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ORIGINAL ARTICLE

Effects of trait anxiety, somatosensory amplification, and facial pain on self-reported oral behaviors

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Abstract

Objectives Oral behaviors are activities, like gum chewing, teeth clenching, and biting of objects, that go beyond normal functioning demands and contribute to the onset of temporomandibular disorders (TMD). Somatosensory amplification refers to the tendency to experience somatic sensations as intense, noxious, and disturbing and is related to bodily hypervigilance. Clinical experience suggests that individuals with bodily hypervigilance also present with occlusal hypervigilance and continuously check their occlusion. This study aimed at investigating whether somatosensory amplification and trait anxiety, a characteristic correlated with hypervigilance, are associated with a greater incidence of oral behaviors, and verifying how self-reported facial TMD pain affect this relationship.

Materials and methods The State-Trait Anxiety Inventory, the Somatosensory Amplification Scale, the Oral Behavior Checklist (OBC), and the TMD-Pain Screener Questionnaire were filled out by 255 University students with self-reported facial TMD pain (PAIN group; 47 subjects, 24.8 ± 4.2 years) and without pain (CTR group; 208 subjects, 26.0 ± 4.8 years) using a web survey.

Results Trait anxiety, somatosensory amplification, and OBC scores were greater in the PAIN than CTR group (all $p < 0.05$). Trait anxiety and somatosensory amplification were positively associated with the frequency of oral behaviors, as measured with the OBC (all $p < 0.05$). A significant effect of the interaction study group*trait anxiety ($p = 0.028$) on OBC scores was found.

Conclusions Individuals with greater trait anxiety and somatosensory amplification report more frequent oral behaviors. The relationship between anxiety and oral behaviors is affected by concurrent facial pain.

Clinical relevance Individuals with increased trait anxiety and concurrent facial pain report more frequent oral behaviors than those without pain. Clinicians should evaluate patients' anxiety and somatosensory amplification before starting dental treatment.

Keywords Oral parafunctional behaviors · Awake bruxism · Trait anxiety · Somatosensory amplification · Temporomandibular joint disorders

Introduction

Oral behaviors are activities like gum chewing, teeth clenching, and biting of objects, which deviate from functional activities [1]. These activities need to be carefully evaluated in the clinical setting because they are known to be predictors of temporomandibular disorders (TMD) [2].

Awake bruxism is an oral behavior characterized by repetitive clenching of teeth [3]. Experimental studies have shown that sustained wake-time clenching elicits jaw muscle fatigue and pain in healthy subjects [4], contributes to TMD onset [5, 6] and tooth wear [7, 8].

The contribution of anxiety to oral behaviors and wake-time clenching has been largely verified. Anxious individuals have frequent oral behaviors and wake-time clenching episodes [9–12]. However, high levels of anxiety are also a characteristic of individuals with facial pain [11, 13–15]. Therefore, it is not clear whether the relationship between anxiety and wake-time clenching is due to the higher prevalence of painful TMD in individuals with frequent self-reports of clenching episodes.

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Somatosensory amplification refers to the tendency to perceive a given normal somatic sensation (such as heat, cold, and touch) as intense, noxious, and disturbing [16]. Amplification of somatic sensations involves bodily hypervigilance, which is characterized by a heightened attention to the body and a selective focus on detected sensations [16]. Clinical experience suggests that individuals with bodily hypervigilance also may present with occlusal hypervigilance, which is an increased occlusal perception and heightened attention to changes in one's dental occlusion [17]. People with occlusal hypervigilance present a selective focus on detecting occlusal sensations and continuously check their occlusion [17]. Oral behaviors involving repetitive tooth-to-tooth contact and clenching may serve to scan the intraoral environment in search of possible threats, and be more prevalent in individuals with greater somatosensory amplification.

This study aimed at investigating whether increased levels of trait anxiety and somatosensory amplification are associated with a greater incidence of oral behaviors. A second aim was to verify how self-reported facial pain affects this relationship. It was hypothesized that:

1. both anxiety and somatosensory amplification are positively associated with the frequency of oral behaviors, and
2. the relationship between anxiety and oral behaviors is influenced by concurrent facial pain.

Materials and methods

Two hundred fifty-five students (161 females, 94 males; mean age ± SD = 25.8 ± 4.7 years) at the University of Toronto participated in a web survey with five online questionnaires. The survey included a modified version of the Diagnostic Criteria for Temporomandibular Disorders (DC/TMD) demographics questionnaire [18], the TMD-Pain Screener Questionnaire [18, 19], the State-Trait Anxiety Inventory [20], the Oral Behavior Checklist [1, 21], and the Somatosensory Amplification Scale [16]. The validity of these questionnaires has been tested in different settings [1, 16, 19–23]. Incentive for individuals to fully complete the web-survey was established through a lottery system that led to the awarding of gift cards.

