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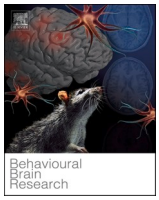

Congenital anosmia and subjective tactile function: A pilot study

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ABSTRACT

Anosmia, the complete loss of olfactory perception, has been associated with sensory compensation in non-chemical senses such as vision and hearing, but its relationship with tactile perception remains unclear. This study investigates whether isolated congenital anosmia (ICA)—a rare condition in which individuals are born without a sense of smell but are otherwise healthy—is linked to heightened self-reported tactile sensitivity compared to healthy controls. Drawing on sensory compensation theory and anecdotal evidence from related studies, we hypothesized that individuals with ICA would report increased tactile sensitivity, particularly in response to discomfort. To test this hypothesis, we surveyed individuals with ICA (n = 40) and healthy controls (n = 40), matched for sex and age, using standardized questionnaires and a specially developed questionnaire focused on discomfort related to materials, food textures, stickiness, and pressure. Contrary to our pre-registered hypothesis, the results revealed no significant differences in overall self-reported touch sensitivity between the groups. However, exploratory analysis indicated that individuals with ICA exhibit greater sensitivity to temperature sensations and to overall tactile discomfort, specifically in response to pressure and food textures, compared to controls. We propose that individuals with ICA may compensate for their olfactory loss through heightened sensitivity to certain tactile stimuli related to discomfort, as both touch and olfaction play overlapping roles in the detection of aversive stimuli. These exploratory findings underscore the need for further investigation into the sensory compensation mechanisms of olfaction on touch.

1. Introduction

Anosmia (i.e., the complete loss of olfactory perception) has been associated with enhanced processing in the non-chemical senses of visual and audition – a process known as sensory compensation (e.g., [18,37,49]). While improved visual and auditory performance may occur following olfactory loss, the influence of anosmia on tactile perception, remains to be determined. As such, the aim of this study is to explore whether isolated congenital anosmia - i.e., when individuals are born without a sense of smell but otherwise healthy – is associated with heightened self-reported tactile sensitivity compared to healthy controls.

Sensory compensation – i.e., when loss in one sensory modality leads to enhanced performance in the remaining intact senses – has been studied most extensively in individuals who have had visual and auditory loss. In particular, visual blindness has been associated with better performance in certain auditory [4,18,30,40,51,52], tactile [17,29] and olfactory tasks [8,9,41]. Similarly, loss of audition (i.e., deafness), may in some cases, lead to improved performance in certain visual [2,12] and tactile tasks [31]. Sensory compensation effects may occur through two non-mutually exclusive mechanisms; (1) learned enhancement of intact senses through increased attention to stimuli and training [13,34]; and/or (2) cortical reorganization resulting from persistent synaptic connections or unmasking of long-ranging cortico--cortical connections post-sensory loss [14].

In contrast to visual and auditory loss, sensory compensation following olfactory loss has received little research with the majority of extant studies exploring the impact of anosmia on performance in the remaining chemical senses (i.e., trigeminal and gustatory perception; [14]). Interestingly, in contrast to the compensatory effects often

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reported in blind and deaf individuals, congenital anosmia has been linked to a reduced taste and trigeminal sensitivity [15,16,22,28] – and this is likely due to the convergence of these senses in similar central processing areas, as in flavor perception [1,13]. However, a few recent studies suggest that sensory compensation may occur for non-chemical senses following congenital anosmia. Namely, individuals with either acquired or congenital anosmia demonstrated enhanced performance in visual-auditory multisensory integration [37]. In line with this, and relative to healthy controls, individuals who had anosmia demonstrated increased neural activity in cerebral areas associated with multisensory integration following multisensory information [36]. In the present study, we focus on individuals with congenital anosmia because they are shown to have the most robust sensory compensation effects compared to those with acquired anosmia [13]. Isolated congenital anosmia is a rare disorder without a clear cause and with an estsimated prevalence around 1 in 10,000. This population is unique in that they experience a life-long absence of olfactory sensations without a marked reduction in quality of life or changes in general behaviors, and the diagnosis is not associated with any other known health condition. This make them a good lesion-like model for studying sensory compensation [26].

