate correlations with measures of anxiety (S-Anxiety: r = 0.40 to 0.38) and depression (BDI: r = 0.39 to 0.38). The strength of the correlations did not significantly differ between the three ACE versions (Steiger's Z, p <.05), indicating that convergent and concurrent validity of the ACE was not significantly affected by scale reduction.

Utilising the Scale Reduction Sample predictive validity of the scales administered pre-treatment was assessed by logistic regressions with the outcomes 'complete treatment abstinent' and 'lapsed or discontinued treatment'. When independently added to the Baseline Model, the five-item ($\Delta\chi^2$ (1) = 15.17, $\Delta p < .001$, *Nagelkerke* ΔR^2 = .044, Model 7, Table 5), seven-item ($\Delta\chi^2$ (1) = 20.19, $\Delta p < .001$, *Nagelkerke* ΔR^2 = .058, Model 8, Table 5), and 11-item (Model 2, Table 2) scales all significantly improved predictive power of the model. Predictive power of OCDS-Obsessions was also assessed for concurrent comparison. Addition of OCDS-Obsessions significantly improved upon the Baseline Model ($\Delta\chi^2$ (1) = 7.78, Δp =.005, *Nagelkerke* ΔR^2 = .022, Model 9, Table 5). The incremental validity of each scale was assessed by systematically adding the weaker of two scales, based on *Nagelkerke's* R^2, to the Baseline Model, followed by the next strongest scale in step two. The 5-item ACE-F was demonstrated to significantly improve upon the predictive power of OCDS-Obsessions ($\Delta\chi^2$ (1) = 7.35, Δp =.007, *Nagelkerke* ΔR^2 = .044, Model 10, Table 5) and the 7-item scale significantly improved upon the 5-item ($\Delta\chi^2$ (1) = 15.43, Δp <.001, *Nagelkerke* ΔR^2 = .088, Model 11, Table 5). The 11-item scale did not improve upon the seven-item scale ($\Delta\chi^2$ (1) = 1.19, Δp = .173, *Nagelkerke* ΔR^2 = .064, Model 12, Table 5).

Insert Table 5

Reliability. Internal consistency was assessed using the Validation Sample. Cronbach's Alpha was above .90 for all scales with only minor reductions in the reduced scales (α = 0.95 to 0.92). Test-Retest reliability utilised session one and two data from 66 patients. Correlations between session one and session two ACE scores indicated that test-retest reliability was acceptable across all scales (r = 0.731 to 0.725). Steiger's Z revealed no significant changes in scale test-retest reliability following reduction.

Scale Selection

The procedures conducted indicate that the ACE-F may be reduced to as few as five items while maintaining theoretical and psychometric integrity. The five-item scale, termed the Mini Alcohol Craving Experience (MACE), was chosen as the most suitable short-form scale for assessment of craving in AUD populations.

DISCUSSION

In place of the two 11–item forms of the ACE, a brief five-item measure of craving was validated (MACE). The MACE maintained high construct, predictive, concurrent, and convergent validity. High internal and test-retest reliability consistent with the ACE-F was also demonstrated. The MACE measures the frequency of past week craving including intense urges, imagery, and intrusiveness of craving related cognitions (Kavanagh et al. 2005). The MACE is simple to administer and may be completed in less than 60 seconds, reducing time burden on respondents, health professionals, and researchers.

In addition to its brevity, the MACE maintains several strengths uncommon among current craving instruments, including a strong theoretical model and absence of drinking constructs known to confound craving measurement (Sayette et al. 2000; Kavanagh et al. 2013). By retaining the items most representative of the ACE factors, and monitoring the

399 resultant model fit, the MACE preserved the construct validity of the ACE. The MACE
400 subsequently retains the capacity for unique insight into intensity and intrusiveness of patient
401 craving, as well and key elements of craving based imagery. This information may inform
402 case formulation and treatment planning.

403 Predictive validity is infrequently examined in existing craving measures. Higher
404 scores on the MACE were predictive of increased risk of lapse or dropout from treatment in
405 this alcohol dependent sample. A one standard deviation increase in MACE score was
406 associated with a 54% increase in the odds of lapse or discontinuation of treatment; relative
407 to OCDS-Obsessions, where a one standard deviation score increase was associated with a
408 10% increase in risk. The practical interpretation of this result is that for every one-point
409 increase on the MACE pre-treatment (maximum score = 50), the odds of a patient completing
410 treatment abstinent reduced by 3.1 percent. The MACE may therefore assist addiction
411 professionals to better assess risk of relapse in their patients.