The TMD-Pain Screener questionnaire investigates about the presence of pain in the jaw or temple area in the last 30 days. Specifically, subjects were asked if they had pain in the jaw or temple area, pain or stiffness in the jaw on awakening, and whether oral activities affected any pain in the jaw or temple area. A score ranging from 0 to 2 points is attributed to each answer [19].

The State-Trait Anxiety Inventory includes 20 items for assessing state anxiety and 20 for assessing trait anxiety. Trait anxiety includes constructs such as "I fell pleasant", "I feel nervous and restless", and "I feel like a failure". Participants indicated how they generally feel by choosing among the following options: "almost never," "sometimes," "often," or "almost always." Each answer is ranked as a score from 1 to 4 [20].

The Oral Behaviors Checklist (OBC) includes 21 items assessing awareness and the self-reported frequency of waking-state oral behaviors [21]. The reliability and validity of the OBC in detecting waking-state oral parafunctions has been previously demonstrated [1, 21]. Participants reported the daily frequency for each oral behavior listed in the questionnaire by choosing among the following options: "none of the time," "a little of the time," "some of the time," "most of the time," or "all of the time." Each answer is ranked as a score from 0 to 4 [21].

Other than computing the total OBC score for each subject, a partial score (OBC6) was calculated by summing the OBC items 3, 4, 5, 10, 12, and 13 (i.e., no. 3: grinding teeth together during waking hours; no. 4: clenching teeth together during waking hours; no. 5: pressing, touching, or holding teeth together other than eating; no. 10: biting, chewing, or playing with tongue, cheeks, or lips; no. 12: holding objects between teeth or biting objects such as hair, pipe, pencils, pens, and fingers; no. 13: use of chewing gum). The rationale for using these items was that these oral activities are characterized by pressing attitudes against soft tissues, objects, or teeth, and may account for oral behaviors involving repetitive tooth-to-tooth contact and clenching.

The Somatosensory Amplification Scale (SSA) [16] includes ten statements investigating participants' sensitivity to bodily sensations, such as "Sudden loud noises really bother me," "I am often aware of various things happening within my body," and "I can sometimes hear my pulse or my heartbeat throbbing my ear". Participants could answer among the following options: "not at all," "a little," moderately," "quite a bit," or "extremely." Each answer is ranked as a score from 0 to 4 [16].

Website for research survey

A website was used to collect the measurements. The website was designed for access from desktop or laptop computers, tablets, and mobile phones and was advertised by use of flyers, social-media networking, and student newsletters including a Quick Response code linked to the website. The website included a set of multiple-choice questionnaires with answers inserted by the participant through the use of radio buttons and was structured to check for the completeness of the answers. A confirmation message after the completion of the survey was generated, including an identification (ID) that was linked to the lottery system. The web-survey accepted one attempt (one fully completed survey) from each and every

registered participant. All collected data was encrypted, protected, and stored in a comma-separated values (CSV) worksheet. Informed consent was obtained on-line.

Statistical analysis

Based on the TMD-Pain Screener scores [19], two study groups were constructed. One group included people with scores ≥ 3 (group reporting facial pain, PAIN group), and the other comprised of participants with scores < 3 (no facial pain, CTR group).

Pearson coefficients (r) and coefficients of determinations (r^2) were computed to test correlations and associations between the study variables (Trait Anxiety, OBC, OBC6, SSA) in both groups.

Contingency tables (2 × 5) were constructed to examine the distribution of the items included in the Oral Behaviors Checklist (questions 1–21) in both the study groups. The Chi-squared test was used to determine whether there was a significant association between the frequency of OBC items and the study groups. Standardized residuals were also computed. The Chi-squared test was also used to test whether the gender distribution was similar between groups. Non-parametric tests (Mann-Whitney) were used to test between-groups (PAIN vs. CTR) in trait anxiety, OBC, OBC6, and SSA scores.

In order to test the concurrent effect of gender, trait anxiety SSA, and pain (study group: OP vs CTR) on oral behaviors, two mixed-effect regression models were constructed. OBC and OBC6 scores were included as dependent variables. Trait anxiety and SSA scores were included in the model as covariates. Gender and the study group (PAIN vs. CTR) as fixed factors. All the interactions between independent variables were tested and retained in the models when statistically significant ($p < 0.05$). Data were analyzed using SPSS version 24.0 (IBM).