While enhanced touch sensitivity has been consistently observed in individuals with deafness and visual blindness, there has been less investigation of the impact of olfactory loss on tactile perception. Tactile sensitivity might be expected to increase following olfactory loss for three reasons. First, olfaction and touch share similar functions, conserved across development and species (see [3,42,46] for reviews). Namely, both olfaction and touch has been suggested to play a role in social communication (e.g., kin recognition, and mother-infant and partner attachment; [3,24,25,42,46]), ingestive behaviour (e.g., determining edibility and ripeness of fruit; [10,11]); and hazard detection (providing important information about the safety of a given environment/stimulus; [35,43,46]). As such, individuals with anosmia, who lack olfactory input for these domains, may rely on and attend more to somatosensory inputs (touch) for these functions.

The second reason tactile perception might be enhanced following congenital anosmia, is because there may be connectivity between tactile and olfactory processing regions, that provide the basis for cortical reorganisation, and in turn, improved tactile processing, following anosmia. In support of this, Villemure and Bushnell [50] found that pleasant odours decreased subjective unpleasantness towards thermal pain (i.e., hot plate pressed on the calf, ranging from 44 to 50 degrees), and pain evoked activity in the somatosensory cortices (S1, S2). Similarly, disgusting odors were found to reduce pleasantness of affective touch [5,6] and increase activation of somatosensory regions associated with discriminative-touch [6].

The third reason we speculate that tactile perception may be enhanced following olfactory loss comes from anecdotal evidence. Namely, in past studies run by JL and MP, patients who had congenital anosmia spontaneously reported increased sensitivity (discomfort) to tactile sensations compared to their peers, especially in relation to food texture and materials such as clothing and bedding. These reports suggest that individuals may compensate for their olfactory dysfunction via increased attention to their intact senses, such as touch.

Taken together theory and anecdotal reports suggest that olfactory loss may lead to enhanced tactile sensitivity. As such, the current study aims to examine if individuals with congenital anosmia (i.e., no reported past experience of smell), report increased tactile sensitivity relative to healthy controls. We surveyed individuals with isolated congenital anosmia, and healthy controls on their subjective sensitivity to different tactile sensations.

2. Method

2.1. Participants

80 native Swedish individuals participated in the following study, comprised of 40 individuals with congenital anosmia (23 females, 17 Males), aged between 21 and 77 years old ($M = 43.3$, $SD = 14.0$), and 40 healthy controls (23 females, 17 Males), aged between 23 and 73 years old ($M = 43.4$, $SD = 13.4$). Control participants were matched to the participants with congenital anosmia, in terms of sex and age. All participants were members of the general public who had participated in prior studies (N = 50, 62.5 %) or were recruited via media advertisements (N = 28, 37.5 %).

The inclusion criteria for the congenital anosmia group required a lifelong, complete absence of olfactory perception, while the control group consisted of individuals with a self-reported, functional sense of smell. Congenital anosmia was screened by two methods. First, participants in the congenital anosmia group self-reported a lifelong complete loss of olfactory function, answering the question: "Have you ever in your life experienced any smell sensation?". Second, as the majority of participants with congenital anosmia (i.e., 29/40; 72.5 %) had participated in previous studies, their olfactory loss was confirmed in prior studies, via the full Sniff'n Stick test (N = 27/29) or its identification subtest (N = 2/29). All participants provided informed written consent via the online system. Participants received a movie ticket as compensation for their time. The study was approved by the regional ethical review board of Stockholm (2018/2461–32).

2.2. Study design procedure

This study used a cross-sectional survey design. The surveys, formulated in Swedish, were administered online using the Karolinska Institute's internet platform for data collection between May and October 2019. In addition to several sensory perception questionnaires described in detailed below, participants provided socio-demographic information (i.e., age, sex, education) and completed the Patient Health Questionnaire-9 to assess depressive symptoms, a common comorbidity to anosmia [7]. All the questionnaires are available on the Open Science Framework (OSF) webpage (https://osf.io/qhd6f/?view_only=e9008dbc6e5b4700a30c677f8056ae21)

2.3. Study measures

Several types of tactile sensations have been identified in literature – i.e., discrimination, affective, ingestive, and social communication. However, in lieu of a unified questionnaire, we administered a combination of pre-existing validated questionnaires (i.e., Sensory Perception Quotient, Social Touch Questionnaires), and developed questions that specifically examined discomfort related to the feel of material, food, stickiness, and pressure. This approach allowed us to examine a wide variety of functional domains of touch.

