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The relationship between self-reported sensory experiences and autistic traits in the general population: a mixed methods analysis

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The Relationship Between Self-Reported Sensory Experiences and Autistic Traits in the General Population: A Mixed Methods Analysis

Abstract

There have been few examples of inductive research in sensory reactivity, particularly in relation to autistic traits among the general population. This study used a mixed methods approach to explore the nature of sensory experiences among people with different levels of autistic traits. Participants completed a sensory questionnaire as well as the Autism Spectrum Quotient. Responses to the open questions were analysed as part of this study and both quantitative and qualitative analyses were performed on the data. The closed questionnaire data have been reported elsewhere (Robertson & Simmons, 2013). Data were coded and responses quantitatively compared by group. In addition, data were qualitatively analysed using a general inductive approach, which resulted in two themes: 'problematic sensory experiences' and 'calming sensory experiences'. Results show that coping mechanisms and certain aspects of the sensory experience vary according to autistic trait level, and provide insight into the nature of sensory reactivity across the general population.

Keywords: autism, sensory, autistic traits, mixed methods, thematic analysis

Introduction

Individuals with Autism Spectrum Disorders (ASD) often report unusual responses to sensory stimuli, which can result in aversive, low responsive or seeking behaviours (Robertson & Simmons, 2015). Studies using parent report techniques to investigate sensory responsiveness have found that children with ASD routinely respond differently from both typically developing (TD) individuals (Leekam, Nieto, Libby, Wing & Gould, 2007) and other clinical groups (Wiggins, Robins, Bakeman, & Adamson, 2009). However, these sensory issues are not unique to ASD, with researchers finding similar behaviour in children with Fragile-X (Rogers, Hepburn & Wehner, 2003) and individuals with specific sensory impairments (Wing & Gould, 1979).

Qualitative Studies of Sensory Issues in ASD

Jones, Quigney and Huws (2003) conducted the first qualitative study of sensory issues in ASD. They used Grounded Theory (Strauss & Corbin, 1998) to examine five autobiographical accounts, finding that people with autism reported feeling both enjoyment and distress from their interaction with sensory stimuli. Elwin, Ek, Schröder, and Kjellin (2012) investigated pre-existing autobiographical accounts of sensing in people with Asperger's Syndrome (AS) or high-functioning autism (HFA) and found that strong reactions and apprehension were related to stimuli they reported being hyper-reactive (higher-than-usual sensitivity) to, which tended to be externally generated. In contrast, hypo-reactivity (lower-than-usual sensitivity) was reportedly related to internal processes, e.g., proprioception and pain.

As well as investigating autobiographical accounts, researchers have also conducted qualitative studies in which individuals with ASD, or their caregivers, have discussed their experiences of sensory perception. Dickie, Baranek, Schultz, Watson, and McComish (2009) investigated sensory responses in pre-schoolers by holding interviews with parents of children

with autism and parents of TD children. Children with autism were reported to have more extreme or unusual sensory experiences than TD peers.

More recently, Smith and Sharp (2013) conducted a qualitative study with nine individuals who had a diagnosis of AS. They used a modified Grounded Theory approach (Charmaz, 2006) to explore unusual sensory experiences in AS, concentrating on the effect that these experiences could have as well as the types of coping strategies utilised, and developed a model to explain how the categories and codes interacted in their data. They found that unusual sensory events stemmed from a reported heightened sensitivity to stimuli. The interaction with such stimuli was impacted by additional factors, in particular "other people," who either had a positive or negative impact on the individual with AS. They could also contribute to sensory stress by being a source of sensory stimulation (e.g., being part of a crowd). Thus, Smith & Sharp (2013)'s model suggested that interaction with other people had a significant role in how sensory stimuli were perceived by their informants. The model also highlighted that negative experiences with sensory stimuli could lead to avoidance, which is relevant when considering the role that anxiety could play. Overall, the model depicted how engagement with sensory stimuli could either be a positive or negative experience, leading in turn to either fascination or stress.

Autistic Traits in the General Population

High levels of autistic personality traits are common in the general population (Constantino & Todd, 2003). There has been a recent surge in publications showing that people with high, yet subclinical, levels of autistic traits exhibit many differences from people with low autistic trait levels, including brain structure and function (Von dem Hagen et al., 2011), biological processes (e.g. Whitehouse, Maybery, Hickey, & Sloboda, 2011), performance in visual tasks (e.g. Grinter et al.,, 2009), face perception (e.g. Wilson, Freeman, Brock, Burton, & Palermo, 2010), speech

perception (e.g. Yu, 2010) and reported sensory sensitivity (Robertson & Simmons, 2013; Tavassoli, Miller, Schoen, Nielson, & Baron-Cohen, 2014). The similarities in performance of people with high levels of autistic traits to individuals with ASD could be indicative of an endophenotype. Endophenotypes are measurable, heritable characteristics normally associated with, but not symptomatic of, a disorder. Research into the endophenotypes of ASD is potentially valuable, as it could help guide the search for associated genes.