Results

The PAIN group comprised 47 individuals (33 females, 14 males; mean age ± SD = 24.8 ± 4.2 years). The CTR group included 208 subjects (128 females, 80 males; mean age ± SD = 26.0 ± 4.8 years).

Between-group comparisons

Median scores for trait anxiety, oral behaviors (OBC and OBC6), and somatosensory amplification (SSA) are reported in Fig. 1. Trait anxiety and SSA were greater in the PAIN than CTR group ($p = 0.001$ and $p = 0.003$, respectively). OBC and OBC6 scores were higher in the PAIN than CTR group (all $p < 0.001$). Most of the OBC items were more prevalent in the OP group (all $p < 0.05$) than the CTR group (see Table 1). OBC scores were greater in female than in male individuals ($p < 0.05$).

Correlations and associations between trait anxiety, oral behaviors (OBC and OBC6), and somatosensory amplification (SSA)

In the PAIN group, trait anxiety was correlated to SSA ($r = 0.519$, $p < 0.001$; $r^2 = 0.27$), OBC ($r = 0.586$, $p < 0.001$; $r^2 = 0.34$), and OBC6 ($r = 0.436$, $p = 0.001$; $r^2 = 0.19$) scores.

SSA was significantly correlated to OBC ($r = 0.352$, $p < 0.001$; $r^2 = 0.12$) and OBC6 ($r = 0.270$, $p = 0.033$; $r^2 = 0.07$).

In the CTR group, trait anxiety was correlated to SSA ($r = 0.242$, $p < 0.001$; $r^2 = 0.06$), OBC ($r = 0.290$, $p < 0.001$; $r^2 = 0.08$), and OBC6 ($r = 0.298$, $p = <0.001$; $r^2 = 0.09$).

SSA was significantly correlated to OBC ($r = 0.263$, $p < 0.001$; $r^2 = 0.07$) and OBC6 ($r = 0.211$, $p < 0.001$; $r^2 = 0.04$).

Mixed effect regression models

A significant main effect of gender ($p = 0.039$), trait anxiety ($p < 0.001$), SSA ($p = 0.002$), and of the interaction group*trait anxiety ($p = 0.028$) on OBC scores was found (Table 2).

Figure 2 depicts the interaction effect in the regression model.

A significant main effect of gender ($p = 0.045$), trait anxiety ($p < 0.001$), SSA ($p = 0.032$), and the study group ($p = 0.002$) on OBC6 scores was also determined (Table 2).

Discussion

This study investigated the prevalence of oral behaviors in University students and tested the association between trait anxiety, somatosensory amplification, and oral behaviors. In addition, it evaluated whether facial TMD pain affected this relationship.

For this study, we used the TMD-Pain Screener Questionnaire [19] to detect individuals with facial TMD pain. The specificity and sensitivity of the TMD-Pain Screener Questionnaire for detecting painful TMD versus healthy controls have been reported to be 99.1% and 96.9%, respectively [19]. Therefore, this questionnaire is a valid tool to identify individuals with painful TMD. Similarly, the Oral Behaviors Checklist was shown to be valid (as compared to surface electromyography) for detecting wake-time oral parafunctional behaviors [1], as effectively predicts these activities in the natural environment [24].

The prevalence of facial TMD pain was 18% (21% in females and 15% in males). This finding is consistent with a recent study reporting the prevalence of TMD pain in Finnish students be 25.9% in women and 11.4% in men [25]. Differently from our study, other investigators found a higher

