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Exploring Age as a Moderator in the Relationship between Trait-Anxiety and Cue-Induced Anxiety

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Abstract

Background: Regular and excessive alcohol consumption has severe psychological, physical, and social consequences. Nevertheless, alcohol use disorder (AUD) is highly prevalent with 76.3 million estimated cases worldwide diagnosed with AUD (World Health Organization [WHO], 2004). Virtual Reality (VR) holds promise to broaden the horizons of AUD assessment by providing more insights to the clinician regarding the underlying mechanisms of AUD. The current study aimed to explore the moderating role of age in the relationship between trait – and state - (cue-induced) anxiety in individuals diagnosed with AUD. *Method:* This study incorporated a cross-sectional design and is part of a concluded study named the "ALCO-VR" project. By using the data from State and Trait Anxiety Inventory – trait subscale (STAI-T) to measure trait-anxiety and Virtual Reality Assessment (VAS-A) to measure cue-induced anxiety the moderating role of age on the relationship between trait - and state - (cue-induced) anxiety was analyzed. Participants were separated into the age span of 18 to 45 years (young adults) and 46 to 69 years (older adults). *Results:* The sample consists of N = 67 participants (62% male; mean (*SD*) age 51 *(8.93)* years). Most of the respondents reported being in a relationship (43%) and having a moderate socioeconomic status (79 %). The sample had moderate STAI-T scores (M = 27.43, *SD =11.77)*. The VAS-A measure indicated the highest level of state - (cue-induced) anxiety in the VR environments pub (M = 35.14, *SD = 26.92*) and bar (M = 32.98, *SD = 26.97)* and the lowest for the environment restaurant (M = 31.85, *SD = 25.64*). Moreover, the results indicated that age is not a significant moderator in the relationship between trait-anxiety and state (cue-induced) anxiety. Nevertheless, the study found a positive correlation between trait- and - state anxiety. *Conclusion:* There is still a need for further research on this topic first to optimize the VR technology with more objective measures and second to understand which variables moderates the relationship between trait - and state – anxiety.

Keywords: Virtual Reality, Alcohol use Disorder, Age, Trait-Anxiety, State-Anxiety, Assessment

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Introduction

Alcohol misuse is among the leading causes of preventable death worldwide, with 3 million deaths per year (WHO, 2018). According to the World Health Organization, there are 76.3 million people worldwide diagnosed with an alcohol use disorder (AUD) (World Health Organization [WHO], 2004). As stated in the Diagnostic and Statistical Manual of Mental Disorders (2013) AUD is defined as alcohol use causing clinically significant impairment or distress. Individuals suffering from AUD have also high rates of comorbidities with other psychological disorders like substance use disorders, anxiety disorders and depression, which influence the assessment of AUD and make it more complex (Dube et al., 2002). Nowadays, there are several assessment tools available to establish an AUD diagnosis, namely: (1) paper and pencil instruments for example the Alcohol use Disorder Identification Test (AUDIT) (Babor & Grant, 1989), (2) the ecological momentary assessment (EMA) (Morgenstern et al., 2014) and (3) the cue-exposure paradigm (Conklin & Tiffany, 2002). However, due to the high comorbidity of AUD with anxiety disorders, the assessment of anxiety in AUD-diagnosed individuals would require more differentiated and controlled assessment tools, which would enable the assessment in specific environments and the inclusion of different variables (Lebiecka, et al., 2021). In this perspective, virtual reality (VR) became popular which is defined as *"a computerized technology that entails visual, auditory, olfactory, or tactile stimuli to enhance individuals' perception of momentary presence within the VR environment"*. Thus, VR presents the unique opportunity to assess individuals' momentary anxiety levels in various environments and add different variables which hold promise to optimize the assessment of AUD (Lebiecka, et al., 2021).

Alcohol use Disorder

AUD is a chronic mental health disorder that is typically characterized by (1) a strong desire to drink (alcohol craving), (2) difficulties in controlling its use, (3) persistence in its use despite harmful health consequences, (4) a higher priority given to alcohol than other obligations, (5) increased tolerance (the need for increasing amounts of alcohol to feel its effects), and (6) a physical withdrawal state (e.g., nausea, sweating, shakiness and anxiety) in a 12-month period (see Appendix A) [Diagnostic and Statistical Manual of Mental Disorders (5th ed.; DSM–5;
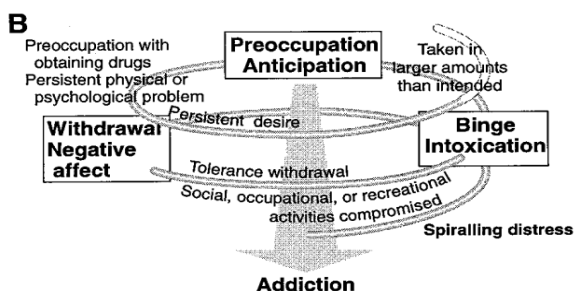
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American Psychiatric Association, (APA), 2013]. Moreover, there are serious implications of AUD such as the withdrawal state, which is usually experienced in three stages. The *first stage* starts a few hours after alcohol abstinence (6-12 hours) with mild symptoms, the *second stage* begins after 12 hours of abstinence with alterations of perceptions such as visual, auditory, and tactile hallucinations and the *third stage* starts after 24 to 48 hours of abstinence with symptoms as colonic seizures, and delirium tremens (rapid fluctuations of perception, autonomic instability, agitation) (Jesse et al., 2017). To develop a full understanding of AUD it is important to assess the underlying mechanisms of this disorder.