412 Few craving measures assess test-retest reliability. The MACE deliberately measures
413 past week frequency of craving, under the assumption that this will have greater stability and
414 subsequently be a more reliable indicator of change than single time point assessments. The
415 correlation of session one and two MACE scores was $r = 0.73$, and is interpreted as an
416 acceptable degree of stability within the clinical context. Given the prominence of craving
417 within clinical and research settings, a measure of craving sensitive to change over time is
418 greatly needed. The MACE may enhance the validity of studies assessing the efficacy of
419 craving interventions, and improve monitoring of patients' treatment response in clinical
420 settings.

421 As this study was conducted in a hospital outpatient clinic, the samples provided
422 optimal, clinically relevant data. However, the practical nature of the research design
423 introduced some limitations. The samples predominantly comprised middle-aged men with

poor social or occupational functioning and moderate to severe alcohol dependence. Future studies should investigate the MACE in more diverse patient populations, as craving profiles may vary across problem severity, age, culture, social-occupational status. An additional limitation is that follow up data of patients who dropped out were not available, and were conservatively recorded as having lapsed. Assessment of test-retest reliability was also impaired by the treatment setting. An increased focus on drinking and attempts to change drinking behaviours is likely to have increased variance in patient craving from session one to two. While this is hypothesised to have led to the underestimation of the MACE's stability future research should assess participants under stable conditions with tightly controlled time points. Further research is also needed to examine the performance of the MACE as a stand-alone measure. As the MACE was only assessed as a sub-selection of the full ACE, the extent to which the variance of the retained items is influenced by the excluded items is unknown. Finally, while craving frequency presents ongoing challenges to the control of drinking, very intense peak levels also constitute significant risk. Utilising both frequency and strength forms of the ACE is recommended when time permits, as they offer a more comprehensive assessment of the patient's experience of craving. The MACE and ACE scales, scoring instructions, and normative data are included in the online supplementary material.

A final recommendation, which applies to the use of all craving measures, is that scale administrators, researchers and clinicians alike, carefully interpret scale scores in light of the definition and theory under which they are proposed. It is argued that unclear definitions, and the absence of theoretical models have impaired craving measurement to date, confounding the craving construct as it is widely understood (Tiffany and Wray 2012; Kavanagh et al. 2013). Interpreting ACE scores in the context of the Elaborated Intrusion Theory of Desire (Kavanagh et al. 2005) will improve understanding of the proposed construct of craving and enhance its clinical utility.

The Mini Alcohol Craving Experience (MACE) reflects the key theoretical elements of the ACE, while maintaining the best performing items and preserving psychometric integrity. Key strengths of the MACE include excellent construct validity, predictive validity, and acceptable test-retest reliability. In conjunction with its brevity, these features make the MACE ideal for use with AUD populations in time limited clinical and research environments.

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CONFLICTS OF INTEREST

There are no conflicts of interest to declare.

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Table 1. Patient sample characteristics

Sample characteristics	Scale Reduction Sample *n* = 519	Validation Sample *n* = 228	TRT Sample *n* = 66
Mean Age, years (SD)	39.82 (11.59)	44.39 (10.82)	45.48 (10.03)
Sex, female	171 (32.9%)	84 (36.8%)	22 (33.3)
Married/*De-facto*	184 (35.5%%)	82 (36.0%)	25 (37.9%)
Education			
Degree	70 (13.5%)	47 (20.5%)	17 (25.8%)
Diploma/Certificate	52 (10.0%)	16 (7.1%)	6 (9.1%)
Senior Secondary (Year 12)	157 (30.3%)	71 (31.1%)	22 (33.3%)
Junior Secondary (Year 10)	190 (36.6%)	82 (36.0%)	17 (25.8%)
Primary (Year 7)	33 (6.4%)	11 (4.8%)	4 (6.1%)
Unemployed	103 (19.8%)	44 (19.3%)	15 (22.7%)
Mean Alcohol (grams) per drinking day (SD)	147.07 (88.90)	169.80 (100.93)	196.12 (119.71)
Median Baseline ACE-F (IQR)	39 (48.00)	42.00 (46.75)	43.50 (45.50)
Mean Baseline AUDIT (SD)	27.25 (8.6)	29.38 (7.01)	27.47 (10.28)
Mean Baseline OCDS-Obsessions (SD)	7.82 (4.47)	8.82 (4.36)	8.46 (4.76)
Medication Prescribed*	315 (60.7%)	25 (11.0%)	10 (15.2%)

*The Scale Reduction Sample records medication (naltrexone/acamprosate/both) if it is prescribed at any point during treatment. Medication is only counted in the Validation and TRT samples if it was taken in the week prior to assessment. As the Validation sample assessment occurred prior to commencement of behavioural treatment and TRT sample was assessed in Session 1, the majority of patients had not yet been prescribed pharmacotherapy.