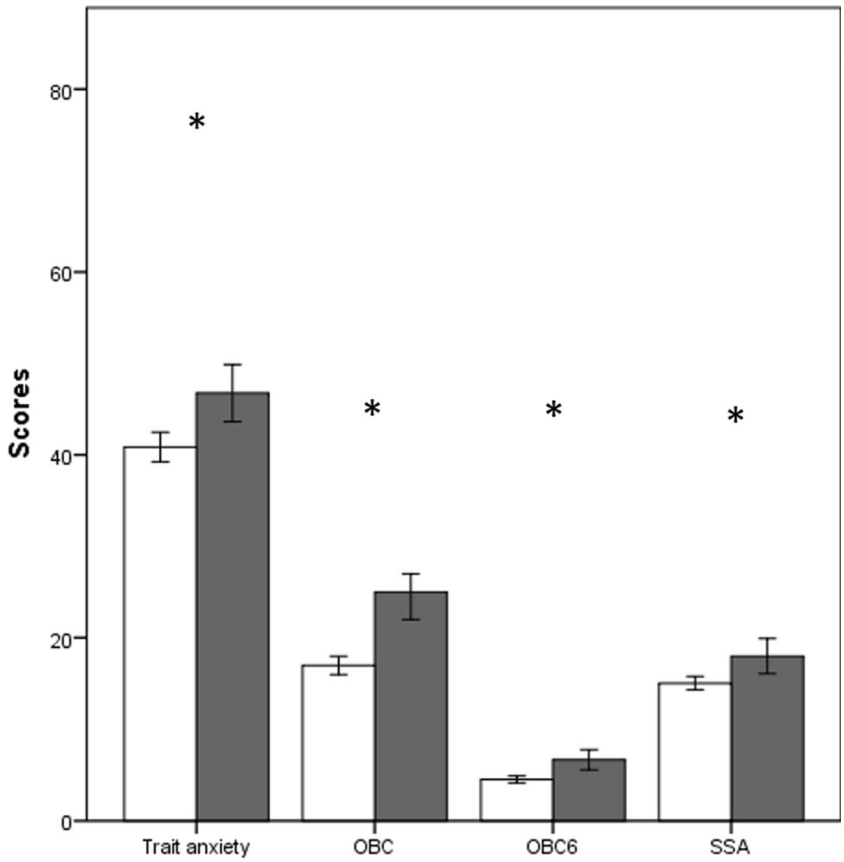

Fig. 1 Median values (± 95% confidence intervals) for Trait Anxiety, OBC, OBC6, and SSA in both groups. White: CTR group, Gray: PAIN group. *Between groups significant differences at $p < 0.005$

prevalence of TMD symptoms (approximately 38–40%) in students [26, 27]. Discrepancies between the studies may be due to the method used to detect TMD. In our report, we used the TMD-Pain Screener Questionnaire, which investigates the presence of painful TMD and does not account for non-painful TMD (e.g., temporomandibular joint clicking). Therefore, the presence of TMD may be underestimated in our sample.

Our study has confirmed that oral behaviors and painful TMD are associated [2, 5, 28]. Clenching and grinding (OBC items 1, 3, 4), holding the teeth together (item 4), tensing the jaw muscles or holding the jaw in a rigid position (items 6, 7, 11), pressing the tongue against the teeth (item 9), playing with the tongue, cheeks or lips (item 10), and using chewing gum (item 13) were more frequent in individuals with facial TMD pain than pain-free individuals. These activities require a sustained and repetitive contraction of the jaw muscles, which may result in muscle overload, local ischemia, and pain [29, 30].

Trait anxiety was measured by using the State-Trait Anxiety Inventory [20]. The reliability of this questionnaire has been shown to be high [20, 31]. Trait anxiety was positively associated with oral behaviors, similarly to other studies reporting that the frequency of oral behaviors is increased in subjects with a more anxious personality disposition [9–12].

Somatosensory amplification scores were within the ranges reported previously [28]. The relationship between somatosensory amplification and oral behaviors has been minimally investigated so far [12, 28]. Our study demonstrated a positive association between these constructs. Somatosensory amplification is related to bodily hypervigilance, which is a heightened perception of somatic sensations. Clinical realms reveal that patients with occlusal hypervigilance continuously check their occlusion [17]. Specific oral behaviors characterized by repetitive tooth-to-tooth contact, tongue-to-teeth contact, and clenching may serve to scan the intraoral environment in search of possible threats.

The relationship between somatosensory amplification, trait anxiety, and oral behaviors is heightened in individuals with concurrent facial TMD pain. Trait anxiety was found to be greater in individuals with facial pain than the pain-free group. The relationship between anxiety and TMD has been object of several studies, which used with different scales [15, 28, 32–35] with contrasting results. A recent study examining TMD patients showed that the association between TMD and anxiety is dependent on the severity of TMD [15]. Our regression model showed a significant interaction effect between trait anxiety and facial pain, which suggests that pain has an additive effect on the relationship between anxiety and oral behaviors: people with high levels of trait anxiety present a

Table 1 Frequency of oral behaviors in the study groups (PAIN vs. CTR). Standardized residuals are reported between squared brackets. Bold type: statistically significant

