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Interoceptive accuracy and interoceptive sensibility in individuals with alcohol use disorder–Different phenomena with different clinical correlations?

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Abstract

Background: Interoception may contribute to substance use disorder as it relates to the body's experience of substance use or withdrawal. However, only a few studies have directly investigated associations between interoception and alcohol use. The objective of this study was to compare individuals with alcohol use disorder (AUD) and healthy controls on interoceptive sensibility and accuracy.

Methods: The sample was comprised of two groups: individuals meeting criteria for AUD (N = 114) and healthy controls (N = 110) not meeting criteria for AUD. Interoceptive sensibility was assessed with a self-report measure (the Private Body Consciousness subscale) and interoceptive accuracy – with a behavioral measure (the Schandry test). In addition, associations between interoception and other well-recognized correlates of AUD (sleep problems, depressive and anxiety symptoms, impulsivity) were tested. Barratt's Impulsiveness Scale, Brief Symptom Inventory, and Athens Insomnia Scale were utilized to assess psychopathological symptoms as covariates.

Results: When controlling for level of anxiety, sleep problems, age, sex and education, individuals with AUD scored significantly higher on self-reported interoceptive sensibility and lower on interoceptive accuracy in comparison to healthy controls. Higher interoceptive sensibility was associated with more severe sleep problems and anxiety symptoms.

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Contributors

All authors contributed to the conceptualization and design of the analyses. MK and AJ designed the study and wrote the protocol. AJ, MK, SJ, ZJ, NM, MA contributed to the data collection. AJ, MK, TEM, HS took responsibility for conducting analyses. AJ, MK, HS, MW, NM, SJ managed the literature search. AJ and MK wrote the first draft of the manuscript. TEM, HS, MW, ZJ, MA provided substantive and conceptual feedback on all drafts. All authors contributed to and have approved the final manuscript.

Conflict of interests

No conflict declared.

Conclusions: These results have to be treated as preliminary and need to be replicated; however, findings indicate that interoception may present a novel therapeutic target for treatment of AUD.

Keywords

Alcohol use disorder; Interoceptive accuracy; Interoceptive sensibility; Anxiety

1. Introduction

Alcohol use contributes significantly to the global health burden and costs to society (Rehm et al., 2009). Alcohol use disorder (AUD) is characterized by persistent vulnerability to relapse even after specialized treatment (Moos and Moos, 2006).

The way an individual experiences body-relevant signals with an external stimulus may impact the degree to which alcohol is consumed or avoided. Recent theories support the role of interoception in the development of addiction (Paulus and Stewart, 2014). Interoception reflects the way one perceives stimuli from the body including temperature, pain, heart rate, and muscular and visceral sensations among others (Craig, 2002). Interoception is thought to serve a homeostatic function such that an individual's approach or avoidance behavior toward stimuli is aimed at maintaining equilibrium in the body's internal state. It is suggested that interoceptive processing may be associated with general levels of arousal (Paulus and Stewart, 2014), which may be important in the context of alcohol – commonly used for regulating the level of arousal.

Interoception may contribute to addiction by incorporating an "embodied" (felt as a state of the body) experience of substance use or withdrawal (Paulus and Stewart, 2014). The difference between an individual's perceived versus actual internal (somatic and simultaneously emotional) state may modulate substance approach or avoidance behavior in order to enhance or decrease the embodied arousal. Neurobiological studies suggest that the neural circuits involved in processing visceral afferents, namely the insula, overlap with those responsible for control, salience assessment, and reward processing (Paulus and Stewart, 2014).