AUD can be broken down into a 3-stage cycle: (1) binge/intoxication (the consumption of alcohol), (2) withdrawal/negative affect and lastly (3) preoccupation/anticipation (craving) (see Figure 1) (Koob & Moal, 1997). These stages interact with each other and build on one another leading consequently to addiction. In this process, there are positive reinforcers such as rewards, and negative reinforcers such as the removal of negative consequences (e.g., consuming alcohol as withdrawal symptoms start to arise) both increasing the probability of alcohol consumption (Koob, 2013). Besides reinforcers, there are also other factors influencing the course of development of AUD. AUD was found to be highly comorbid with other mental health disorders such as depression, anxiety, eating disorders, bipolar disorder, and ADHD (McHugh & Weiss, 2019).

Figure 1

Diagram Describing the Addiction Cycle with three Major Components of Addiction and with Different Criteria for Substance Dependence from the DMS-IV

Note. From *Drug abuse: hedonic homeostatic dysregulation (p. 52-58),* by Koob & Moal, 1997.

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Anxiety and Alcohol use Disorder

The comorbidity of anxiety disorder and AUD is common and is of great interest to researchers and clinicians since it has an impact on the assessment of AUD (Smith & Randall, 2012). Assessment of AUD would require to become more differentiated for a thorough understanding of the patients' experience, to assess choices of medication or therapy and to anticipate the course of illness (Underwood et al., 2011). Anxiety can be described as "*having feelings of tension, worried thoughts, and physical changes as increased blood pressure*" (Bouras & Holt, 2007). To measure individuals' anxiety levels Spielberger (1972) developed the State and Trait Anxiety Inventory (STAI) and divided anxiety into two categories. *State-anxiety* is described as a momentary emotional state that is characterized by subjective feelings of tension and apprehension (Spielberger, 1972). In contrast, *trait-anxiety* is described as a general tendency to appraise situations as threatening and respond with anxiety to perceived danger (Elwood et al., 2012). As trait-anxiety is highly associated with various anxiety-related mental health problems it is important to assess how anxiety disorders are related to AUD (Swendsen et al., 2000).

Drawing upon alcohol literature, there are controversial findings regarding the association of anxiety and AUD where research suggested that (1) anxiety disorder promotes pathological alcohol consumption, (2) pathological alcohol consumption promotes anxiety disorder and lastly that (3) a third variable promotes both conditions (Kushner et al., 2000). The National Epidemiological Survey on Alcohol and Related Conditions (NESARC) reveals that about 15% of individuals having a 12-month anxiety disorder had also been diagnosed with at least one substance use disorder (Sanderson & Andrews, 2002). Moreover, it was reported that among individuals seeking treatment for AUD 33% had also been diagnosed with an anxiety disorder, emphasizing the link between AUD and anxiety disorders (Sanderson & Andrews, 2002). Moreover, research found intensifying effects of these two disorders. For example, Falk et al. (2008) found that anxiety disorders are associated with increased severity and persistence of AUD, thus increasing the risk for relapse. Another study by Bruce et al. (2005) found that AUD is associated with greater severity and chronicity of anxiety disorders. In this perspective, epidemiological and clinical studies have highlighted the frequency and the impact of the comorbidity between anxiety disorders and AUD and have shown that this association is multifaceted and complex (Smith & Randall, 2012).

The common-factor model of comorbid anxiety and AUD supports the view that there is a

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third variable influencing the association of anxiety and AUD (Goodwin et al., 2004). In this perspective, demographic characteristics of individuals were assessed and found that age has a significant impact on the onset and development of AUD, thus might influence the relationship between anxiety and AUD.
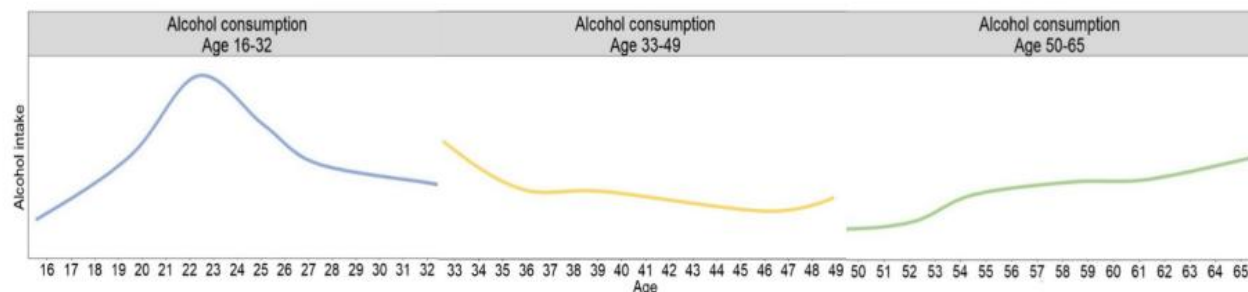
Age and Alcohol use Disorder