2.3.1. Sensory Perception Quotient (SPQ)

The Sensory Perception Quotient (SPQ; [48]) consists of 92 items which measure an individual's subjective detection and/or discrimination abilities in the five primary senses – vision, hearing, touch, smell, and taste (e.g., *"I would be able to detect if a strawberry was ripe by smell alone*"). Individuals are asked to indicate the extent to which they agree with each statement on a scale from 1 (Strongly disagree) to 4 (Strongly agree) – with 43 items reverse coded prior to statistical analyses. The total SPQ score can range from 92 to 368 and had good reliability in our sample (Cronbach's $\alpha = 0.88$). As our primary interest was to determine whether tactile sensation differed between the groups, only subscale scores were used in analyses, as detailed below.

2.3.1.1. Subscale scores. Three subscale scores relevant to the study aims, were used in the analyses – i.e., (1) a Smell sensitivity (SPQ-Smell; sum of all scores for all questions pertaining to smell; N = 16 items), (2) a Touch sensitivity (SPQ-Touch subscale; sum of all scores for all questions pertaining to touch; N = 20 items), and (3) a General Sensory

Sensitivity, which was the sum score of all the questions pertaining to Vision (N = 20 items), Hearing (N = 20 items), and Taste (N = 14 items). Two items were not included in these subscale scores, as they referred to multisensory (flavor) perception (i.e. *"I wouldn't be able to taste the difference between two pieces of dark chocolate"* and *"I would be able to taste the difference between apparently identical pieces of candy"*).

2.3.1.2. SPQ-touch subscale subdomains. In addition, and for the Touch Subscale only – as this was of primary interest to the study's aim, four further tactile subdomains were calculated, based on Tavassoli et al.'s (2014) classification. These were Pressure (N = 5 items), Temperature (N = 5 items), Pain (N = 5 items), and Vibration (N = 5 items). For each of these tactile subdomains, total scores could range from 1 to 20, with higher scores indicating greater sensitivity to pressure, temperature, pain, or vibration, respectively.

2.3.2. Social Touch Questionnaire (STQ)

The Social Touch Questionnaire (STQ; [53]) consists of 20 statements which measure personal attitudes towards social touch (e.g., *"I generally like when people express their affection towards me in a physical way"*). Individuals rate how accurate these statements are, about themselves, on scale ranging from 1 (not at all) to 5 (extremely), with 10 items reverse scored. Scores can thus range from 20 to 100, with higher scores indicating less positive attitudes towards social touch. Only the total score was used in the analysis, and this had good reliability in our sample (Cronbach's α = 0.84).

2.3.3. Tactile discomfort questionnaire

We developed an 8-item questionnaire which measured discomfort towards various tactile sensations. This questionnaire was based on reports from patients with congenital anosmia. These reports, indicated that individuals with congenital anosmia perceived themselves as more sensitive relative to others in their environment with normative olfactory functioning to four sensations: (1) material-based sensations – i.e., the feel of fabric against skin, (2) pressure-sensations – i.e., the feeling of being restricted by clothing; (3) stickiness – i.e., feeling of stickiness on the hands; and (4) food-texture – hand felt and in the mouth. For each sensation, two items were developed, resulting in an 8-item questionnaire. Items included statements like *"I find it hard to knead dough because my hands get sticky"* (see Table 1, for full questionnaire translated into English; the Swedish version can be found in the Supplementary Materials, SM). For each item, participants rated how much they agree with the statement on a scale, ranging from 1 (Strongly disagree) to 4 (Strongly agree). Thus, total scores could range from 8 to 32, with higher scores indicate stronger discomfort towards tactile sensations. Reliability for the whole scale in our sample was acceptable (α = 0.64). The total of the two items, pertaining to each sensation, i.e., Stickiness, Pressure, Material, and Food Texture, was calculated, to form four subscale scores. The reliability of the subscale scores were as follows: Pressure α = 0.28 (poor), Stickiness α = 0.33 (poor), Material α = 0.58 (acceptable), Food texture = 0.82 (good). As pressure and Stickiness had poor internal reliability, results pertaining to these subscales should be interpreted with caution.