Although some quantitative studies (e.g., Grinter et al., 2009; Yu, 2010) have investigated sensory processing in people with a range of autistic traits, there has been no attempt at a similar study using either a qualitative or mixed methods methodology. It is particularly timeous to investigate sensory issues, as hyper- and hypo-reactivity to sensory stimuli has recently been included in the Diagnostic Statistical Manual of Mental Disorders for ASD (DSM-5: American Psychiatric Association, 2013). We previously reported a strong positive correlation between sensory reactivity, as measured by the Glasgow Sensory Questionnaire, and autistic traits, which has recently been replicated by two independent groups of researchers (Takayama et al., 2014; Horder, Wilson, Mendex Hernandez & Murphy, 2014). An important next step is to expand on these findings by exploring the lived experience of people with a range of autistic trait levels.

Mixed Methods Research

Mixed methods research has become an increasingly popular research paradigm (Johnson, Onwuegbuzie & Turner, 2007) and can provide strengths that offset the weaknesses of quantitative and qualitative research alone (Creswell & Plano Clark, 2011). For example, mixed methods research can use a qualitative approach to explore and understand the context of human experience (by investigating the *why* and *how* of a phenomenon) while employing quantitative techniques that allow for generalisation to larger groups (Creswell & Plano Clark, 2011).

The Current Study

The purpose of this study was to explore sensory features and their relationship with autistic traits in the general population. Previous research using qualitative (e.g. Smith & Sharp, 2013) and quantitative (e.g. Crane, Goddard & Pring, 2009) methodologies has demonstrated that individuals with a diagnosis of ASD report hyper- and hypo-reactivity to sensory stimuli. Therefore, we felt it was important to explore the relationship between sensory reactivity and autistic traits in the general population. To compare individuals with different levels of autistic traits, we employed quantitative techniques to determine whether there were group differences in the types or frequencies of responses to open questions. To investigate the lived experience, extent and impact of unusual sensory experiences across people in the general population we identified themes within the self-generated responses to four open questions on the topic of sensory processing, using an inductive thematic qualitative approach (Thomas, 2006). The main purpose of the qualitative data was to help explain and explore the quantitative analyses performed, both within this paper and in our previous work (Robertson & Simmons, 2013).

Method

Participants and recruitment

English speakers were recruited from the general population (n = 212; 142 females, 70 males; mean age = 26.8 years, S.D. = 9.8 years, range = 16–66 years). There were 270 original responders to our advertisement; data were excluded if (a) less than 90% of the items from either of the quantitative questionnaires was completed, and there was no response to at least one qualitative question (n=57) or (b) comprehension difficulties were reported with more than one of the questions posed (n=1). Departmental ethical permission was granted prior to recruitment commencing. Students and colleagues from the University of Glasgow were invited to

participate by email, and encouraged to forward it to others who may be interested. In order to recruit individuals with high Autism Spectrum Quotient (AQ) scores, an advertisement was also placed on an online forum for people with a diagnosis of AS. Most participants were UK-based (n=180).

Materials

Each participant completed the AQ (Baron-Cohen, Wheelwright, Skinner, Martin, & Clubley, 2001) and the Glasgow Sensory Questionnaire (GSQ) and was assigned to a group based on their AQ score. Although two participants disclosed their diagnosis of ASD, we collected data based solely on AQ score. Neither IQ nor comprehension skills were formally assessed, but participants were encouraged to provide feedback on any difficulties they experienced with the questionnaires and were excluded from analysis if they indicated comprehension problems on multiple items (n=1). Limited demographics information was also gathered: participants were asked to disclose their gender, date of birth and the area in which they currently resided.

Autism Spectrum Quotient (AQ). The AQ is a self-report questionnaire which measures subclinical traits associated with autism. Evidence suggests that it is both a valid and reliable tool (Baron-Cohen et al., 2001). DSM-5 characterises ASD in two separate domains, and each of the five subscales of the AQ appears to fall under one of the diagnostic domains (Communication and Social into ‘difficulties with communication and social interaction;’ Attention to Detail, Attention Switching and Imagination into ‘restricted, repetitive patterns of behaviour, interests, or activities’). We used the AQ to separate the participants into three groups for some of the analysis. Group 1 (low scorers) consisted of people who scored less than 19 on the AQ (n=79), Group 2 (medium scorers) comprised individuals who scored between 19 and 31 (n=94) and

people in Group 3 (high scorers; n=39) had a score of 32 or more (because, according to Baron-Cohen et al. (2001), 80% of those scoring 32 or more on the AQ will have diagnosable ASD). The 'medium' group targeted people with 'higher-than-average' AQ scores given that the mean AQ score for controls in Baron-Cohen et al.'s (2001) study was 16.4.

