

Original Article

Chemosensory Dysfunction in Alcohol-Related Disorders: A Joint Exploration of Olfaction and Taste

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Abstract

Chemosensory (olfaction–taste) dysfunctions are considered as reliable biomarkers in many neurological and psychiatric states. However, experimental measures of chemosensory abilities are lacking in alcohol-dependence (AD) and Korsakoff Syndrome (KS, a neurological complication of AD), despite the role played by alcohol-related odors and taste in the emergence and maintenance of AD. This study thus investigated chemosensory impairments in AD and KS. Olfactory–gustatory measures were taken among 20 KS, 20 AD, and 20 control participants. Olfaction (odor detection–discrimination–identification) was assessed using the “Sniffin Sticks” battery and taste was measured using the “Taste Strips” task. Impairments were found for high-level olfaction in AD (odor discrimination) and KS (odor discrimination–identification), even after controlling for psychopathological comorbidities. Gustatory deficits were also observed in both groups, indexing a global deficit for chemosensory perception. Finally, the gradient of impairment between the successive disease stages for odor identification suggests that the hypothesis of a continuum between AD and KS regarding cognitive deficits can be generalized to chemosensory perception. AD and KS are thus characterized by deficits in chemosensory abilities, which could constitute a marker of the AD–KS transition. In view of its deleterious influence on everyday life, chemosensory dysfunction should also be taken into account in clinical settings.

Key words: alcohol-dependence, Korsakoff syndrome, olfaction, taste

Introduction

Chemosensory perception, which is crucially involved in major human abilities like nutrition behaviors, harm avoidance, and social communication (Rolls 2006) has recently emerged as a blooming research field in neurological and psychiatric populations and is now considered as a reliable biomarker of disease stage, improving early diagnosis (Atanasova et al. 2008). However, olfaction and taste abilities remain underexplored in several pathological states, and particularly in alcohol-related disorders despite the importance of alcohol-related chemosensory cues in the development and maintenance of alcohol-dependence (AD) (Bragulat et al. 2008). Controversial results have indeed been found for olfaction, and taste abilities remain unexplored in AD. Moreover, the evolution of chemosensory impairments across the different stages of alcohol-related disorders remains unknown, particularly regarding the transition between AD and Korsakoff syndrome (KS), a classical neurological complication of AD centrally characterized by massive memory deficits.

An influential proposal in this field is the “continuity hypothesis” (Ryback 1971), which postulates a continuum between AD and KS characterized by a gradient in neurological and cognitive dysfunctions from early stages of AD to KS, the latter presenting much more serious behavioral and cerebral impairments. This hypothesis has been confirmed for memory impairments but has not been explored for other abilities, and notably for olfactory and gustatory functions. Indeed, chemosensory functions in KS have not been explored using validated and reliable experimental tools, and have never been directly compared with the performance of matched alcohol-dependent individuals.

The present study thus aimed at exploring olfaction and taste abilities in AD and KS by means of a standardized experimental design allowing the exhaustive evaluation of olfactory subcomponents and gustatory function with validated measures [Sniffin Stick Test (Kobal et al. 2000) and Taste Strips Test (Landis et al. 2009)] and with a strict control of psychopathological biasing variables.