601 **Table 2.** Summary of hierarchical logistic regression models assessing predictive validity of the ACE-F and ACE-S.

602

		95% CI for Odds Ratio		603
	β (SE)	Lower	Odds Ratio	Upper
Baseline Model				
Constant	1.18*** (.13)		3.26	
Medication	0.11 (.22)	0.73	1.12	1.71
AUDIT	-0.00 (.11)	0.81	1.00	1.23
Model 1				
Constant	1.19*** (.14)		3.28	
Medication	0.23 (.22)	0.81	1.26	1.96
AUDIT	-0.04 (.11)	0.77	0.96	1.20
ACE-S	0.46*** (.11)	1.28	1.59	1.97
Model 2				
Constant	1.21*** (.14)		3.34	
Medication	0.23 (.22)	0.81	1.26	1.95
AUDIT	-0.05 (.11)	0.76	0.95	1.18
ACE-F	0.53*** (.12)	1.34	1.69	2.14
Model 3				
Constant	1.2*** (.14)		3.32	
Medication	0.24 (.23)	1.27	1.27	1.98
AUDIT	0.05 (.11)	0.95	0.95	1.18
ACE-S	0.15 (.19)	1.17	1.17	1.70
ACE-F	0.39 (.20)	1.48	1.48	2.21

Note: * $p < .05$, ** $p < .01$, *** $p < .001$,

604

605 **Table 3.** Mean rank comparison of abstinent patients and those who lapsed or dropped out of treatment across all ACE-F items scores.

How often did these things happen over the last week?	Complete Abstinent		Lapse or Dropout					
	n	Mean Rank	*n*	Mean Rank	U	Z	*p*	*r*
1. Did you want a drink?	118	196.24	398	276.96	16135.00	-5.19	<.001	-0.23
2. Did you think about needing a drink?	118	203.00	399	275.56	16933.00	-4.67	<.001	-0.20
3. Did you have an urge to drink?	118	203.95	399	275.28	17045.00	-4.58	<.001	-0.20
4. Did you picture alcohol or drinking?	118	215.42	399	271.89	18398.50	-3.64	<.001	-0.16
5. Did you imagine what it would taste like?	118	215.79	398	271.16	18442.50	-3.59	<.001	-0.16
6. Did you imagine what it would smell like?	118	217.61	399	271.24	18656.50	-3.54	<.001	-0.16
7. Did you imagine what it would feel like in your mouth or throat?	118	214.71	399	272.10	18315.00	-3.74	<.001	-0.16
8. Did you imagine how your body would feel if you had a drink?	118	223.04	398	269.01	19298.00	-2.96	0.003	-0.13
9. When you thought about alcohol over the last week, how often were the thoughts intrusive?	117	223.46	388	261.91	19241.50	-2.51	0.012	-0.11

10. When you thought about alcohol over the last week, how often were you trying not to think about alcohol?	117	211.29	398	271.73	17818	-3.88	<.001	-0.17
11. Did you find it hard to think about anything else?	118	203.59	399	275.56	17003	-4.55	<.001	-0.20

606

607 **Table 4.** Robust fit indices for the 3-factor and unifactorial structures of the ACE scales (*n* = 228).

Scale	*χ2 (df)*	*χ2 /df*	*p*	CFI	RMSEA	SRMR	AIC
ACE-F 11							
Unifactorial	302.13 (44)	6.87	<.001	0.898	0.160	0.069	11236.7
3-Factor	158.92 (41)	3.88	<.001	0.954	0.112	0.056	11013.50
ACE-F 7							
Unifactorial	78.91 (14)	5.64	<.001	0.955	0.143	0.040	7321.29
3-Factor	35.59 (11)	3.24	<.001	0.983	0.099	0.027	7265.35
ACE-F 5							
Unifactorial	23.23 (5)	4.65	<.001	0.983	0.126	0.026	5197.70
3-Factor	23.47 (4)	5.87	<.001	0.982	0.146	0.026	5199.57

608

609

610 **Table 5.** Summary of hierarchical logistic regression models assessing predictive validity of the reduced ACE-F Scales and OBS.