Glasgow Sensory Questionnaire (GSQ). The GSQ consists of 42 closed questions with a 5-point likert response scale, and four open questions. Participants were originally asked 70 closed questions (equally split between hyper- and hypo-reactivity, as well as for seven sensory modalities). Data were only reported on 42 of the questions after Principal Components Analysis was conducted to reduce the number of items. Participants were then asked to respond to four open questions designed to elicit details about problematic stimuli or environments. The results of the closed questions have been reported elsewhere (Robertson & Simmons, 2013), so only the data from the open questions is reported here. All questions were constructed by the authors and piloted on a small group of people (n=5) with varied AQ scores. One of the participants in the pilot group had a confirmed diagnosis of autism, and we worked with him individually to ensure that the questions were clear and understandable. Two ASD researchers and a consultant psychiatrist specialising in ASD revised the questions. The questionnaire has reasonable face validity, as all items ask questions about sensory experiences. There is also reasonable content validity, as all items were checked by five independent observers and deemed appropriate for inclusion within the questionnaire and the number of sensory experiences discussed in the open questions increased alongside reported sensory reactivity in the closed questions (Robertson & Simmons, 2013).

The open questions that were presented to the participants were:

1. Can you describe which environments/situations, if any, cause you difficulty or cause

you to panic?

2. Do you ever find yourself reaching "meltdown" due to too much sensory input – for example feeling like too much noise/lights/smells cause an 'overload'?
3. How do you calm yourself down if you start to panic?
4. Do you find going to leisure centres/supermarkets difficult? If so, what makes it difficult?

These particular questions were designed in order to elicit (a) details of the specific stimuli which cause issues for people, (b) whether participants felt that they reacted strongly to sensory input, (c) details of any coping mechanisms used, and whether these would be sensory-based or not, and (d) whether leisure centres and supermarkets were a particular issue. Question 4 specifically targeted leisure centres and supermarkets as previous pilot work we had conducted indicated that these two environments were particularly stressful for individuals with ASD (Robertson & Simmons, 2008).

Procedure

This study was conducted online using a survey website (Survey Monkey: www.surveymonkey.com), which participants accessed by clicking on a hyperlink. Recruitment materials did not include any mention of 'autistic traits' in an effort to blind participants to the purpose of the study. Instead, potential participants were told the aims of the study were (a) to improve our understanding of how people react to environmental stimuli and (b) to provide first-hand information about how environmental stressors affect different groups of people. Individuals were advised that completion of the study would take approximately 25 minutes. Participants from the UK were offered the chance to enter into a prize draw for one of three £15 vouchers. Guidelines on the Ethical Practice of Research on the Internet (British Psychological

Society, 2007) were followed as a supplement to the BPS Code of Ethics and Conduct (British Psychological Society, 2009). The qualitative questions were presented after the quantitative questions, and before the AQ, for all respondents.

Analysis

Our quantitative analysis of the open question responses consisted of allocating each response to one of a small number of "categories", derived from the data as described below, and determining whether there were any group differences in the content and/or frequency of these categories between groups. Previous research has indicated that there are discernable differences between people with higher and lower levels of autistic traits; we were interested in exploring whether these differences could also be observed in free responses to open questions.

We also explored the content of the data for themes by using qualitative analysis. The purpose of this qualitative analysis component of the study was to expand upon the results obtained in the quantitative analysis, as well as our previous results reported elsewhere (Robertson & Simmons, 2013). An inductive approach was deemed most appropriate for this aspect of the study, as the purpose was to discover more about the sensory experiences rather than test prior assumptions. We analysed the data using a general inductive qualitative approach (Thomas, 2006), which aims to elucidate the core meanings that are evident in the data. This process is described as follows:

1. Preparing the raw files for analysis (e.g., transcribing using a standard template).
2. Close reading of the data to become familiar with it.
3. Creation of categories: Lower-level categories and codes are derived from repeated readings of the data and high-level themes are generated to explain these underlying categories. For example, some codes identified were specific qualities of noises (e.g.,

loud, abrasive, unpleasant), which then formed the category ‘unpleasant auditory stimuli’.

4. Continuing revision and refinement: The data within each category are explored for new insights and contradictory evidence. Quotations that convey the core theme are selected.

The primary mode of analysis is the development of categories, and the outcome of the data analysis process is the generation of key themes. In order to be included as a category in the single question analysis for our study, one of the three groups had to have at least 5% of their responses coded for each option. When less than 5% of examples were coded as the same category for all three groups, they were included as ‘other’.