Table 1
Tactile Discomfort Questionnaire.

	Questions	Subscale
1	I find it hard to knead dough because my hands get sticky	Stickiness
2	I think it feels so uncomfortable to wear jewellery/watches that I avoid wearing them	Pressure
3	What material bedding is made of is very important to me: some materials cause discomfort	Material
4	When I use hair products such as wax, I wash my hands very thoroughly to be sure to remove the sticky feeling	Stickiness
5	I react strongly if a piece of food has an unexpected texture	Food
6	I am more sensitive than others to how clothes fit, e.g. for tight or spun/twisted garments	Pressure
7	I avoid wearing clothes made of specific materials because they cause discomfort (e.g. slippery polyester, sticky wool)	Material
8	I choose food that has a texture I don't like, even if the taste is good	Food

2.3.4. Patient Health Questionnaire-9 (PHQ-9)

PHQ-9 was administered [27,45] to ensure that effects of interest were not due to differences in depression between the groups, a common comorbidity to anosmia [7]. The PHQ-9 is a widely used and behaviourally validated screening tool to measure depressive symptoms [27,32]. The PHQ-9 assesses each of the 9 DSM-IV diagnostic criteria for depression. Participants indicate how frequently they experience each criterion on a scale from 0 ("not at all") to 3 ("nearly every day"). Cronbach's α reliability coefficient in our sample was α = 0.81.

2.4. Analysis

Analyses reported below follows a preregistered analysis plan (https://aspredicted.org/8n6cv.pdf), unless otherwise specified. All data are available on the OSF webpage (https://osf.io/qhd6f/?view_only=e9008dbc6e5b4700a30c677f8056ae21). Descriptive statistics including Mean scores (M) and standard deviations (SD) for relevant control and dependent variables are shown in Table 2. All analyses were run on R version 4.3.1 [39].

Non-parametric tests were used because the data were non-normally distributed. As specified in the preregistration document, outliers were defined as values 2.5 + standard deviations below or above the group mean [21,33]. There were 9 outliers in total: one on the Pain, one on the Vibration and one on the Temperature subdomains of the Sensory Perception Quotient Touch subscale; one on the Sensory Perception Quotient Smell scale; one on the General Sensory Sensitivity score; two on the PHQ-9; and two on the Material subscale of the Tactile Discomfort questionnaire. These outlier values were replaced with the value that represented 2.5 standard deviations from their respective scale's sample mean.

To determine whether individuals with congenital anosmia had an altered tactile perception compared to healthy controls, we first used two-sided Wilcoxon rank sum tests with continuity correction (*wilcox.test* function in R) to compare both groups across the Sensory Perception Quotient Touch subscale (i.e., sum of all scores for all questions pertaining to touch) and the Social Touch Questionnaire scores. Then, we conducted non pre-registered two-sided Wilcoxon rank sum tests with

Table 2
Descriptives statistics for each variable by group (Congenital Anosmia, Control).

	Anosmia: M (SD)	Controls: M (SD)
SPQ Smell	**18.0 (2.9)**	**50.3 (5.9)**
SPQ Touch	60.8 (6.1)	58.9 (5.1)
SPQ Touch (Pain)	15.7 (1.8)	15.3 (2.0)
SPQ Touch (Pressure)	14.3 (2.2)	14.0 (2.1)
SPQ Touch (Temperature)	**14.3 (2.1)**	**13.2 (1.8)**
SPQ Touch (Vibration)	16.5 (2.4)	16.3 (1.9)
SPQ General Sensory Sensitivity (vision, hearing & taste)	146.2 (11.6)	148.0 (10.6)
STQ	49.1 (9.7)	50.1 (11.4)
Tactile Discomfort Scale Total	**22.0 (3.6)**	**18.8 (4.0)**
Tactile Discomfort Scale (Stickiness)	5.3 (1.6)	4.8 (1.3)
Tactile Discomfort Scale (Material)	5.8 (1.8)	5.4 (1.4)
Tactile Discomfort Scale (Pressure)	**5.1 (1.5)**	**4.1 (1.2)**
Tactile Discomfort Scale (Food)	**5.9 (1.9)**	**4.6 (1.4)**
PHQ−9	**13.9 (3.9)**	**11.9 (2.8)**