Despite this strong conceptual background (Verdejo-Garcia et al., 2012), research on the role of interoception on substance use is inconsistent. Some studies find that "poor interoceptors" are protected against intense cravings (Naqvi et al., 2007), while others suggest that patients with high interoceptive awareness experience more aversive states associated with substance use (Verdejo-Garcia and Bechara, 2009). One study investigating the association between alcohol use and interoception among healthy volunteers found an association between self-reported sensitivity to bodily sensations and alcohol consumption (Betka et al., 2018). Another study demonstrated that alcohol use may impair interoceptive accuracy among social drinkers (Abrams et al., 2018). Most studies tend to include only self-reported measures of interoception, a notable limitation as several studies indicate that behavioral measures of interoception are often weakly correlated with self-reported measures (i.e., interoceptive sensibility) (Ainley and Tsakiris, 2013; Garfinkel et al., 2015). To the best of our knowledge, no study has examined interoception among individuals with AUD. However, there is substantial evidence (Schuckit et al., 2009, 2012; Kramer et al., 2008) that lower levels of physical self-reported perception of alcohol intoxication, predicts higher AUD risk. Therefore, it is plausible that interoception may impact AUD and there may be utility in examining interoceptive sensibility and accuracy as separate constructs consistent with recent conceptualizations.

Moreover, there has been increasing interest in the association between interoception and psychopathological symptoms that commonly co-occur with AUD: sleep problems, depression and anxiety (Turner et al., 2018; Brower, 2003). Some studies suggest differences in interoceptive signaling among individuals with anxiety and those with a comorbid depressive disorder (Hofmann et al., 2010). There is converging evidence for increased interoceptive sensitivity among those with anxiety symptoms and sleep problems. Namely, individuals with anxiety or sleep problems tend to demonstrate a significant discrepancy between their self-reported interoceptive sensitivity and more objective measures of interoception (Domschke et al., 2010; Ewing et al., 2017). Poor sleep quality and higher anxiety were associated with lower interoceptive accuracy, albeit higher interoceptive sensibility. Given the overlap between sleep problems, anxiety symptomatology, and problematic alcohol use, it is possible that individuals with AUD may demonstrate a similar pattern of lower interoceptive accuracy and higher self-reported interoceptive sensibility. Yet, these associations have not been empirically tested.

The aim of this study was to compare individuals with AUD and non-dependent healthy controls (HCs) in terms of self-reported interoceptive sensibility and behaviorally measured interoceptive accuracy. Associations between interoception and clinical correlates of AUD (sleep problems, depressive and anxiety symptoms, impulsivity) were also analyzed. In contrast to other studies, the effects of alcohol drinking on embodied perception were not investigated, rather interoceptive accuracy and sensibility in healthy controls and sober individuals with AUD were assessed. We hypothesized that individuals with AUD would score significantly higher on self-reported interoceptive sensibility and lower on interoceptive accuracy compared to HCs.

2. Material and methods

2.1. Participants and procedures

The current study employed a cross-sectional design and was conducted in the Addiction Treatment Center and Primary Care Ambulatory Service in Warsaw, Poland. Participants older than 18 (n = 114) entering an eight-week, abstinence-based, inpatient treatment program for individuals meeting criteria for severe AUD were recruited. Recruitment procedures were implemented during the admission to the treatment center and were provided by medical doctors who were members of the study team employed in the study site. Due to a significant overrepresentation of men in Polish addiction treatment programs, the AUD group was composed primarily of men (89.5%).

The diagnosis of AUD was based on the International Classification of Diseases and Related Health Problems 10th Revision (WHO, 1992) and supported by the MINI International Neuropsychiatric Interview (Sheehan et al., 1998). Patients were not eligible for the treatment program if they had a clinically significant cognitive deficit (< 25 on the Mini-

Mental State Examination) (Folstein et al., 1975) or met any of the following criteria: a history of psychosis, co-occurring psychiatric disorders requiring medication (e.g., psychosis, bipolar disorder, active depressive or anxiety disorder) or the presence of acute alcohol withdrawal symptoms.

HCs (n = 110; 82 [74.5%] men) included patients presenting to a general practitioner for treatment of an infection, for a prophylactic examination, or for medical advice. The primary exclusion criterion for the HC group was presence of AUD symptoms or harmful alcohol use as assessed by the Alcohol Use Disorders Identification Test (AUDIT) (Babor and Higgins-Biddle, 2000). Other exclusion criteria were similar to those for the AUD group.

This study received approval from the Bioethics Committee at the Medical University of Warsaw (approval number KB/258/2016).

2.2. Measures

Sociodemographic characteristics (e.g., age, biological sex, education) were obtained using a self-report questionnaire.