AR was the sole coder for these data. However, in an effort to increase reliability: (1) codes were developed by AR and discussed with DS as coding developed; (2) DS coded 20% of the transcript (A Kappa Coefficient of .916 was obtained for AR’s and DS’s attribution of codes for this section, showing a high level of agreement); (3) Intra-rater reliability was obtained (.952) for 20% of the transcript, where AR coded the transcript twice, one month apart.

Results

The core category emerging from the data was ‘problematic sensory experiences,’ with ‘calming sensory experiences’ also being of interest. Analysis showed that participants in our sample routinely experienced difficulties with sensory stimuli, often resulting in strong physiological (e.g., experiencing pain) and emotional reactions (e.g., experiencing a surge of hostility towards others). Lastly, it was found that sensory stimuli could have a calming effect.

It should be noted that the ‘Attention to Detail’ subscale of the AQ contains five items that could be related to sensory features (e.g., ‘I often notice small sounds when others do not’). However, when the group means for the subscales were compared for the high scorers in the AQ, there was very little difference between them (Attention Switching: 8.86; Attention to Detail:

7.53; Communication: 8.69; Imagination: 6.40; Social: 8.46), suggesting that the scores are not dominated by a particular subscale but broadly equal across all five domains of the AQ.

Quantitative analysis

In order to explore whether high scorers in the AQ differed in the issues reported in the open questions, we investigated the percentages of responses coded for each question. It is important to note that high AQ scorers were more likely to respond to these questions than medium or low scorers and medium scorers were more likely to respond to the open questions than low scorers. There was no group difference in the percentage of respondents to Q3 ($\chi 2$ (2, N=212) = 4.34, p=.12*),* whereas high and medium AQ scorers were more likely to respond to Q1 ($\chi 2$ (2, N=212) = 23.89, p<.001*),* Q2 ($\chi 2$ (2, N=212) = 53.28, p<.001*)* and Q4 ($\chi 2$ (2, N=212) = 42.93, p<.001).

Figure 1 shows the categories identified and the percentages of responses for Q1: 'Can you describe which environments/situations, if any, cause you difficulty or cause you to panic?' Responses to this question fell into one of five categories: phobias, crowds, being put under pressure (e.g., by a deadline), sensory stimuli and other (which included rarely-mentioned triggers). The percentage of examples related to sensory stimuli was higher in the medium-AQ group than in the low-AQ group, and higher still in the high-AQ group. Furthermore, the causes of panic and discomfort were more equally distributed for the low-AQ group than the other two groups, who were more likely to give sensory examples. This suggests that sensory stimuli are more likely to present problems for participants in the high- and medium-AQ group. This, in turn, meant that the percentage of examples given for other causes of discomfort was reduced in comparison. Chi-squared analysis showed that there was a significant group difference in the frequency distribution of the examples (($\chi 2$ (8, N=265) = 27.16, p<.001*),* with high AQ scorers

more likely to give sensory-related reasons than low- and medium-scorers.

The categories identified and the percentages of responses for Q2 'Do you ever find yourself reaching "meltdown" due to too much sensory input – for example feeling like too much noise/lights/smells cause an 'overload'?' are shown in Figure 2.

Responses to this question fell into one of six categories: sensory stimuli, overheating, crowds, exhaustion, social stressors and attention switching. There appeared to be little difference in the types of responses given by group. Only high-AQ scorers mentioned social stressors being a potential trigger, with only low and medium scorers reporting that exhaustion could be an antecedent. However, it should be noted that this is a small difference and, in general, responses were similar across the three groups. Chi-squared analysis showed that there was no significant group difference in the frequency distribution of the examples ($\chi 2$ (10, N=154) = 17.755, p>.05).

The third question explored the types of things that people did to deal with uncomfortable situations by asking 'How do you calm yourself down if you start to panic?'. The responses to this question were coded into five different categories: distraction, avoidance, sensory self-soothing, non-sensory self-soothing and seeking support from others (Figure 3).

The low- and medium-AQ groups were most likely to self-soothe using non-sensory techniques, e.g., deep breathing and mindfulness. More than half of the examples given by participants in these groups fell into this category. In contrast, the most common example given by the high-AQ group was avoidance. 40% of the examples given by individuals with a high level of autism traits involved avoidance, compared to 20% in the low- and medium-AQ groups. If the high-AQ scorers stayed in a difficult situation, they reported being more likely to use sensory-based self-soothing techniques (e.g., rocking) than individuals in the other groups. Chi-squared analysis showed that there was a significant group difference in the frequency distribution of the

examples ($\chi 2$ (8, N=250) = 40.43, p<.001), with high-AQ respondents more likely to avoid a situation or soothe using sensory stimuli than people with medium- or low-AQ scores.