	None of the time	*< 1 night/month*	*1–3 nights/month*	*1–3 nights/week*	*4–7 nights/week*
Clench or grind teeth when asleep, based on any information you may have **p < 0.001**	99 CTR (48.1%) [0.8] 13 PAIN (27.7%) [− 1.7]	27 CTR (13.1%) [0.9] 1 PAIN (2.1%) [− 1.8]	40 CTR (19.4%) [− 0.1] 10 PAIN (21.3%) [0.2]	19 CTR (9.2%) [− 0.5] 7 PAIN (14.9%) [4.0]	21 CTR (10.2%) [− 1.7] 16 PAIN (34.0%) [3.5]
Sleep in a position that puts pressure on the jaw (for example, on stomach, on the side) *p* = 0.081	70 CTR (34.0%) [0.9] 7 PAIN (14.9%) [− 1.9]	10 CTR (4.9%) [0.3] 1 PAIN (2.1%) [− 0.7]	8 CTR (3.9%) [− 0.3] 3 PAIN (6.4%) [− 0.7]	26 CTR (12.6%) [− 0.5] 9 PAIN (19.1%) [1.0]	92 CTR (44.7%) [− 0.5] 27 PAIN (57.4%) [1.0]
		A little of the time	**Some of the time**	**Most of the time**	**All of the time**
Grind teeth together during waking hours **p = 0.004**	155 CTR (75.2%) [0.6] 26 PAIN (55.3%) [− 1.3]	36 CTR (17.5%) [− 0.5] 12 PAIN (25.5%) [1.0]	11 CTR (5.3%) [− 1.3] 9 PAIN (19.1%) [2.7]	4 CTR (1.9%) [− 0.4] 0 PAIN (0%) [− 0.9]	0 CTR (0%)- 0 PAIN (0%)-
Clench teeth together during waking hours **p < 0.001**	93 CTR (45.1%) [0.9] 11 PAIN (23.4%) [− 1.9]	79 CTR (38.3%) [0.3] 15 PAIN (31.9%) [− 0.6]	27 CTR (13.1%) [− 1.6] 18 PAIN (38.3%) [3.3]	7 CTR (3.4%) [− 0.4] 3 PAIN (6.4%) [0.8]	0 CTR (0%)- 0 PAIN (0%)-
Press, touch, or hold teeth together other than while eating (that is, contact between upper and lower teeth) **p < 0.001**	79 CTR (38.3%) [1.0] 8 PAIN (17%) [− 2.0]	85 CTR (41.3%) [0.5] 14 PAIN (29.8%) [− 1.0]	34 CTR (16.5%) [− 0.6] 12 PAIN (25.5%) [1.2]	8 CTR (3.9%) [− 2.2] 13 PAIN (27.7%) [4.6]	0 CTR (0%)- 0 PAIN (0%)-
Hold, tighten, or tense muscles without clenching or bringing teeth together **p < 0.001**	142 CTR (68.9%) [1.3] 15 PAIN (31.9%) [− 2.6]	42 CTR (20.4%) [− 0.6] 15 PAIN (31.9%) [1.4]	16 CTR (7.8%) [− 1.6] 13 PAIN (27.7%) [3.3]	6 CTR (2.9%] [− 0.8] 4 PAIN (8.5%) [1.6]	0 CTR (0%)- 0 PAIN (0%)-
Hold or jut jaw forward or to the side **p = 0.001**	160 CTR (77.7%) [0.5] 29 PAIN (61.7%) [− 1.0]	37 CTR (18.0%) [0.2] 7 PAIN (14.0%) [− 0.4]	7 CTR (3.4%) [− 1.7] 9 PAIN (19.1%) [3.5]	2 CTR (1.0%) [− 0.7] 2 PAIN (4.3%) [1.5]	0 CTR (0%)- 0 PAIN (0%)-