Note. SPQ-Smell (range 16–64), PHQ-9 (range 0–27), SPQ-Touch (range 20–80) and its SPQ-touch subscales Pain, Pressure, Temperature and Vibration (range 5–20), STQ (range 20–100), Tactile Discomfort Scale (pilot questions, range 8–32) and its subscales Stickiness, Material, Pressure and Food (range 2–8). Variables exhibiting a statistically significant difference between groups ($p < .05$), as determined by Wilcoxon rank sum tests, are highlighted in bold.

continuity correction to explore whether the two groups differed in term of subdomain scores on the Sensory Perception Quotient-Touch subscale (Pressure, Temperature, Pain, and Vibration), and on their total and subscales scores pertaining to the Tactile Discomfort questionnaire. Finally, to rule out the influence of control variables – i.e., general sensory sensitivity (as measured by the General Sensitivity Subscale of the SPQ) and Depressive Symptoms (as measured by the PHQ-9) – two-sided Wilcoxon rank sum tests with continuity correction were performed to compare scores between individuals with anosmia and controls. All Wilcoxon Z statistics (z) and effect sizes (r) were computed with the R functions *WilcoxonZ* (*rcompanion* package) and *wilcox_effsize (rstatix package)* respectively.

3. Results

3.1. Group differences on subjective sensory sensitivity

To confirm that individuals with congenital anosmia had significantly impaired subjective olfactory sensation relative to controls, their SPQ Smell subscale scores were compared. As we predicted, participants with congenital anosmia had significantly lower SPQ-Smell scores than healthy controls (Wilcoxon rank sum test with continuity correction, z = -7.78, $p < .001$, effect size $r = 0.87$). On average, individuals with congenital anosmia scored less than 5 % of the total score possible on the scale (i.e., $M = 18.0$, $SD = 2.9$; scale range 16–64), confirming that they had significantly impaired subjective olfactory function. Importantly, individuals with anosmia had comparable general sensory sensitivity scores (i.e., vision, hearing and taste) to the controls (z = -1.05, $p = .30$, $r = 0.12$, see Table 2).

3.2. Touch and anosmia

3.2.1. Sensory perception quotient - touch

In contrast to our prediction, the assessment of subjective touch sensitivity through SPQ-Touch scores revealed no significant differences between individuals with congenital anosmia and controls (Wilcoxon rank sum test with continuity correction, $z = 1.57$, $p = .12$, $r = 0.18$, see Table 2 & Fig. 1A). Nevertheless, exploratory analyses comparing the sensitivity scores within each of the four subdomains of the SPQ-touch – namely, temperature, pain, pressure, and vibration sensations – show that individuals with congenital anosmia had significantly higher subjective temperature sensitivity than controls ($z = 2.28$, $p = .02$, $r = 0.25$, Fig. 1B). No significant group differences were found for Pain ($z = 0.83$, $p = .41$, $r = 0.09$, Fig. 1C), Pressure ($z = 0.53$, $p = .60$, $r = 0.06$, Fig. 1D), or Vibration ($z = 0.60$, $p = .55$, $r = 0.07$, Fig. 1E) sensitivity scores.

3.2.2. Social touch questionnaire

In contrast to expectations, individuals with congenital anosmia did not significantly differ to controls in their attitudes towards social touch (Wilcoxon rank sum test with continuity correction, z = -0.4, $p = .69$, $r = 0.05$, see Table 2 & Fig. 2).

3.2.3. Tactile discomfort questionnaire

Exploratory analyses comparing whether the two groups differed in their discomfort to various tactile sensations indicate that individuals with congenital anosmia had significantly higher total scores on the Tactile Discomfort Questionnaire than the control group (Wilcoxon rank sum test with continuity correction, $z = 3.6$, $p < .001$, $r = 0.40$, see Table 2 & Fig. 3A). In terms of the subscale-score comparisons, individuals with congenital anosmia had significantly higher scores on the Pressure ($z = 3.26$, $p = .001$, $r = 0.36$, Fig. 3B) and Food ($z = 3.20$, $p = .001$, $r = 0.36$, Fig. 3C) subscales, with no group differences for the Stickiness ($z = 1.47$, $p = .14$, $r = 0.17$, Fig. 3D) and Material subscales ($z = 1.11$, $p = .27$, $r = 0.12$, Fig. 3E). Note, however, that the Pressure and Stickiness subdomains had poor internal consistencies.