The categories identified and the percentages of responses for Q4 ('Do you find going to leisure centres/supermarkets difficult? If so, what makes it difficult?') are shown in Figure 4. Responses to this question fell into one of three categories: sensory stimulation, crowds and others' irritating behaviours. The percentage of examples related to sensory stimulation was higher in the high-AQ group than in either the low- or medium-AQ groups. Furthermore, the percentage of responses for medium and low scorers was higher for crowds than the high AQ group. There was little difference between the groups in the percentage of examples given which were related to others' irritating behaviours and there was no significant group difference in the frequency distribution of the examples ($\chi 2$ (4, N=96) = 5.186, p>.05).

Qualitative analysis

Problematic sensory experiences. Individuals with high AQ scores were more likely to report uncomfortable interaction with sensory stimuli when visiting supermarkets or leisure centres. This contrasted with low and medium scorers, who reported that crowds were more problematic. Participants were more likely to describe hyper-reactivity to sensory stimuli than hypo-reactivity, with issues involving auditory noise being most commonly reported. A large variety of sounds were problematic to our sample, including 'the constant squeaking on the floor from shoes' and 'the noise from TVs (not just volume, the buzzing from them as well...).'

Sound loudness was the main and most severe cause of distress with auditory stimuli. One person found it very hard to cope with 'overwhelmingly noisy environments.' Six participants reported adverse effects when faced with too much noise ('sounds ... are just headache inducing') and four reported having to withdraw from situations when experiencing high noise

levels (‘[They] made more noise than I could cope with and I had to stop’).

Sound pitch was also often an issue. Both high-frequency (‘screeching sounds ... can be a problem,’ ‘high-pitched noises [are an issue]’) and certain low- frequency (‘persistent low-frequency noises’) sounds were described as being difficult to cope with. Participants reported feeling strong negative physiological reactions to both high- (‘very high sounds make me feel sick’) and low-pitched sounds (‘painful sounds – motorcycles’). Noises with sudden onsets were often described as causing anxiety or being particularly difficult to deal with. Examples included sudden (‘a sudden bang of sound’) and unexpected (‘loud unexpected noises’) noises.

Five participants also reported that noises that were repetitive or fluctuated in amplitude (‘repetitive sounds, such as beeping [can be a problem]’) could be difficult to endure. One person described that experiencing this increased their discomfort and feelings of annoyance (‘if there are a lot of repetitive noises I can often get very irritated and uncomfortable’). Four participants also mentioned that experiencing different sounds at the same time could be unpleasant; ‘discordant noise’ was mentioned as being irritating, as was ‘excess mixed noise.’

Stimuli related to four of the other sensory domains (vision, touch, taste and smell) were also described as being difficult to deal with at times. The main complaints in the visual domain involved strong stimuli (‘bright lights’) and certain types of lighting (‘Bright, humming fluorescent lights’). Thirty-six participants disclosed that they disliked fluorescent lighting, with one person describing it as ‘horrible.’ Five participants in our sample mentioned flickering lights as being problematic for them. As with auditory stimuli, ill effects with visual stimuli were reported. One person disclosed that they felt unwell when they went to the supermarket (‘lights in the big supermarkets give me [a] headache and I feel sick’), with another reporting that colours could make them feel physically unusual (‘Some bright, fluorescent colours make me

feel really weird, like time is disjointed!').

Within the tactile domain, the main complaints involved the feeling of certain textures. One person told us that 'some clothing textures...really irritate me,' but did not mention the types of fabric that caused most issues. Two people mentioned that touching paper could feel strange ('hand on writing paper – felt too smooth somehow'), with one reporting discomfort ('touching too much paper makes me feel uncomfortable').

Participants reported that particular food could be problematic. The texture of the food was often an issue ('slippery, slimy things, especially foods'), sometimes invoking a gag reflex ('some food textures make me gag: avocado, tomato, onion, any overcooked, mushy vegetable') or, in one case, vomiting ('With the food issues, I just throw up'). One participant noted tastes that they found to be repellent ('certain tastes...spearmint, liquorice, aniseed, citrus').

Seventeen participants also reported finding unwanted smells difficult to deal with in their everyday lives. People were most bothered by intense smells ('overpowering smells ... give me headaches'), certain types of smell ('musky smells [are horrible]') or multiple scents ('I find perfume shops quite unpleasant even though I like single fragrances on their own – even when they're quite strong'). As with other modalities, participants mentioned experiencing strong reactions when faced with certain olfactory stimuli ('Smells induce a feeling of being unable to breathe' and 'I can't smell more than 2-3 different kinds of perfume... I feel dizzy and sick').