Age was widely explored in the context of addictive research. By analyzing age-related differences in drinking patterns results about the onset and the course of pathological drinking can be obtained thus, allowing for more qualitative assessment and treatment outcomes. Early alcohol consumption is highly prevalent among adolescents in Western countries, suggesting that adolescence is a critical age period for the onset of alcohol consumption (Kraus et al., 2018). Furthermore, cross-sectional (Hingson et al., 2006) and longitudinal studies (Pitkänen et al., 2008) indicated that age of onset drinking is one of the strongest predictors for the development of AUD. From this can be concluded that adolescents are more vulnerable to developing an AUD compared to older individuals. Indeed, age-related differences were found in drinking patterns where young adults (16-32 years) and old adults (50-65 years) were most likely to excessively consume alcohol compared to middle-aged individuals (33-49 years) (see Figure 2) (Deeken et al., 2020). The Global Burden of Disease Study (2019) supported these findings and reported that the AUD prevalence is highest in individuals aged between 25 and 34 years. Overall, it can be concluded that age has an impact on individuals' drinking patterns and the development of AUD whereas it is still important to identify whether there is a link between age and anxiety.

In this perspective, Johnson (2000) analyzed the predicting factors of increased alcohol consumption among old adults and found that those individuals diagnosed with an anxiety disorder and depression had increasingly higher alcohol consumption levels compared to individuals without an anxiety diagnosis depicting the link between age, excessive alcohol consumption and anxiety. There are various studies suggesting that there might be a relationship between age, excessive drinking, and anxiety however, it should be further analyzed whether these variables are related to AUD.

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Figure 2

Age-related Differences in Alcohol Consumption

Note. From *Risk and Protective Factors for Alcohol Use Disorders Across the Lifespan* (p. 245-251), by Deeken, Banaschewski & Kluge, 2020.

Cue-Exposure Technique and Virtual Reality

There is a growing body of literature regarding the assessment of anxiety in the field of addictions. One of the most common and used approaches in AUD assessment is the cue-exposure paradigm which involves in vivo, imaginary techniques, or simulated exposure by presenting auditory, visual, or photographic cues (Ramirez et al., 2015) and is based on classical conditioning (Pavlov, 1927). Hereby, classical conditioning assumes that alcohol-related stimuli produce conditioned responses such as anxiety even when no alcohol stimuli are present (Ghiţă & Gutiérrez-Maldonado, 2018). However, Conklin and Tiffany (2002) found that the cue-exposure paradigm had inconsistent results and only modest effectiveness. One possible reason for that could be that in most cases cue-exposure was conducted in a safe room with only one cue presented at a time (Conklin & Tiffany, 2002). The assessment of anxiety in AUD-diagnosed individuals is however more complex and involves the interaction and processing of multiple variables at once (Ghiţă & Gutiérrez-Maldonado, 2018).

VR is a computerized technology that is well established in the fields of neuroscience and psychology and has various benefits over the cue-exposure paradigm (Hone-Blanchet et al., 2014). VR is designed to mimic real-world settings by using visual, auditory, olfactory, and tactile stimuli that create a feeling of immersion (Lebiecka, et al., 2021). Hereby, VR allows for a better ecological validity than the cue-exposure paradigm, therefore, ensuring more generalizable and reliable results in the assessment (Ghiţă & Gutiérrez-Maldonado, 2018). One of the

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advantages of VR is the experienced immersion in a simulation of a complex real-life environment (Otkhmezuri et al., 2019). Hereby, the individual can be an active participant within a specific context which provides significant insights for the clinician regarding the behavior, feelings, and other underlying mechanisms (Otkhmezuri et al., 2019). Moreover, the potential of VR to physically immerse individuals, activate relevant memory schemas and evoke individuals' interpretation and emotional responses which in turn allow better assessment of complex disorders such as anxiety in AUD-diagnosed individuals (Otkhmezuri et al., 2019). Furthermore, VR offers increased control over the variables in the assessment. The possibility to develop a specific VR scenario leads to a high degree of standardization, leaving the experimenter to control the field of gaze, and guide individuals through a scenario in a specific order while exposing them to cues for a predefined period (Stoermer et al., 2000). Overall, it can be concluded that by using VR together with already existing assessment tools a more differentiated, ecologically valid assessment of anxiety in AUD-diagnosed individuals can be reached.

Previous studies ascribe AUD high comorbidity with anxiety disorders however there are inconclusive findings regarding the nature of this association assuming that there is a third variable influencing the association between anxiety and AUD (Goodwin et al., 2004). Since age was widely researched in the context of addiction and anxiety, and was found to be linked to both constructs it can be assumed that age moderates the relationship between anxiety and AUD. This study will focus on trait-anxiety as measured by the State and Trait Anxiety Inventory Trait subscale (STAI-T) and state-anxiety as measured by the VR technology (VAS-A) and will investigate the research question: *"Does age moderate the relationship between trait-anxiety and state-anxiety in AUD diagnosed individuals during VR exposure?"* using a moderation analysis.