3.3. PHQ-9 (depression) and differences between groups

To determine whether depressive symptoms differed between individuals with congenital anosmia and controls, PHQ-9 scores were compared using a Wilcoxon rank sum test with continuity correction. Individuals with congenital anosmia ($M = 13.9$; $SD = 3.9$) had significantly higher ratings of depressive symptoms than controls ($M = 11.9$, $SD = 2.8$; $z = 2.47$, $p = .01$, $r = 0.28$). For sake of interpretability, a score of above 14 should be evaluated for clinical depression according to international norms [27].

Because groups differed in the PHQ-9 scores (depression symptoms),

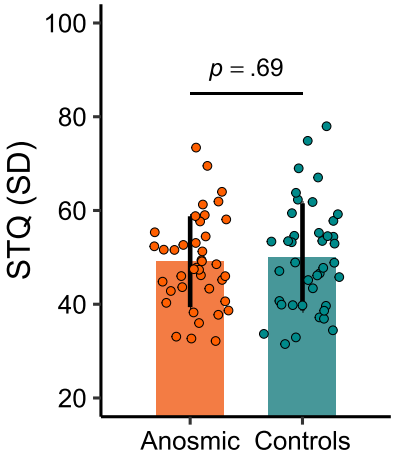

Fig. 2. Differences in Social Touch Questionnaire scores between individuals with congenital anosmia and controls.

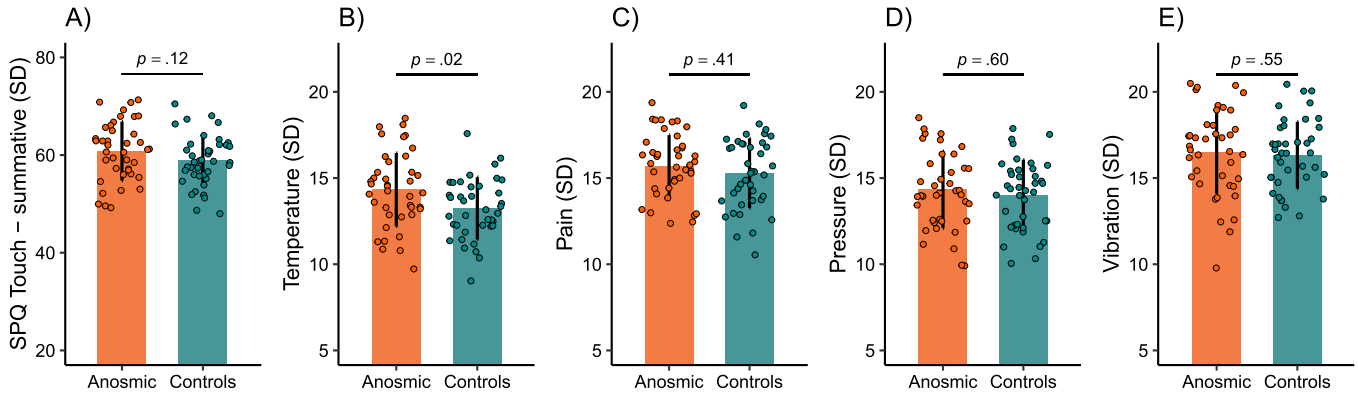

Fig. 1. Differences in Sensory Perception Quotient – Touch subscale scores and its subdomains between individuals with congenital anosmia and controls.