2.2.1. Psychiatric comorbidity was assessed with the Polish version of the MINI International Neuropsychiatric Interview (Masiak and Przychoda, 1998)— The Brief Symptom Inventory (BSI) (Derogatis and Melisaratos, 1983) was utilized to assess depressive and anxiety symptoms. Sleep problems were assessed using the Polish version of Athens Insomnia Scale (Fornal-Pawlowska et al., 2011).

2.2.2. Impulsivity—The 30-item Barratt Impulsiveness Scale (BIS-11) (Patton et al., 1995) was utilized as a subjective measure of impulsivity.

2.2.3. Interoceptive accuracy—The mental tracking task developed by Schandry (Schandry, 1981) was applied by instructing participants to silently count their heartbeats in three trials of different lengths (25, 35 and 45 s) by concentrating on bodily sensations that might be associated with heart activity while monitoring their heartbeat. Interoceptive accuracy was calculated according to the following formula:

$$1/3\,\Sigma\,(1-(|\text{actual heartbeats}-\text{reported heartbeats}|)/\text{actual hearbeats})\,.$$

Perfect correspondence between the reported and actual heartbeats is represented by a value of 1. The heartbeat perception test was available for 66 individuals in the AUD group, and for 104 HCs. There were no significant differences between those individuals with and without available Schandry test data.

2.2.4. Interoceptive sensibility—The Private Body Consciousness subscale (PBCS) (Miller et al., 1981) from the Body Consciousness Questionnaire consists of 5 items reflecting the tendency to focus on internal body sensations. Specifically, it assesses awareness of heart beating, internal bodily tensions, hunger, dry mouth/throat, and body temperature (e.g., “I am sensitive to internal body tensions”). Higher scores indicate higher levels of interoceptive sensibility. PBCS data were available for 107 individuals in the AUD group, and for 106 HCs. Analyses were performed for all participants. Results were similar among individuals with available Schandry test data.

2.3. Statistical analyses

Study variables, except for age, were not normally distributed. Study groups were first compared in terms of sociodemographic and clinical characteristics. For this purpose, one-way analysis of variance (ANOVA) was utilized. ANOVA is considered to be robust against violations of the normality distribution assumption using both real and simulated data (Keselman et al., 2008; Schmider et al., 2010). As there was not a significant association between interoceptive accuracy and interoceptive sensibility in either of the study groups, two sets of oneway between group analysis of covariance (ANCOVAs) were performed (separately for the Schandry and PBCS scores as dependent variables). Variables that differed across study groups were included as covariates in ANCOVA models. Correlations between interoceptive accuracy and sensibility and correlates of AUD (sleep problems, impulsivity, depressive and anxiety symptoms) were also assessed.

3. Results

3.1. Between group comparisons

The AUD group was significantly older, less educated, and more likely to be male than HCs (see Table 1). Moreover, individuals with AUD were significantly more impulsive, and reported more sleep problems, depressive symptoms, and anxiety symptoms. Given the high correlation ($r = 0.83$) between anxiety and depressive symptoms, only anxiety symptoms were included as a covariate. Individuals with AUD scored significantly lower on interoceptive accuracy and significantly higher on self-reported interoceptive sensibility.

The ANCOVA models revealed that the differences between the groups remained significant even when controlling for all factors that were significant in the bivariate analyses (see Table 2).

3.2. Additional analyses

Additional analyses indicated that among individuals with AUD, the Schandry score was not associated with any of the study variables. However, higher interoceptive sensibility was associated with more sleep problems ($r = 0.24$, $p = 0.014$) and anxiety symptoms ($r = 0.27$, $p = 0.005$). There was no association between interoceptive sensibility and either impulsivity or depressive symptoms among individuals with AUD. These correlations were similar among HCs (i.e., the Schandry score was not associated with any of the study variables; higher interoceptive sensibility was associated with more sleep problems [$r = 0.33$, $p < 0.0001$] and anxiety symptoms [$r = 0.30$, $p = 0.001$], but not with impulsivity or depressive symptoms).