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Method

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Design

This study is a part of a concluded study named the "ALCO-VR" project that was conducted at the Hospital Clinic of Barcelona. The first study in this project focused on the identification of alcohol-related cues and contexts that trigger anxiety to create clinically significant VR environments (Ghiţă et al., 2019). Moreover, the project focused on developing a virtual reality cue exposure therapy (VR-CET) protocol for individuals diagnosed with severe alcohol use disorder (AUD) and comorbid psychopathologies. The VR protocol included eight individual sessions: two assessment sessions (pre-and post- VR program) and six VR-based therapy sessions with an emphasis on cue-induced alcohol craving and anxiety. In the present study, data will be only used from the assessment sessions for the variable anxiety. The current study is descriptive, incorporating a cross-sectional design. The variables assessed in this study were participants' age, trait-anxiety as measured by the STAI-T and the state-anxiety as measured using the VAS-A after participants were exposed to the four different VR environments (house, restaurant, pub, and bar). These environments were used since previous research indicated that those environments elicit the highest anxiety levels among AUD-diagnosed individuals (Ghiţă et al., 2019). The independent variable was trait-anxiety, and the dependent variable was state-anxiety where age served as a moderator. Ethical approval for the study was obtained from the ethics committee of the University of Barcelona and the Hospital Clinic of Barcelona. The participation of voluntary individuals was possible after providing written informed consent.

Participants and recruitment

The participation of 81 patients was voluntary with the inclusion criteria: (1) to be older than 18 years, (2) diagnosed with a moderate or severe AUD, and (3) resistant to treatment as usual (TAU) which includes having at least one relapse within six months after they undergo treatment, and lastly, (4) to abstain from alcohol for at least three days before the start of the project.

Next to the inclusion criteria, several exclusion criteria had been predefined: (1) severe

cognitive impairments, (2) severe psychopathology (e.g., schizophrenia or major depressive disorder) or neuropathology (e.g., dementia), (3) diagnosed opioid use disorder, (4) severe visual impairments, (5) epilepsy, (6) pregnancy, and lastly (7) use of anti-craving medication. The descriptive statistics of the participants can be found in Table 2 in the results section.

Materials

Alcohol Use Disorder Identification Test (AUDIT)

The AUDIT was implemented as a self-reported measurement for screening for excessive drinking patterns among the participants. The AUDIT consists of 10 items ranging from 0 to 40 measuring alcohol intake, dependency, and negative consequences (WHO, 1980). Hereby, the maximum total score of the AUDIT is 40 while the minimum total score is 0 (WHO, 1980). A total score of 8 or more is an indicator of hazardous alcohol consumption while AUDIT scores of 20 emphasize undergoing further diagnostic evaluation for alcohol dependence (WHO, 2002). The AUDIT demonstrates an acceptable internal consistency ($\alpha = 0.86$) and a high test-retest reliability ($r = .86$) (López et al., 2019; WHO, 2002).

State-Trait Anxiety Inventory (STAI)

The trait anxiety levels of each participant were measured with the Spanish version of the STAI. This questionnaire is a self-report questionnaire with two subscales consisting of 20 non-overlapping items measuring how a person feels at the moment (state anxiety) and how anxious a person is in general (trait anxiety). The items range from 0 meaning "not at all" to 3 "very much" where higher scores are indicative of increased anxiety. For this research data from the trait anxiety subscale will only be used (STAI-T). The maximum total score for the STAI-T is 60 while the minimum total score is 0. The STAI has a moderately high to excellent internal consistency reliability ($\alpha = .86$ to .95), test-retest reliability ($r = .65$ to .75) (Spielberger, 1983). A cut-off score of 40 will be used to identify the presence or absence of trait anxiety as suggested by previous research (e.g., Hart & McMahon, 2006).

Virtual Reality Assessment (VAS-A)

To measure the cue-induced anxiety (state-anxiety) in four virtual reality environments (house, restaurant, pub, and bar) (see Figure 3) the single item measurement VAS-A was used. The VAS-A is a self-report measurement used within the VR software to measure the subjective and momentary experience of anxiety (Bordnick et al., 2008). VAS-A allows for a collection of real-time responses while participants are exposed to the VR environments (Ghiţă & Gutiérrez-Maldonado, 2018). Scores ranged from 0 meaning "No anxiety at all" to 100 "Intense anxiety".

Virtual Reality Software. The VR software included four environments (house, restaurant, pub, and bar) that were shown at different day and night times. Participants choose their first five preferred alcoholic beverages from the menu of drinks. The software itself was set to create a hierarchy of exposure from the lowest-rated environment (context) with the lowest-rated alcoholic drink to the highest-rated environment and drink. To mimic social interactions human avatars were included. First participants were presented with a neutral background with a glass of water to introduce them to the VR technology. Participants then were exposed to the different environments and beverages and asked to rate each according to the momentary level of anxiety.