Finally, an interesting issue that emerged from the data was that unpleasant sensory input could impact negatively on an individual's perception of other people. For example, three participants discussed their dislike of sudden tactile input from others ('People touching me without warning'), especially if they were unable to understand the motivation for it ('people touching me for no apparent reason'). If someone is already sensitive to tactile stimulation, being

touched unexpectedly could be a difficult experience. One participant mentioned that they experienced extreme levels of anger when touched in a certain way by others ('Being prodded/poked in general makes me unreasonably angry'). The use of the word 'unreasonably' shows that this person is aware that their reaction is out of proportion to the stimulus.

Enjoyable and calming sensory experiences. The second category showed that sensory stimuli can be enjoyable. Within the sample, the number of sensory-based examples given for calming down increased as AQ score rose. One participant liked the feeling of certain fabrics, but mentioned that she would only touch them when she felt it would not be observed by others ('I really like [them], and will rub between my fingers if I think no one would notice or care'). This suggests that some individuals may temper their use of sensory activities for calming because they are aware that they may be perceived as unusual or inappropriate.

A variety of sensory techniques were reported to help participants calm down when experiencing stress. Typically, participants would mention some kind of tactile or proprioceptive-based input. Examples included 'rock[ing],' 'rub[bing] the outside of my ear with my fingers' and 'jump[ing] on a trampoline.' These techniques were all described as bringing relief from anxiety and distress and helping the individual cope with uncomfortable situations.

Discussion

This paper reports a mixed methods analysis of the sensory experiences of individuals with varied levels of autistic traits in the general population. We also specifically recruited individuals who were likely to have a high level of autistic traits (through an online forum for individuals with AS) in order to reach a wide variety of people. By using an inductive qualitative approach (Thomas, 2006), we elucidated details of sources of discomfort and coping strategies employed by people with different levels of autistic traits. Furthermore, by separating participants into

groups based on AQ score and performing quantitative analysis, we observed whether the categories generated changed according to group.

The participants in our sample reported a number of issues with visual, auditory, tactile, olfactory, gustatory and proprioceptive stimuli. Intensity appeared to be the most important aspect. Taking the auditory domain, participants reported that loud noises could cause headaches, migraines or nausea, and cause them to leave difficult situations or environments. In addition, the frequency content and modulation of sounds appears to play an important role (Gray, 2000). However, it is important to consider the person's own sensitivity to auditory stimuli as well as the acoustic properties of a noise. If people with high AQ scores are more sensitive to sounds, then it stands to reason that they may be increasingly disturbed by noises known to annoy the general population. However, whilst there appear to be no differences in the absolute auditory thresholds (Jones et al., 2009), peripheral thresholds (Gravel, Dunn, Lee, & Ellis, 2006) or auditory brain stem responses (Tharpe, et al., 2006) of individuals with ASD, there is some evidence that the subjective experience of louder noises in children with ASD is different from that of typically developing individuals (Khalfa et al., 2004).

Other reasons reported for discomfort included duration, the nature of the stimulus, the type of onset, expectation of interaction with a stimulus, and the mixing of different stimuli within the same domain. It is important to note that the quality of the stimulus was the most important factor in the tactile and gustatory domains. This seems intuitive, as these are the two domains which require direct contact, meaning that they are more easily avoidable. These findings echoed the 'moderating effects' that Smith and Sharp (2013) reported in their recent qualitative study. They found that, in terms of adverse sensory experiences, the qualities of sensory input that increased distress were: 1) multiple inputs of sensation, 2) high intensity

stimuli, 3) chaotic environments, and 4) the person's own emotional state. Our data also showed that multiple stimulus inputs were more uncomfortable, that intensity was an integral factor in the response, that predictability was important (also see Pellicano & Burr, 2012) and that emotional state played a role in how stimuli were perceived.

Surprisingly, some participants described feeling overwhelming negative emotions towards people, due to exposure to a sensory stressor. One participant gave an example of how being 'prodded/poked' was likely to make them 'unreasonably angry.' From the example given, we are unable to discern whether it is the feeling of being poked or the interaction with other people that causes this participant's anger level to rise. This difficulty in parsing out the social and the sensory is also evident in the account given by another participant, who detailed that 'I hate strangers brushing against me or standing so close they are touching me.' They later mention that it 'give[s] me feelings of hostility towards others.' It could be the case that the difficulties interacting with people and some of the sensory issues that people experience are linked. Smith and Sharp (2013)'s model of unusual sensory experiences in AS reports interaction with other people to be a factor in sensory experiences. It is possible that if someone consistently feels anxiety, hostility and anger towards others partially as a result of uncomfortable sensory experiences, that person may develop negative reactions to people in general, which could manifest in a difficulty with social interaction and increased anxiety.