4. Discussion

As hypothesized, individuals with AUD scored higher on self-reported interoceptive sensibility and lower on interoceptive accuracy in comparison to HCs. Interoceptive sensibility was positively associated with sleep problems and anxiety symptoms, which are well-recognized clinical correlates of AUD (Brower, 2003; Turner et al., 2018). Between group differences emerged when controlling for anxiety and sleep problems. This suggests that interoception may represent an independent factor influencing risk of problematic alcohol use. While the significance of interoception has been discussed in relation to other substances of abuse (Paulus and Stewart, 2014; Verdejo-Garcia et al., 2012), to the best of our knowledge this is the first study to investigate interoceptive accuracy and sensibility in a clinical sample of individuals with AUD. The current study utilized both a self-report questionnaire measure of interoception, as well as a behavioral tool to verify ones' feelings regarding somatic ("embodied") processes. The difference between one's perception (subjective) compared to what is actually happening (objective) in their body is a crucial aspect of investigating interoception in clinical populations. This conceptualization of interoception characterizes most of the recent studies and findings in this area (Abrams et al., 2018; Garfinkel et al., 2015; Ainley and Tsakiris, 2013), but has not been employed in studies on AUD samples. Moreover, in contrast to other studies (Schuckit et al., 2009, 2012; Kramer et al., 2008), effects of alcohol drinking on embodied perception were not investigated, rather interoceptive accuracy and sensibility in sober individuals was assessed. Therefore, our assessment was independent of the acute effects of alcohol, which is also (to the best of our knowledge), a novel approach.

Our results indicate that individuals with AUD are characterized by a discrepancy between self-reported interoceptive sensitivity and heartbeat perception (Domschke et al., 2010; Ewing et al., 2017). Prior work demonstrates that in clinical populations with impaired emotion processing, reduced interoceptive accuracy may lead to elevated interoceptive sensibility (Garfinkel et al., 2016). Prior research suggests that the degree of overlap between subjective and behavioral dimensions of interoception can predict emotional states and affective psychopathology (Critchley and Garfinkel, 2017). It was shown that interoceptive sensitivity may predict inter-individual differences in recruiting adaptive autonomic response strategies (Ferri et al., 2013).

Interestingly, in our sample, interoceptive sensibility was associated with anxiety symptoms but, in contrast to prior work (Harshaw, 2015), not with depressive symptoms. Some studies indicate possible differences in interoceptive signaling among individuals with anxiety and those with a comorbid depressive disorder (Hofmann et al., 2010). Although our methodology did not allow this, future studies should examine possible mechanisms reflecting differences among individuals with AUD and other comorbid disorders.

It is possible that individuals with AUD may experience higher interoceptive sensibility, higher arousal, and an approach attitude towards alcohol as a compensatory strategy for poor interoceptive accuracy. Notably, poor accuracy may represent a risk factor of AUD. Consistent with prior work (Schuckit et al., 2009, 2012; Kramer et al., 2008), lower levels of embodied perception of alcohol intoxication predicted higher risk for AUD. Moreover, alcohol likely impairs interoceptive accuracy (Abrams et al., 2018), characterizing the vicious cycle that maintains the disorder.

It is possible that individuals with AUD may deal with embodied experiences using their drug of choice, as alcohol may affect their body and emotions in a certain, specific, and expected way. Schuckit et al. (2012) demonstrated that low response to alcohol (both somatic and emotional) increased alcohol use due to more positive expectancies (e.g., alcohol can help cope with stress) of the effects of alcohol. From a neurobiological perspective, the neural circuits involved in processing visceral afferents overlap substantially with those involved in arousal-related processing. Namely, the insula has been found to be responsible for control, salience assessment, and reward processing (Paulus and Stewart, 2014). These connectivity patterns suggest that the insula may be important for translating interoceptive/emotional stimuli into activation of the cognitive control network to implement goal-directed behavior, especially those aimed at decreasing arousal (like drinking alcohol). Similarly, adolescents diagnosed with substance use disorder demonstrated altered insula response to pleasant interoceptive stimuli (Migliorini et al., 2013).

Consistent with prior work demonstrating that interoceptive awareness training may help increase the number of abstinent days and decrease craving (Price et al., 2018), the current study could help improve existing AUD treatments. Given that alcohol urges (both somatic and emotional) are associated with higher interoceptive sensibility (Rohsenow et al., 1994; Monti et al., 1993), individuals with AUD may benefit from interventions focused on redirecting interoceptive input towards competitive natural reinforcers like physical exercise. However, given the preliminary nature of our results, specific recommendations for treatment may be premature.