Virtual Reality Hardware. The VR hardware included an Oculus Rift S head-mounted display (HMD), sensors, touch controllers, and a computer (Intel INTEL® Core™ i7–2,600 CPU,16.0 GB RAM, 64-bit operating system, x64 processor, and a NVIDIA GeForce GTX 1080 Ti graphic card).

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Figure 3

Demonstration of the Four Different VR Environments

Note. The environments demonstrate from the top left to the bottom right: a home environment, a restaurant, a bar, and a pub. Different daytime have been chosen based on what patients reported to be most likely to elicit anxiety

Procedure

Individuals diagnosed with AUD and meeting all inclusion criteria were informed about the study during the appointment with their psychiatrist at the Hospital Clinic Barcelona. Once the individuals agreed to participate in the study, they were referred to the researcher in charge of the study and signed the consent form. All patients took part in an initial assessment to gather information on their demographics and clinical anamnesis (age, gender, socio-economic status, civil status, comorbid psychopathologies, substance consumption in the mast month before the study, abstinence days and mediation use). Thereafter, the researcher asked the participants to fill out the questionnaires AUDIT and STAI-T. Next, the VR technology was presented through a short instruction explaining the use of the head-mounted display (HMD), sensors and touch controllers. Participants then were exposed for 20 seconds to each of the different environments and beverages and asked via the VAS-A about their momentary anxiety level dependent on the drinks and environments they were exposed to. Additionally, olfactory information of the

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beverages presented within the VR environment was introduced to the patients by a small amount of the actual drink being presented to the participants on a cotton pad to enhance a realistic experience (Ghiţă et al., 2021).

Data Analysis

First, the program SPSS 27 was used to analyze the (1) demographic variables age, gender, and socio-economic status. Hereby, the mean, standard deviation and minimum and maximum values were calculated. The variable age was transformed into a dichotomous variable to separate the age span of 18 to 45 years (young adults) to 46 to 69 years (older adults) as recommended by Ghiţă et al. (2021).

To test the research question, a series of four moderation analyses were carried out. Hereby, the dependent variable was cue-induced anxiety (as depicted by VAS-A), the independent variable was trait anxiety (as depicted by STAI-T), and the moderator was age. Consequently, moderation analysis was carried out to analyze whether participants' age moderates the relationship between trait- and state-anxiety in four different VR environments.

Figure 4

Representation of the Moderation effects of Age on Trait-Anxiety and VAS-A
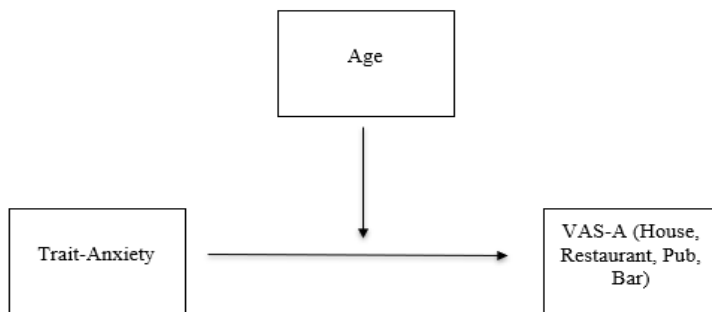
Note. VAS-A reflects the cue-induced anxiety (state-anxiety)

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<p style="text-align:center">Results</p>

Descriptive Statistics

The descriptive statistics of the sample can be found in Table 2. Overall, 81 participants were recruited for the study however, only 67 were included in the analysis. Due to incomplete data entry of 14 participants and thus, missing data on the VAS-A scale those participants were excluded from the study. The mean age of the sample was 51 years ranging from 25 to 69. 62.7% of the sample was represented by males. Overall, most of the participants reported to be either in a relationship or a marriage (43.3%) and had a moderate socio-economic status (79.1%) at the time of their inclusion in the study. Regarding psychiatric comorbidities, participants reported being diagnosed with personality disorder (37.3%), depression (19.4%) and anxiety (3%). In terms of using other substances besides alcohol 31.3% of the sample reported consuming other drugs. The overall mean score of the AUDIT was 16.43 (SD = 9.98), where the total scores range from 0 to 40 and the overall mean score of the STAI was 27.43 (SD = 11.77), where the total scores range from 0 to 60.

Table 2

Descriptive Statistics of the Participants (N = 67)

Variables	Categories	All Participants (N = 67)
Age, M (*SD*)		51 *(8.93)*
Gender, N (%)	Male	42 (62.7%)
	Female	25 (37.3%)
Socio Economic Status	Low	12 (17.9%)
	Moderate	53 (79.1%)
	High	2 (3 %)

Civil Status	In a Relationship/Married	29 (43.3%)
	Divorced	20 (20.9%)
	Single	12 (17.9%)
	Widower	5 (7.5%)
Comorbid Psychopathologies	Personality Disorder	25 (37.3%)
	Depression	13 (19.4%)
	Anxiety Disorder	2 (3%)
	Depression and Anxiety	6 (9%)
	Depression, Anxiety and Personality Disorder	2 (3%)
Other Substance Consumption in the past Month	No	46 (68.7%)
	Yes	21 (31.3%)
Abstinence Days, M (*SD*)		83.76 *(98.88)*
Medication	None	27 (40.3%)
	Antidepressants	13 (19.4%)
	Anxiolitics	10 (14.9%)
	Antipsychotic	2 (3%)
	Combination of Antidepressants and Anxiolitics	15 (22.4%)