One strength of this mixed methods research is the large sample size obtained. By accessing over 200 participants, we were able to ascertain the general difficulties people have in difficult/uncomfortable situations, while also being able to compare the types of responses by AQ group. Furthermore, we were able to delve into the particular stimulus properties that people find most difficult to cope with, as well as investigate the methods that people use to deal with

difficult stimuli and problematic situations. Our study suggests that, while some types of stimuli are often difficult for participants regardless of AQ score, there are certain issues that are more problematic for medium and high scorers. These include the negative reactions experienced from sensory stimuli and the differing coping mechanisms, e.g., an increase in avoidance and sensory-based self-soothing in high AQ scorers, compared to the medium- and low-AQ groups. It could be argued that some of the higher AQ scorers may have a diagnosis of ASD and therefore would be far more aware of the propensity for sensory issues in ASD, which could potentially lead to a reporting bias. However, this argument does not explain the differences identified between low and medium scorers, neither of whom would be likely to be aware of the link between sensory issues and ASDs.

Limitations and directions for future research

One of the limitations of the study was that the presentation order of the questionnaires was not counterbalanced. Every participant was presented with the forced-choice questions first, followed by the open questions reported here. The AQ was always administered last in order to minimise any pre-conceived bias between sensory reactivity and autistic traits. It is possible that participants may have been more likely to choose examples specifically mentioned in the previous questionnaire. However, although this may have affected the nature of the responses given, it does not explain the differences observed between the groups. Although the high-scorers recruited through the online forum are likely to have been aware of the relationship prior to completing the questionnaire, this is unlikely to have been the case for the majority of low and medium scorers, as there was no mention of autistic traits in any recruitment correspondence.

Another limitation of the study is that the questions could have been worded more effectively to specifically target sensory experiences. For example, by asking about ‘panic,’ it is

possible that the questions may have been interpreted in terms of anxiety, which is reflected in the categories extracted from Question 1. One advantage, though, of having questions not wholly restricted to sensory experiences was that we were able to explore the myriad reasons underlying certain behaviours (e.g., people with high levels of autistic traits reported a clear preference for sensory-based self-soothing as compared to individuals with low levels of autistic traits). In addition, the questions targeted high-stress situations, meaning that participants would have been more likely to report difficult, rather than enjoyable, experiences with sensory stimuli. Furthermore, question 2 is not a truly open question as it asks for a 'yes' or 'no' response ('Do you ever find yourself reaching "meltdown" due to too much sensory input – for example feeling like too much noise/lights/smells cause an 'overload'?). It would be particularly important that future research explores how to frame questions in a way that encourages both positive and negative interactions with stimuli. Future studies could also refine the questions asked here, in order to more specifically target sensory issues.

This study used the AQ to investigate the relationship of autistic traits and sensory features in the general population. Another limitation of the study is that the sample is unlikely to be truly representative of the general population, as we primarily recruited through multiple Higher Education establishments in the UK. Although some demographic information was collected (e.g., age, gender, location), data were not collected on socioeconomic status, making it difficult to assess the sample for this characteristic. We would recommend that future studies in this area recruit participants from a wider range of backgrounds, in order to ensure the data is truly representative of the general population. Furthermore, it would be important to investigate whether individuals with a clinical diagnosis of ASD report similar experiences to individuals with no diagnosis, but high AQ scores. We would therefore suggest that future research be

conducted with individuals who do and do not have a diagnosis of ASD.

A final limitation of the study is that a deeper understanding of both enjoyable and problematic sensory processing could have been gained by using a different methodology. For example, if we had interviewed participants, we would have been able to probe them by asking follow-up questions. However, the purpose of the current study was to provide additional information to supplement quantitative data previously gathered, rather than to be the focus of the study itself.

Implications of the research

These findings offer important insights for individuals with ASD into the differences in sensory reactivity that they experience. They also support the notion that ASD is an endophenotypic disorder, with many people experiencing subclinical traits. Finally, the findings could also be important for future intervention studies, as they offer insight into the development of coping strategies as well as strategies to adapt the environment to match atypical sensory processing. The results also indicated that, although individuals with high AQ scores may seek out sensory stimuli as a soothing tool, some individuals are aware that their engagement with such stimuli may not be socially 'typical.' Therefore, they may then regulate their interaction with such stimuli. It would be interesting to determine whether individuals with a diagnosis of ASD also use such skills, as this information could be very useful when designing future interventions.

Our results demonstrate that many people in the general population report difficulty with sensory stimuli and that this can have a significant impact on various aspects of their lives. Therefore, discomfort with sensory stimuli is not restricted to individuals with diagnosed ASD: people with subclinical traits report experiencing difficulty with some types of sensory

stimuli as well. This has particular implications for people in schools and other learning establishments, especially given the data that those with a propensity for mathematics and scientific subjects tend to have higher levels of autistic traits (Baron-Cohen et al., 2001). Thought should be given to adapting educational environments to reduce sensory stressors as this would benefit everyone and increase inclusiveness.