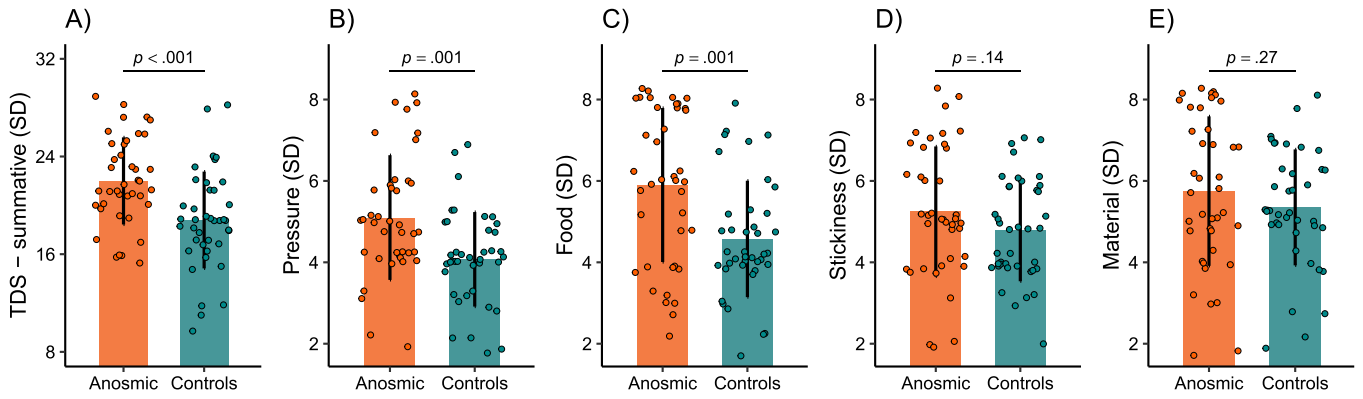

Fig. 3. Differences in Tactile Discomfort Questionnaire scores between individuals with congenital anosmia and controls.

we conducted additional exploratory analyses exploring whether this difference could account for the significant effects reported above. An analysis of covariance (ANCOVA) was conducted with group (Congenital anosmia, Controls) as the between group factor and PHQ-9 scores as covariate. Our dependent variables were SPQ-Touch, SPQ-Touch-Temperature, STQ, and the overall score on the Tactile Discomfort Questionnaire and its subscales related to Pressure and Food. Because the independent variables may be intercorrelated, we checked for multicollinearity among the variables by calculating the Variance Inflation Factor (VIF). However, we found no evidence of multicollinearity, as the variables had low VIF values (VIF < 1.10).

The pattern of results remained the same as previously mentioned, when controlling for the potential confounding effect of depression (see Supplementary Material, for detailed information). Namely, individuals with congenital anosmia had significantly higher total scores on temperature sensitivity ($F_{(1,77)}= 6.14$, $p = .015$, generalized effect size $\eta^2_G = 0.07$), and on the Tactile Discomfort Questionnaire ($F_{(1,77)}= 10.19$, $p = .002$, $\eta^2_G = 0.12$), Pressure ($F_{(1,77)}= 6.55$, $p = .01$, $\eta^2_G = 0.08$), and Food ($F_{(1,77)}= 10.02$, $p = .002$, $\eta^2_G = 0.12$) subscales.

4. Discussion

This study aimed to examine if subjective tactile sensitivity differed between individuals with isolated congenital anosmia and matched healthy controls. Contrary to our *a priori* predictions, and anecdotal reports, the pre-registered analyses revealed no significant differences in self-reported touch sensitivity or enhanced perception of social touch among individuals with congenital anosmia compared to controls. However, exploratory analyses suggest that those with congenital anosmia had greater subjective sensitivity to temperature sensations, as well as heightened overall, and food-related discomfort, to tactile sensations. In line with the anecdotal reports, while individuals with congenital anosmia also reported greater tactile discomfort in response to pressure sensations relative to controls, low internal reliability of the pressure subscale limits interpretability of these findings. Conversely, no self-reported differences were observed between individuals with congenital anosmia and controls in other tactile sensations, including pain, vibration sensitivity, and discomfort related to materials and stickiness.

Complete olfactory loss may result in increased audio-visual integration through sensory compensation [37]. Our findings suggest that congenital anosmia may also impact tactile perception. Indeed, individuals with olfactory loss had higher scores on the tactile discomfort questionnaire and temperature sensitivity than matched controls. This further suggests that in the absence of olfaction – i.e., a sensory modality pertinent to detecting unpleasant stimuli in the environment [46] – individuals may rely on texture and temperature inputs more to warn them of unpleasant and, in turn, potentially hazard related threats [42]. In line with this, people are able to identify unpleasant tactile objects and textures associated with fear (e.g., spiky objects) and disgust (slimy, wet, sticky objects) – emotions pertinent to non-disease related and disease-related hazard detection in olfaction, respectively [23]. The role of temperature in detection of environmental (object-based) and food-related hazards (e.g., hot foods) is also self-evident [19]. Thus, future research examining whether individuals with anosmia have greater fear and disgust to hazard related textures (e.g., spiky, noxious temperatures, wet, sticky, oily), relative to healthy controls, is warranted to test this hypothesis.