611

		95% CI for Odds Ratio		
	β (SE)	Lower	Odds Ratio	Upper
Model 7				
Constant	1.19*** (.14)		3.28	
Medication	0.22 (.22)	0.8	1.25	1.93
AUDIT	-0.04 (.11)	0.78	0.96	1.19
ACE-F-5 item	0.43*** (.12)	1.23	1.54	1.93
Model 8				
Constant	1.19*** (.14)		3.3	
Medication	0.24 (.23)	0.82	1.27	1.98
AUDIT	-0.04 (.11)	0.77	0.96	1.19
ACE-F-7 item	0.50*** (.12)	1.31	1.65	2.06
Model 9				
Constant	1.18*** (.14)		3.24	
Medication	0.20 (.22)	0.79	1.23	1.9
AUDIT	-0.07 (.11)	0.75	0.93	1.16
OBS	0.31** (.11)	1.09	1.37	1.71
Model 10				
Constant	1.19*** (1.4)		3.29	
Medication	0.225 (.23)	0.8	1.25	1.95
AUDIT	-0.06 (.11)	0.76	0.95	1.18
OBS	0.10 (.14)	0.84	1.1	1.44
ACE-F-5 item	0.37** (.14)	1.11	1.45	1.9

Model 11				
Constant	1.22 (0.14)		3.38	
Medication	0.26 (0.23)	0.83	1.29	2.02
AUDIT	-0.03 (0.11)	0.77	0.97	1.21
ACE-F-5 item	-2.21 (0.7)	0.03	0.11	0.43
ACE-F-7 item	2.67 (0.7)	3.65	14.39	56.77
Model 12				
Constant	1.22 (0.14)		3.37	
Medication	0.21 (0.23)	0.8	1.24	1.93
AUDIT	-0.06 (0.11)	0.76	0.94	1.17
ACE-F-7 item	-0.40 (0.67)	0.18	0.67	2.48
ACE-F-11 item	0.93 (0.69)	0.66	2.55	9.82

Note: * $p < .05$, ** $p < .01$, *** $p < .001$.

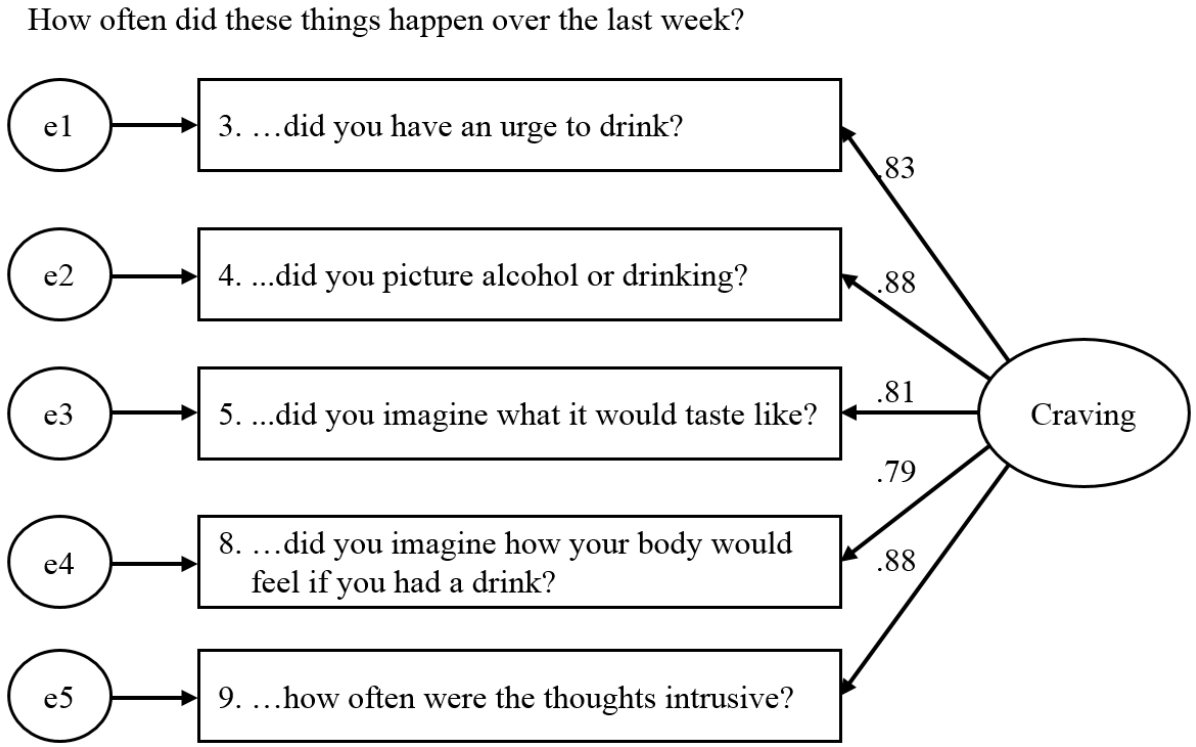

Figure 1. Unifactorial model of the 5-item ACE-F with standardised parameter. All paths are significant at $p < .001$.