5. Limitations

Only participants with severe AUD from an inpatient treatment program were recruited. These individuals may be more attuned to alcohol-related phenomena and thus have increased sensibility towards interoceptive stimuli. The majority of the study sample was men. In addition, individuals with active depressive or anxiety disorders were not recruited. However, we believe that using anxiety and sleep problems as continuous variables allowed to detect subtle nuances that may emerge based on severity of these symptoms in our group.

The Schandry test was only available for 58% of individuals with AUD. Also, the validity of the Schandry test as a measure of interoceptive accuracy has recently been questioned since this task may be influenced by beliefs and expectancies about heart rate and working memory (Zamariola et al., 2018). However, there is also evidence that the Schandry test is correlated with other interoceptive tasks (Herbert et al., 2012).

In general, our results should be treated with caution and need replication. Future research should attempt to replicate these findings with a larger sample size and assess how interoception may be associated with comorbidities and severity of AUD symptoms. Also, it would be informative to explore potential associations between interoception and more distinct emotional processes, such as emotion regulation (Critchley and Garfinkel, 2017) in AUD.

6. Conclusions

This is the first study to show that individuals with AUD are likely characterized by both high interoceptive sensibility and low interoceptive accuracy. Higher interoceptive sensibility was shown to be associated with important clinical correlates of AUD, however between group differences emerged even when controlling for anxiety and sleep problems. This suggests that interoception may represent an independent factor associated with problematic alcohol use. Although preliminary, results indicate a possible novel therapeutic target for treatment of AUD.

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Table 1

Comparison between healthy controls and individuals with alcohol use disorder (AUD).

	Individuals with AUD (mean ± SD)	**Healthy controls (mean ± SD)**	***p***
Age	43.35 ± 11.5	40.57 ± 8.2	0.039
Sex (% men)	89.5%	74.5%	0.005
Education (years)	11.8 ± 3.2	15.6 ± 4.3	< 0.0001
Depressive symptoms (BSIdep)	1.1 ± 0.8	0.2 ± 0.3	< 0.0001
Anxiety (BSIanx)	0.89 ± 0.8	0.24 ± 0.3	< 0.0001
Impulsivity (BIS total)	69.5 ± 9.9	55.95 ± 6.9	< 0.0001
Sleep problems (AIS)	7.56 ± 4.7	3.71 ± 3.1	< 0.0001
Interoceptive accuracy (Schandry score)	0.46 ± 0.3	0.72 ± 0.1	< 0.0001
Interoceptive sensibility (PBCS)	17.52 ± 4.2	14.85 ± 4.1	< 0.0001

BSI – Brief Symptom Inventory, BIS – Barratt’s Impulsiveness Scale, AIS – Athens Insomnia Scale, SD – Standard Deviation, dep – depressive symptoms, anx – anxiety symptoms, PBCS – Private Body Consciousness subscale.

Table 2

Models of one-way analysis of covariance (ANCOVA) for dependent variable: Schandry score and interoceptive sensibility.

	Interoceptive accuracy (Schandry score, N = 169)		**Interoceptive sensibility (PBCS, N = 213)**	
	p	**Partial eta square**	***p***	**Partial eta square**
Age	**< 0.0001**	**0.137**	0.2	0.008
Sex	0.16	0.012	0.38	0.004
Education	0.29	0.007	0.73	0.001
Impulsivity (BIS total)	0.22	0.009	0.104	0.013
Anxiety symptoms (BSIanx)	0.94	0.001	**0.022**	**0.025**
Sleep problems (AIS)	0.76	0.001	**0.014**	**0.029**
Group	**< 0.0001**	**0.251**	**0.011**	**0.031**
	Rsquare = 0.387		Rsquare = 0.198	
	Corrected Rsquare = 0.361		Corrected R square = 0.170	

BSI – Brief Symptom Inventory, BIS – Barratt's Impulsiveness Scale, AIS – Athens Insomnia Scale, PBCS – Private Body Consciousness subscale, anx – anxiety symptoms.