Press tongue forcibly against teeth **p = 0.001**	148 CTR (71.8%) [0.6] 25 PAIN (53.2%) [− 1.6]	43 CTR (20.9%) [− 0.4] 13 PAIN (27.7%) [− 0.8]	15 CTR (7.3%) [− 0.5] 6 PAIN (12.8%) [1.1]	0 CTR (0%) [− 1.6] 3 PAIN (6.4%) [3.3]	0 CTR (0%)- 0 PAIN (0%)
Place tongue between teeth **p = 0.001**	154 CTR (74.8%) [1.0] 21 PAIN (44.7%) [− 2.0]	40 CTR (19.4%) [− 0.9] 17 PAIN (36.2%) [2.0]	9 CTR (4.4%) [− 1.1] 7 PAIN (14.9%) [2.3]	3 CTR (1.5%) [− 0.5] 2 PAIN (4.3%) [1.1]	0 CTR (0%)- 0 PAIN (0%)-
Bite, chew or play with your tongue, cheeks, or lips **p = 0.001**	90 CTR (43.7%) [1.0] 9 PAIN (19.1%) [− 2.2]	69 CTR (35.5%) [0.2] 14 PAIN (29.8%) [− 0.4]	36 CTR (17.5%) [− 1.1] 17 PAIN (36.2%) [2.3]	11 CTR (5.3%) [− 1.0] 7 PAIN (14.9%) [2.0]	0 CTR (0%)- 0 PAIN (0%)-
Hold jaw in rigid or tense position, such as to brace or protect the jaw **p < 0.001**	179 CTR (86.9%) [0.8] 28 PAIN (59.6%) [− 1.7]	25 CTR (12.1%) [− 0.8] 11 PAIN (23.4%) [1.7]	2CTR (1.0%) [− 1.8] 6 PAIN (12.8%) [3.7]	0 CTR (0%) [− 1.3] 2PAIN (4.3%) [2.7]	0 CTR (0%)- 0 PAIN (0%)-
Hold between the teeth or bite objects such as hair, pipe, pencils, pens fingers, and fingernails *p* = 0.151	132 CTR (64.1%) [0.2] 28 PAIN (59.6%) [− 0.3]	47 CTR (22.8%) [0.5] 7 PAIN (14.9%) [− 1.0]	21 CTR (67.7%) [− 0.8] 10 PAIN (21.3%) [1.8]	6 CTR (2.9%) [− 0.2] 2 PAIN (4.3%) [0.4]	0 CTR (0%)- 0 PAIN (0%)-
Use chewing gum **p = 0.029**	55 CTR (26.7%) [− 0.9] 31 PAIN (44.7%) [1.8]	73 CTR (35.4%) [0.3] 14 PAIN (29.8%) [− 0.5]	60 CTR (29.1%) [0.9] 6 PAIN (12.8%) [− 1.8]	18 CTR (8.7%) [− 0.3] 6 PAIN (12.8%) [− 0.7]	0 CTR (0%)- 0 PAIN (0%)-
Play musical instruments that involves use of mouth or jaw (for example, woodwind, brass, string instruments) *p* = 0.261	189 CTR (91.7%) [− 0.2] 46 PAIN (97.9%) [0.4]	13 CTR (6.3%) [0.7] 0 PAIN (0%) [− 1.6]	2 CTR (1%) [0.3] 0 PAIN (0%) [− 0.6]	2 CTR (1%) [− 0.3] 1 PAIN (2.1%) [0.6]	0 CTR (0%)- 0 PAIN (0%)-
Lean with your hand on the jaw, such as cupping, or resting the chin in the hand *p* = 0.094	37 CTR (18%) [0.9] 2 PAIN (4.3%) [− 1.9]	70 CTR (34%) [0.0] 16 PAIN (34%) [0.0]	70 CTR (34.0%) [− 0.3] 19 PAIN (40.4%) [0.6]	29 CTR (14.1%) [− 0.5] 10 PAIN (21.3%) [1.0]	0 CTR (0%) 0 PAIN (0%)-
Chew food on one side only	82 CTR (39.8%) [1.1]	66 CTR (32.0%) [−0.1]	31 CTR (15.0%) [− 1.2]	27 CTR (13.1%) [− 0.3]	0 CTR (0%)-