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AUDIT, M (*SD*)	16.43 *(9.98)*
STAI-T, M (*SD*)	27.43 *(11.77)*
VAS-A Pub, M (*SD*)	35.14 *(26.92)*
VAS-A Bar, M (*SD*)	32.98 *(26.97)*
VAS-A House, M (*SD*)	32.84 *(27.32)*
VAS-A Restaurant, M (*SD*)	31.85 *(25.64)*

Note. The abbreviations stand for the following: Means (M), Standard Deviation (*SD*), Quantity (N), Percentages (%). Other substance consumption in the past month infers the use of any other addictive substances besides alcohol (e.g., cannabis). AUDIT refers to the Alcohol use Disorder Identification Test. STAI-T refers to the trait anxiety subscale of the State and Trait Anxiety Inventory. VAS-A refers to the cue-induced (state) anxiety measurement tool.

The Moderating Effect of Age on the Relationship between Trait-Anxiety (STAI-T) and State Anxiety (VAS-A House)

The VR environment house had an overall mean score of M = 32.84, *SD = 27.32* for momentary anxiety as measured by the VAS-A scale which ranges from 0 to 100. In the VR environment *house*, the overall regression model was significant R^2 .25 $F(2,64)$ 10.68 = $p<$ *.0005*. Without including the moderation effect the R^2 value was .25. This indicates that a 25% change in VAS-A house is accounted for by trait-anxiety. With the inclusion of the interaction term, the R^2 decreased to 0%. Further the significance of the moderation effect was analyzed, and the results revealed no significant moderation effect (b = -.002, *SE* = 24.03 t = -.189, p = .851, 95 % CI [-.028 - .023]). Either young adult's (p = .985) nor older adult's (p = .985) showed a significant effect. This implies that age had no effects on cue-induced anxiety as experienced in the VR environment house.

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The Moderating Effect of Age on the Relationship between Trait-Anxiety (STAI-T) and State Anxiety (VAS-A Restaurant)

   The VAS-A scale of momentary anxiety identified that sample had a mean score of M = 31.85, *SD =25.64* for the environment restaurant. By running a regression analysis in the VR environment *restaurant*, the regression model showed significant effects $F(2, 64) = 7.29$, $p = .001$, with an R^2 of .186. Without including the moderation effect the R^2 value was .186. This illustrates that an 18.6% change in VAS-A restaurant is accounted for by trait-anxiety. With the inclusion of the interaction term, the R^2 remained the same. Further the significance of the moderation effect was analyzed, and the results revealed no significant moderation effect ($b = .000$, $SE = 23.50$ $t = -.011$, $p = .991$, 95 % *CI* [-.024 - .025]). By analyzing the influences of the variable age on cue-induced anxiety it was found that either young adults ($p = .955$) or older adults ($p = .955$) have significant effects.

The Moderating Effect of Age on the Relationship between Trait-Anxiety (STAI-T) and State Anxiety (VAS-A Bar)

   The VAS-A scores for the VR environment bar were M = 32.98, *SD = 26.97*. Next, in the VR environment *bar* the regression analysis indicated significant effects $F(2, 64) = 6.67$, $p = .002$, with an R^2 of .166. Without including the moderation effect the R^2 value was .17. This indicates that a 16.6% change in the VAS-A bar is accounted for by trait anxiety. With the inclusion of the interaction term, the R^2 increased to 17,3%. Further the significance of the moderation effect was analyzed, and the results revealed no significant moderation effect ($b = -.009$, $SE =24.91$ $t = - .694$, $p = .49$, 95 % *CI* [-.035 - .017]). No significant effects were found by assessing the influence of age on cue-induced anxiety in the VR environment bar (both young and older adults $p = .43$).

The Moderating Effect of Age on the Relationship between Trait-Anxiety (STAI-T) and State Anxiety (VAS-A Pub)

   The VAS-A scores of the momentary anxiety showed overall mean scores of M = 35.14, *SD = 26.92* which were the highest among all other environments. In the last VR environment *pub,* the regression model was significant $F(2, 64) = 7.105$, $p = .002$, with an R^2 of .175. This demonstrates that a 17.5% change in VAS-A pub is accounted for by trait anxiety. With the

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inclusion of the interaction term, the R^2 increased to 18.2%. Further the significance of the moderation effect was analyzed, and the results revealed no significant moderation effect ($b = -.010$, $SE = 24.73$ $t = -.735$, $p = .465$, 95 % CI [-.035 - .016]). No significant effects were found in both young and older adults $p = 5.31$.

Discussion

Age as Moderator of the Relationship between Trait- and State-Anxiety (VAS-A)

  The objective of the study was to examine whether the relationship between trait – and state-anxiety is moderated by age. Based on the results it can be concluded that age does not have a significant moderating impact on the relationship between trait- and state-anxiety in all four environments, depicting that there must be other variables accounting for the relationship. There are inconclusive findings regarding the influences of age on anxiety where some studies suggested that there is no relationship whereas other do find a significant association.