Materials and methods

Participants

Three groups of 20 participants, matched for gender, age, and education, took part in the study: 1) 20 KS participants, diagnosed with “amnesia due to substance abuse” according to DSM-IV criteria and recruited during their long-term stay at the Neuropsychiatric Hospitals of Saint-Martin and Beau-Vallon (Belgium). All KS participants had a history of AD and presented severe memory disorders with social repercussions. The KS diagnosis was confirmed by an exhaustive neuropsychological evaluation. All KS participants had been abstinent for at least 6 months and were given adapted nutrition and vitamin supplementation; 2) 20 uncomplicated AD participants, diagnosed with AD according to DSM-IV criteria and recruited during their third week of detoxification treatment. They had all been abstinent for at least 2 weeks and were free of KS; 3) 20 healthy control subjects (CS) without past alcohol abuse or dependence, with a current alcohol consumption lower than 10 units per week and without any alcohol consumption during the 3 days preceding testing session. All participants were free of any major medical problem, other psychiatric disorder, neurological impairment (including head trauma and epilepsy), positive history of olfactory loss or olfactory disorder and polysubstance abuse, as assessed by an exhaustive examination. Participants’ characteristics and chemosensory raw scores are presented in Table 1. Education level was assessed according to the number of years of education completed since starting primary school. Nicotine dependence was assessed according to the number of cigarettes smoked per day. The study was approved by the Ethics Committee of the Medical School (Université catholique de Louvain, Belgium) and was conducted according to the principles of the Declaration of Helsinki. All participants provided written informed consent to take part in the study and were tested individually. The complete evaluation required 1 h and participants were given breaks between tasks. Depression [Beck Depression Inventory (Beck et al. 1996)] and anxiety [State and Trait Anxiety Inventory, form A and B (Spielberger et al. 1983)] were measured. Sample size was estimated with an a priori power analysis based on previous studies (Rupp et al. 2006; Maurage et al. 2011a, 2011b).

Table 1. Demographic, psychopathological and raw chemosensory results for CS, AD, and KS participants: mean (SD)

	CS (N = 20)	AD (N = 20)	KS (N = 20)	Post hoc <i>t</i> -tests [<i>t</i> (38)]		
				CS-AD	CS-KS	AD-KS
Demographic measures						
Age	53.20 (5.27)	49.90 (8.52)	55.45 (8.14)	1.47	1.04	1.82
Gender ratio (F/M)	11/9	9/11	10/10	0.40	0.10	0.10
Education level (years)	15.90 (3.27)	13.90 (4.01)	12.40 (2.28)	1.64	3.58***	1.36
Alcohol consumption (units/day) ^a	0.86 (0.73)	18.92 (10.46)	16.75 (6.29)	7.69***	11.23***	0.72
Nicotine addiction (cigarettes/day)	0 (0)	8.30 (10.06)	11.02 (10.24)	3.69***	4.81***	0.84
Psychopathological measures						
Beck Depression Inventory	2.30 (2.63)	8.95 (7.15)	6.65 (5.67)	3.90***	3.10**	1.12
State Anxiety Inventory	29.00 (8.22)	37.60 (14.84)	37.05 (13.10)	2.26*	2.32*	1.24
Trait Anxiety Inventory	36.40 (6.06)	49.40 (12.10)	43.85 (8.78)	4.29***	3.12**	1.66
Raw chemosensory scores						
Olfactory total score	36 (3.99)	32.27 (4.29)	24.92 (7.71)	1.67	4.79***	3.36**
Olfactory threshold	8.81 (2.64)	7.93 (2.79)	5.61 (2.97)	0.08	2.14	2.25
Olfactory discrimination	13.90 (1.55)	11.70 (1.95)	9.80 (3.33)	3.09**	4.37***	1.29
Olfactory identification	13.30 (1.66)	12.65 (2.08)	8.91 (3.61)	0.86	4.39***	3.86***
Taste total score	12.45 (2.58)	9.70 (3.21)	8.25 (3.51)	3.01*	3.75***	0.70

^aCurrent alcohol consumption for CS, consumption before detoxification for AD and KS.

P* < .05; *P* < .01; ****P* < .001.

Task and procedure

Psychophysical testing of olfactory and gustative functions

Olfactory testing was conducted through the “Sniffin’ Sticks test” (Kobal et al. 2000) consisting in 3 subtests (score range: 0–16) respectively evaluating odor threshold (T), discrimination (D), and identification (I), leading to a composite score (TDI, score range: 0–48). Gustatory testing was conducted through the “Taste Strips Test” (Landis et al. 2009) evaluating the 4 basic tastes and leading to a total score (range: 0–16).