Table 1 (continued)

	None of the time	*< 1 night/month*	*1–3 nights/month*	*1–3 nights/week*	*4–7 nights/week*
p = 0.002	7 PAIN (14.9%) [− 2.3]	16 PAIN (34.0%) [0.2]	16 PAIN (34.0%) [2.5]	8 PAIN (17.0%) [0.6]	0 PAIN (0%)-
Eating between meals	15 CTR (7.3%) [0.5]	75 CTR (36.4%) [0.2]	88 CTR (42.7%) [0.2]	28 CTR (13.6%) [− 0.9]	0 CTR (0%)-
$p = 0.083$	1 PAIN (2.1%) [− 1.1]	15 PAIN (31.9%) [− 0.4]	18 PAIN (38.3%) [− 0.4]	13 PAIN (5.1%) [2.0]	0 PAIN (0%)-
Sustained talking (for example, teaching, sales, customer service	70 CTR (34.0%) [0.2]	94 CTR (45.6%) [0.2]	28 CTR (13.6%) [− 0.2]	14 CTR (6.8%) [− 0.6]	0 CTR (0%)-
$p = 0.480$	14 PAIN (29.8%) [− 0.4]	19 PAIN (40.4%) [− 0.4]	8 PAIN (17.0%) [0.5]	6 PAIN (12.8%) [1.2]	0 PAIN (0%)-
Singing	128 CTR (62.1%) [0.6]	62 CTR (30.1%) [− 0.6]	14 CTR (6.8%) [− 0.4]	2 CTR (1.0%) [− 0.3]	0 CTR (0%)-
$p = 0.172$	21 PAIN (44.7%) [− 1.3]	20 PAIN (42.6%) [1.2]	5 PAIN (10.6%) [0.8]	1 PAIN (2.1%) [0.6]	0 PAIN (0%)-
Yawning	16 CTR (7.8%) [0.6]	131 CTR (63.6%) [0.3]	45 CTR (21.8%) [− 0.7]	14 CTR (6.8%) [− 0.2]	0 CTR (0%)-
$p = 0.191$	1 PAIN (2.1%) [− 1.2]	26 PAIN (55.3%) [− 0.6]	16 PAIN (34.0%) [1.4]	4 PAIN (8.5%) [0.4]	0 PAIN (0%)-
Hold telephone between your head and shoulders	116 CTR (56.3%) [0.0]	72 CTR (35.0%) [− 0.2]	18 CTR (8.7%) [0.6]	0 CTR (0%) [− 0.9]	0 CTR (0%)-
$p = 0.074$	26 PAIN (55.3%) [− 0.1]	19 PAIN (40.4%) [0.5]	1 PAIN (2.1%) [− 1.3]	1 PAIN (2.1%) [1.9]	0 PAIN (0%)-

Table 2 Results from the regression models. Italic type: statistically significant

Independent variables	OBC *F* value (*p* value)	OBC6 *F* value (*p* value)
Group	0.803 (0.371)	*9.846 (0.002)*
Gender	*4.309 (0.039)*	*4.068 (0.045)*
Trait anxiety	*22.434 (< 0.001)*	*18.813 (< 0.001)*
SSA	*9.687 (0.002)*	*4.639 (0.032)*
Group*trait anxiety	*4.914 (0.028)*	–

greater frequency of oral behaviors if pain is present (Fig. 2).In agreement with previous reports [28, 36], somatosensory amplification was slightly greater in people reporting facial pain than pain-free individuals. This results suggests that concurrent pain heightens somatic bodily sensations and contributes to hypervigilance [37]. The stronger relationship we found between somatosensory amplification and oral behaviors in individuals with facial TMD pain contributes to explain the general framework that links painful temporomandibular disorders to increased occlusal awareness [17]. In a previous study, it was shown that individuals with TMD continued to clench their teeth and in some cases increased their parafunctional activities when exposed to experimental changes to their dental occlusion [38]. Differently, healthy individuals reduced the frequency of tooth contacts when exposed to the same condition [39].

In agreement with previous reports [5, 40], in our study, oral behaviors were found to be gender-related and to be more frequent in females. However, due to the greater number of female participants in the current study, it is possible that this finding has been overestimated.

This study has some limitations. Firstly, the sample analyzed is composed of University students with a limited age range that may be not representative of the general population. Secondly, ethnic, racial, and cultural factors have been reported to influence anxiety and related disorders [41]. Our survey included more than ten different races and ethnicities. We decided not to include this data in the statistical analysis. Indeed, controlling for these variables may have significantly affected the power of our investigation. Thirdly, we used the TMD-Pain Screener Questionnaire [18, 19] to detect individuals with TMD pain but did not examine the participants clinically. Although this questionnaire has very high sensitivity and specificity (> 0.95) [19] in detecting painful TMD, it cannot account for a clinical diagnosis and does not inform about the precise location of pain. Additionally, the TMD pain screener is able to inform only about painful TMD and does not account for non-painful TMD. Hence, the effect of non-painful TMD on the outcome measures could not be