  For example, Booth et al. (2016) assessed age as a predictor variable of state-anxiety in children and found a weak negative correlation between age and state-anxiety. Meaning that older children experience lower levels of state-anxiety than younger children. These results imply that there is an association between age and state-anxiety however, this study does not assess the moderating role of age on the relationship between trait-and state anxiety. Knowles and Olatunji (2020) compared trait-anxiety scores among individuals with depressive disorders and anxiety disorders and assessed the moderating effect of age. The authors had similar results as in the current study. Age was not a significant moderator in the relationship between (1) trait-anxiety and anxiety disorders and (2) trait-anxiety and depressive disorders (Knowles & Olatunji, 2020). However, the results changed as specific phobias were analyzed. The analysis indicated that older adults portrayed higher trait-anxiety scores than younger individuals, depicting the implications of age as a significant moderator of trait-anxiety and phobia in this regard (Knowles & Olatunji, 2020). Interestingly, the phobia is related to symptoms associated with an elevated sympathetic nervous system (e.g., racing heart rate, sweating, dizziness, and trembling) similar to state-anxiety (Spielberger, 1972). Since the findings are inconclusive, it is important to assess the moderating role of age in state-and trait-anxiety in further research. Moreover, due to the inconclusive results, it might also be of great importance to assess other variables that might have a moderating effect on the relationship between trait- and state anxiety.

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Moderator Variables

Various studies indicated that variables like *gender, perceived behavioral control, and religiosity* might have a moderating role in the relationship between trait- and state-anxiety (Hishinuma et al., 2000; Kearns et al., 2018). Gender was widely analyzed in addictive research but also studies examining anxiety. Research found that females are more vulnerable to various anxiety disorders (Somers et al., 2006) and tend to have higher levels of trait-anxiety than males (Hishinuma et al., 2000; Paillard et al., 2013). Besides that, Hishinuma et al. (2000) found that gender interacted with trait-anxiety in predicting state-anxiety. Based on these findings it can be inferred that gender is associated with trait- and state-anxiety and should be therefore, assessed in further research concerning its moderating role.

Besides gender, perceived behavioral control (individuals' belief about perceived ease or difficulty of performing a behavior) was widely assessed in the addictive field (Kearns et al., 2018). In a sample of adolescents, the moderating role of perceived behavioral control in the relationship between anxiety sensitivity (fear of anxiety symptoms) and alcohol use was assessed where significant effects were found (Kearns et al., 2018). More specifically, higher levels of anxiety sensitivity were associated with more alcohol use days for individuals with low perceived behavioral control over the anxiety. Therefore, it can be concluded that perceived behavioral control might serve as a protective factor against the development of AUD.

Interestingly, another moderating variable that was found to be also a protective factor for AUD is youth religiosity. A significant overall mean effect size indicated that youth religiosity has a negative correlation with alcohol use (Russell et al., 2020). Moreover, Russell et al. (2020) demonstrated that religiosity dimensions like the importance of beliefs and public religiosity (e.g., church attendance) significantly moderate the relationship between alcohol use and youth religiosity. Overall, it can be stated that gender was found to be the most interesting potential moderator of trait- and state anxiety which should be assessed in further research. Perceived behavioral control and religiosity were found to be rather protective factors against the development of AUD, which might be relevant in the development of relapse prevention strategies.

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Relationship between Trait Anxiety and State Anxiety (VAS-A)

Another finding in this study was, that there is a causal relationship between trait- and cue-induced anxiety (state-anxiety). This means that high levels of trait-anxiety that is, individuals' general tendency to appraise situations as threatening is related to higher levels of cue-induced anxiety (individuals' momentary levels of anxiety during VR exposure). This is in line with previous research which reported a positive correlation between trait-and state-anxiety. Xie and Newhagen (2014) analyzed the relationship between trait- and state-anxiety as induced by crime alerts via the mobile phone and demonstrated that trait-anxiety significantly predicts cue-induced anxiety. Moreover, Booth et al (2016) found that children that scored high in trait-anxiety had also elevated state-anxiety scores in stressful situations. Furthermore, a correlation between trait-anxiety and cue-induced anxiety is consistent with the idea that individuals high in trait-anxiety tend to have elevated attention towards a threat, might overestimate a potential threat and have an enhanced memory of threatening information (Bar-Haim et al., 2007; Mitte, 2008). Therefore, it is likely for AUD-diagnosed individuals who score high on trait-anxiety to experience also higher state-anxiety levels when presented with a threatening stimulus such as an alcoholic drink in a VR environment.

Notably, the results in the current study displayed different state-anxiety levels in all four environments whereas the highest momentary anxiety levels were experienced in a pub environment and the lowest momentary anxiety levels in the restaurant environment. These results indicate that a pub environment produces more anxiety in an AUD-diagnosed individual compared to a restaurant environment. This is in line with previous research suggesting that a permissive environment, cheap alcohol availability, poor cleanliness, crowding, loud music, a focus on dancing and poor staff practice are all related to excessive drinking and alcohol-related problems (Hughes et al., 2011). Indeed, there are different standards in a pub and a restaurant when it comes to drinking patterns. In a restaurant setting, it is usual to order food, and have a good service with an overall formal atmosphere whereas a pub is a more informal place where people come to hang up and drink together (Hughes et al., 2011).