Differences in tactile discomfort were evidenced for food-related tactile sensations. These findings are consistent with past studies suggesting an increased preference for trigeminal sensations (e.g., increased preference for spicy, hot foods following anosmia) and oral-somatosensory texture (e.g., increased preference for crunchy food), following COVID-19 induced olfactory disorder [20]. Thus, individuals with anosmia may attend more to hand and mouth-felt texture of food, to determine its edibility. In line with this hypothesis, touch like olfaction, can be used to determine food-edibility *prior* to consumption (e.g., lumpy-feeling/appearance of milk; or sour-smell of milk, both suggest the milk may have soured; [47]). Touch also occurs in tandem with other sensory modalities – i.e., texture can be perceived visually, auditorily, and in the mouth, making it a versatile sensory modality to compensate for olfactory loss [1].

In contrast to expectations, there was comparable social-touch perception between individuals with congenital anosmia and matched controls. This may suggest that sensory compensation occurs more for aversive or hazard-related experiences, as outlined above, than for affiliative-functions [3]. Alternatively, our reliance on forced-choice questionnaires, rather than open-ended questions, may have led to a limited understanding of all the areas touch may be adopted to compensate for functional losses following anosmia.

Two limitations were present in the current study. First, as this is the first, to our knowledge, study to examine self-reported tactile sensitivity in individuals with isolated congenital ansomia, the questionnaires (SPQ – touch, Social Touch Questionnaire, and Tactile Discomfort Questionnaire) used have not been validated in this population. In line with this, there was low internal consistencies for subscales of the Tactile Discomfort Questionnaire. Thus, more work is needed to validate questionnaires measuring tactile function in individuals living with loss of olfactory perception. A second and related limitation of this study, is that it relied on self-reported measures to determine an individual's tactile sensitivity. This means it is difficult to ascertain whether the differences in tactile sensitivity found between groups is due to enhanced tactile perception in individuals with congenital anosmia or perceived differences. Perceived differences may not necessarily reflect changes in objective tactile perception. In line with this, a recent study found that individuals with blindness and their sighted counterparts held a shared conviction that sensory compensation following blindness occurs in all sensory modalities [38], despite little past evidence for this,

at least, in the chemical senses [44]. It is also possible that participants' knowledge of the study's aims, impacted their self-reported sensitivity. However, this self-report bias was unlikely to have occurred, given individuals with anosmia did not have significantly higher self-reported sensory sensitivity for all modalities (as measured by the Sensory Perception Quotient) - and only reported so for specific domains of tactile sensitivity. That said, future studies following up on the current study's findings should use objective sensory assessments of tactile sensitivity – and compare these to results from tactile sensitivity questionnaires – to better understand if and how olfactory loss may influence tactile perception.

In conclusion, this preliminary study provides tentative evidence that individuals with congenital anosmia may compensate for their olfactory loss by greater sensitivity to certain tactile sensations, especially those related to discomfort. We suggest that this may be because touch and olfaction both serve overlapping roles in detection of aversive (hazard related) stimuli. These exploratory findings pave the way for an overlooked investigation into the sensory compensation of olfaction on touch. To further ascertain the range of areas touch may be upregulated for in the absence of olfaction, future studies examining sensory compensation in anosmia should use objective assessments of tactile function.

CRediT authorship contribution statement

Saluja Supreet: Writing – review & editing, Writing – original draft, Formal analysis. **Tognetti Arnaud:** Writing – review & editing, Writing – original draft, Supervision, Project administration, Formal analysis. **Lundström Johan N:** Writing – review & editing, Writing – original draft, Supervision, Project administration, Funding acquisition, Conceptualization. **Fondberg Robin:** Writing – review & editing, Methodology, Investigation, Data curation, Conceptualization. **Tóth Anna Laura:** Writing – review & editing, Formal analysis. **Peter Moa G.:** Writing – review & editing, Methodology, Investigation, Data curation, Conceptualization.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.bbr.2025.115487.

Data Availability

All data are available on the OSF webpage (https://osf.io/qhd6f/?view_only=c580bf3e707f4df990f7afef129b6364).

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