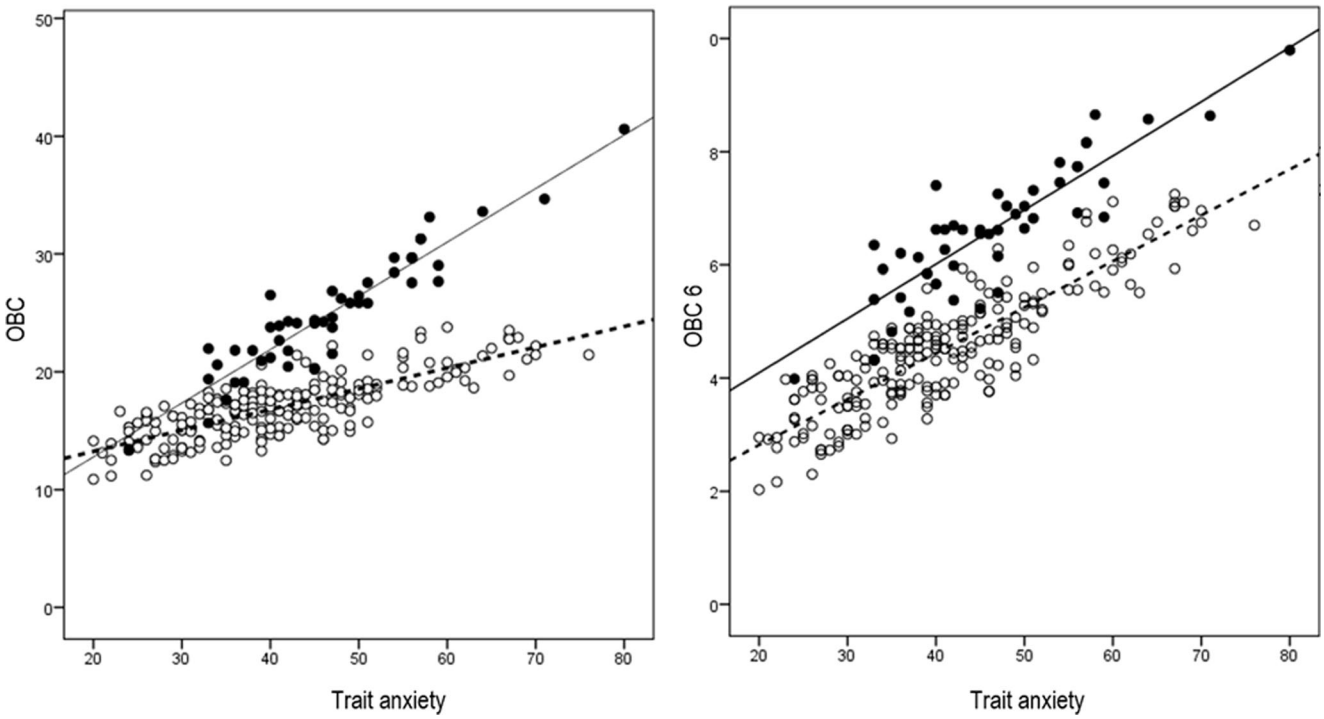

Fig. 2 Scatter plots with regression lines showing the relationship between Trait Anxiety and OBC (predicted values) and Trait Anxiety and OBC6 (predicted values) in both groups. White: CTR group, Gray: PAIN group

estimated. Also, we did not measure the severity of facial pain, which could also have affected trait anxiety and oral behaviors in our sample. Moreover, it may be argued that including both somatosensory amplification and trait anxiety as predictors in the regression model may account for multi-collinearity. Somatosensory amplification and trait anxiety were positively correlated [12], as reported previously [42]. However, the correlation between these variables was found to be weak to moderate ($r = 0.321$, $p < 0.001$), and could have not have affected the analysis [43]. In addition, our results indicate that the facial pain group reported more frequent clenching activities during sleep than the pain-free group. Nonetheless, the validity of the oral behaviors checklist for the assessment of sleep bruxism is limited. Finally, research surveys present some limits. Indeed, data are retrieved only from those willing to participate and fill out a battery of questionnaire. Therefore, the validity of surveys may be somehow limited.

In conclusion, this study has shown the following:

1. Both somatosensory amplification—an estimate of bodily and occlusal hypervigilance—and trait anxiety are positively associated with oral behaviors.
2. Concurrent facial pain heightens the relationship between trait anxiety and oral behaviors.

Therefore, clinicians should gather information about patient's psychological traits before starting dental treatments as they influence oral behaviors. Indeed, oral behaviors may cause jaw muscle overloading and pain, favor orthodontic relapse, compromise patient's adaptation to dental rehabilitations, and thereby increase the risk of failure during treatment.

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Compliance with ethical standards

Conflict of interest Dr. Jeffrey CF Chow declares that he has no conflict of interest. Dr. Iacopo Cioffi declares that he has no conflict of interest.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent For this study was obtained on-line from all individual participants included in the study. The study was reviewed and approved by the University of Toronto Research Ethics Board (protocol #32797).

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