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Assessment Implications by using VR

Ghiţă et al. (2019) tested the VR software used in this study and demonstrated it to be an ecologically valid tool to elicit cue-induced anxiety responses in patients diagnosed with AUD. Based on experience sampling methodology, the VR software can perform assessment of momentary cue-induced anxiety. Moreover, the software depicted statistically significant differences between AUD patients and social drinking patterns (Ghiţă et al., 2019). Overall, it can be stated that using VR technology together with already existing assessment tools for the assessment of anxiety in AUD-diagnosed individuals can assist the clinician and provide more insights regarding the underlying mechanisms of anxiety in AUD-diagnosed patients (Otkhmezuri et al., 2019). Hereby, the individual can be an active participant within a specific context which provides significant insights for the clinician regarding the behavior, feelings, and other underlying mechanisms (Otkhmezuri et al., 2019). Moreover, the potential of VR to physically immerse individuals, activate relevant memory schemas and evoke individuals' interpretation and emotional responses which in turn allow better assessment of complex disorders such as the AUD (Otkhmezuri et al., 2019).

Strengths, Limitations and Future Research Directions

The present study was based on the "ALCO VR" project and therefore, one of the strengths of this study is that the VR software is an ecologically valid assessment tool which was extensively researched and developed in collaboration with AUD patients (Ghiţă et al., 2019; Hernández-Serrano et al., 2020; Ghiţă et al., 2021). Moreover, to the best of my knowledge, this study is one of the first studies assessing the moderating role of age in the relationship between trait- and state-anxiety in AUD-diagnosed individuals.

The results of this study should be considered in light of its limitations. The "ALCO-VR" project was conducted at the Hospital Clinic of Barcelona and the sample consisted only of Spanish participants. This has an impact on the generalizability of this study since there are cultural differences in drinking patterns also among pathological drinkers which might imply that there are also differences in experienced levels of anxiety concerning alcohol (Aresi & Bloomfield, 2021). Next, the anxiety levels were measured utilizing self-reports only (STAI-T and VAS-A) which have several disadvantages like different conceptual comprehensions of anxiety, a lack of specified wording, or the referral to past events which might have resulted in an

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inaccurate measurement of anxiety (Paulhus & Vazire, 2007). Therefore, the inclusion of more objective measures would benefit the assessment and guarantee an accurate measurement of anxiety. Lastly, this study did not control for other covariables that might influence the results of this study. Research suggested that variables like gender and perceived behavioral control have effects on the relationship between trait- and state anxiety (Hishinuma et al., 2000; Kearns et al., 2018).

Future research can benefit from exploring the assessment of various mental health disorders with the VR technology further. By adding more psychophysiological parameters such as the heart rate or respiration to the VR technology objective measures would be included. Moreover, eye-tracking parameters could be included in the VR technology to explore individuals' eye movements in VR. By gaining insight into individuals' psychophysiological parameters and their eye movement more substantiated conclusions could be made, which are based not only on self-reports but also on objective measures of the VR technology. Another recommendation would be to explore other moderating variables like gender on the relationship between trait – and state – anxiety. This would give insights into significant moderators that influence these constructs and thus, allow for a more substantiated understanding of anxiety in AUD-diagnosed individuals.

Conclusion

There is a need for more updated assessment tools in the field of mental health and VR technology is a promising tool that can be used complementary to already existing instruments adding more insights and thus allowing for better assessment of complex mental health disorders like AUD. However, there is still a need for further research on this topic first to optimize the VR technology with more objective measures and second to investigate potential moderators of trait - and state – anxiety since age, was not moderating the relationship.

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Appendices

Appendix A

Table 1. DSM-IV Alcohol Abuse and Dependence Criteria

Alcohol Abuse		
Brief Identifier		Abstracted DSM-IV criterion
A1	Role Impairment	Frequent intoxication leading to failure to fulfill obligations at school, work, home
A2	Hazardous Use	Recurrent use when physically hazardous (e.g., drinking and driving)
A3	Legal Problems	Recurrent alcohol-related legal problems
A4	Social Problems	Continued use despite social or interpersonal problems caused or exacerbated by use

Alcohol Dependence		
Brief Identifier		Abstracted DSM-IV criterion
D1	Tolerance	Need to consume more to obtain the same effect; decreased effect at the same dose
D2	Withdrawal	Withdrawal symptoms; drinking to avoid or relieve withdrawal
D3	Larger/Longer	Drinking more or longer than intended
D4	Quit/Cut Down	Persistent desire or repeated unsuccessful attempts to quit or cut down on alcohol use
D5	Much Time	Much time spent obtaining, using, or recovering from the effects of alcohol
D6	Reduced Activities	Reduce or stop important activities in order to drink
D7	Physical/ Psychological Problems	Continued use despite physical or psychological problems caused or exacerbated by use