Data analytic plan

Statistical analyses were performed using SPSS 21. One-way ANOVA were computed on control measures. ANCOVAs were computed for experimental measures, with control variables (education, depression, anxiety, nicotine dependence) as covariates: for olfaction, a 3×3 MANCOVA was conducted with groups as between-subjects factor and olfaction measures as within-subjects factors; for taste, a 1-way ANCOVA was conducted with groups as between-subjects factor and taste score as within-subjects factor. Bonferroni tests were used for post hoc comparisons. Pearson’s correlations were conducted to explore the link between experimental variables. The alpha level was set at 0.05.

Results

Control measures

Groups did not differ for gender [$\chi^2(2, n = 60) = 0.4$, NS] and age [$F(2, 57) = 2.81$, NS], but differences were found for education level [$F(2, 57) = 5.26$, $P < 0.01$], nicotine dependence [$F(2, 57) = 9.60$,

$P < 0.001$], depression [$F(2, 57) = 7.57$, $P < 0.001$], state anxiety [$F(2, 57) = 3.02$, $P < 0.05$], and trait anxiety [$F(2, 57) = 9.80$, $P < 0.001$]. Post hoc t -tests are presented in Table 1.

Psychophysical olfactory measures

A significant main group effect was found [$F(2, 52) = 12.97$, $P < 0.001$] as well as a significant interaction between group and olfaction subcomponents [$F(4, 104) = 2.51$, $P < 0.05$], as illustrated in Figure 1. Post hoc t -tests are presented in Table 1.

Psychophysical taste measures

A main effect of group was found [$F(2, 52) = 7.51$, $P < 0.001$], as illustrated in Figure 1. Post hoc t -tests are presented in Table 1.

Complementary analyses

Pearson’s correlations were computed between experimental measures, showing positive correlations between the 3 olfactory subcomponents as well as positive correlations between taste score and odor discrimination-identification. These results are reported in Table 2.

Additional analysis was conducted within pathological groups to test the association between smoking and chemosensory impairment. Within each group separately, a 2×4 MANOVA with smoking habits (smoker vs. nonsmoker) as between-subjects factor and experimental measures as dependent variables was conducted. Smokers and nonsmokers did not significantly differ for olfactory threshold [KS: $F(1, 18) = 0.01$, NS; AD: $F(1, 18) = 0.34$, NS], discrimination [KS: $F(1, 18) = 0.01$, NS; AD: $F(1, 18) = 0.56$, NS], or identification

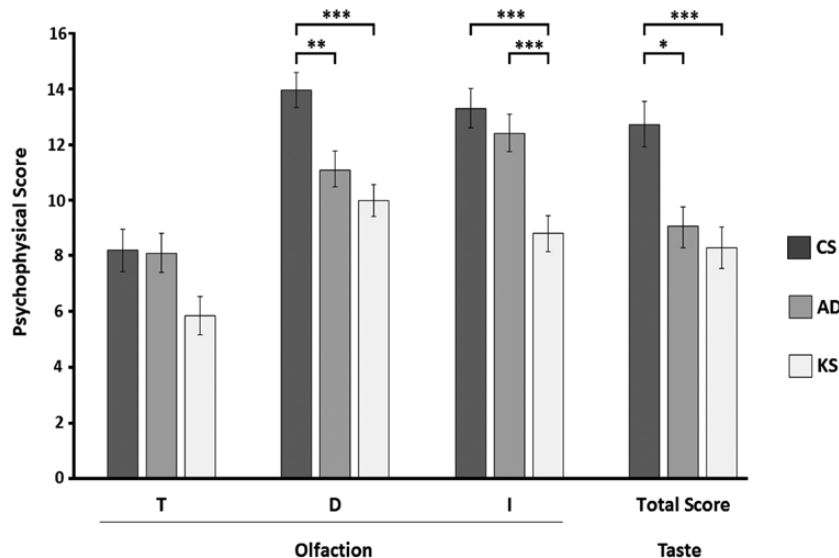


Figure 1. Olfactory and gustatory results for CS, AD, and KS participants. The scores presented for each olfactory subscale (threshold, discrimination, identification) and total taste score are corrected for depression, state anxiety, trait anxiety, education level, and nicotine dependence using covariance analyses. Covariates appearing in the model are evaluated at the following values: 5.97 for Beck Depression Inventory, 34.55 for State Anxiety Inventory, 43.22 for Trait Anxiety Inventory, 14.07 for education level, and 6.44 for nicotine dependence. * $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$.

Table 2. Pearson’s correlations across groups ($N = 60$) between olfactory and gustatory measures: r -value (P -value)

	Olfactory threshold	Olfactory discrimination	Olfactory identification	Taste total
Olfactory threshold	1.00			
Olfactory discrimination	0.45 ($P < 0.01$)	1.00		
Olfactory identification	0.41 ($P < 0.01$)	0.64 ($P < 0.01$)	1.00	
Taste total	0.09 ($P = 0.49$)	0.43 ($P < 0.01$)	0.46 ($P < 0.01$)	1.00

Significant results are indicated in bold text.

[KS: $F(1, 18) = 0.24$, NS; AD: $F(1, 18) = 0.45$, NS], nor for taste [KS: $F(1, 18) = 1.61$, NS; AD: $F(1, 18) = 0.14$, NS].

Discussion

The main results can be summarized as follows: 1) AD and KS both showed impaired olfactory discrimination compared with paired CS, which suggests that high-level olfactory functions, and particularly the ability to discriminate between different complex odors, is impaired in alcohol-related disorders (Rupp et al. 2006; Maurage et al. 2011a). Olfactory abilities may thus serve as a biomarker of alcohol-related disorders, in line with previous results in other neuropsychiatric disorders (Atanasova et al. 2008); 2) AD and KS diverged regarding olfactory identification, which was preserved in AD and impaired in KS (indexing a global impairment for high-level olfactory functions in KS). This progressive deficit across the successive stages of alcohol-related disorders leads to the proposal that olfactory assessment may constitute a complementary tool to assess the severity level of alcohol-related disorders; 3) These olfactory deficits cannot be attributed to a general olfactory impairment (e.g., due to peripheral neurological deterioration of the olfactory nerve), as both groups presented preserved primary low-level olfactory processing (i.e., threshold detection); 4) This first experimental exploration of gustatory abilities in AD and KS clearly showed that alcohol-related disorders are associated with reduced taste abilities. AD and KS are thus not merely associated with olfactory alterations but rather with a global deficit for chemosensory perception, which makes sense in view of the strong convergences between olfactory and taste abilities, notably regarding their cerebral bases (Rolls 2006).

Despite the need for confirmation on larger samples and with stronger control of potentially biasing variables and AD characteristics, the current results already have several crucial implications. At the most fundamental level, they show that olfaction and taste are strongly and jointly impaired in AD and KS, suggesting a global deficit for chemosensory perception in alcohol-related disorders. Chemosensory testing might thus constitute an efficient tool for the early diagnosis of AD, and be used as a reliable biomarker of this pathological state. They also offer insights concerning the generalization of the continuum hypothesis (Ryback 1971), with regard to: 1) olfaction, where a continuum between AD and KS is observed (KS being characterized by a worsening of olfactory impairments shown in AD, that is, an extension to odor identification), and 2) taste, where a global deficit is found for AD and KS, potentially indicating that taste abilities are impaired early in the course of alcohol-related problems and are then stable through the successive stages of the disease. At the therapeutic level, although chemosensory perception has, up to now, been totally unexplored and untreated in clinical practice, the present results show the extent and importance of olfactory and gustatory impairments in alcohol-related disorders. Chemosensory dysfunctions, which alter perception of food flavor, are thus worth considering in clinical neurology settings. Indeed,

as it is widely known that KS is often provoked or aggravated by nutritional deficiencies, these dysfunctions could play a role in the vicious circle linking alcohol-consumption and nutritional deficiencies among these patients. Olfactory evaluation and rehabilitation, which have shown their efficiency in neurological states (Damm et al. 2014), should thus be included in therapeutic programs.

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