Ideas that arise directly from this research include: (1) paying specific attention to lighting in classrooms, so as to move away from fluorescent lighting; (2) making sure that classrooms are well sound-proofed, so as to reduce distracting extraneous noise; (3) being aware that noisy, unstructured activities may be distressing to a significant number of students; (4) being aware that noises from electrical equipment, such as fans and data projectors, might be distracting for some students; (5) being aware of potential over-reactions in some students to unsolicited physical contact; (6) being aware that strong smells (e.g. perfume, food smells) may be problematic for some students.

Conclusions

The quantitative data showed that people with higher levels of autistic traits are more likely to avoid difficult situations, which has also been observed in individuals with a confirmed diagnosis of AS (Smith & Sharp, 2013). A systematic avoidance of people and places as a result of sensory intolerances could lead to social isolation, perhaps resulting in phobias of people, places or certain types of environmental stimuli. In our study, it appears that a significant proportion of the population is affected to some degree by sensory hyper-reactivity, and that autistic traits appear to affect the response to sensory stimuli. As such, consideration should be given to modifying the environment to counter at least the most severe sensory stressors for the benefit of all (Davidson, 2010).

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Figure 1

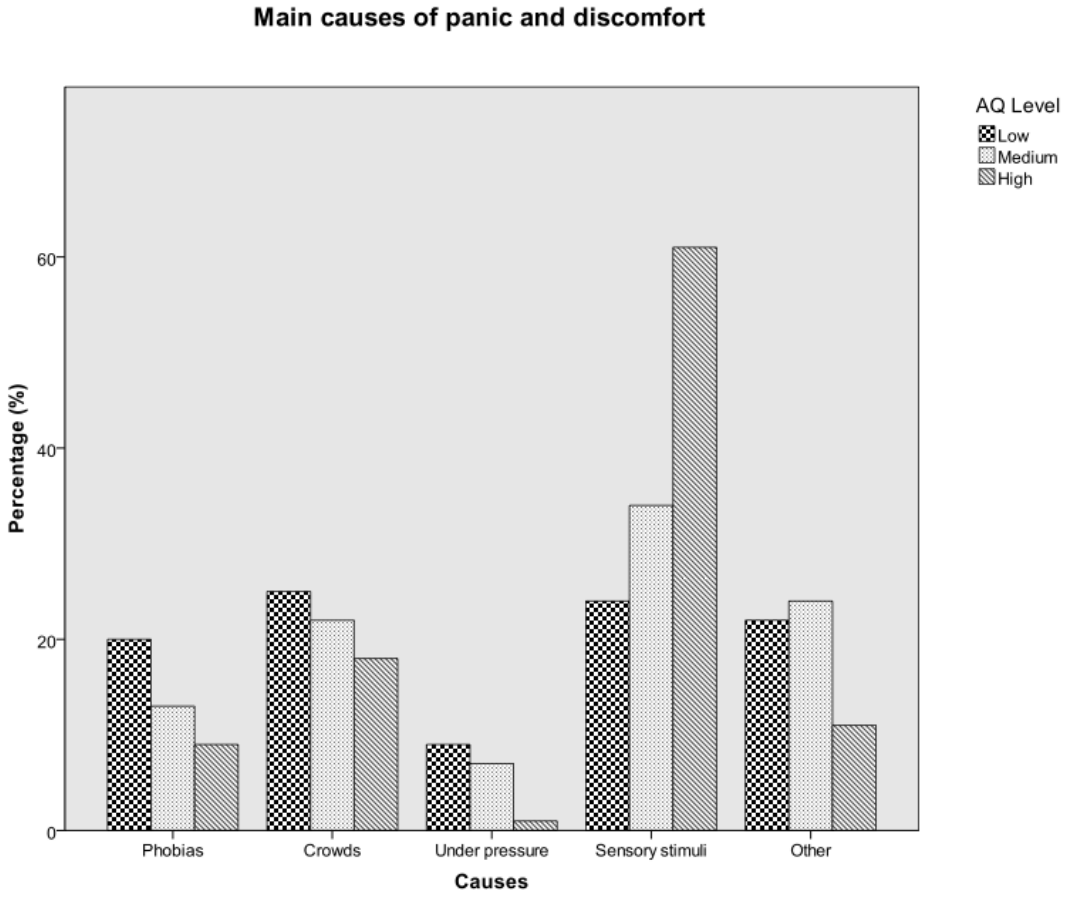
Main causes of panic and discomfort
AQ Level
Low
Medium
High
Percentage (%)
0
20
40
60
Phobias
Crowds
Under pressure
Sensory stimuli
Other
Causes

Figure 2

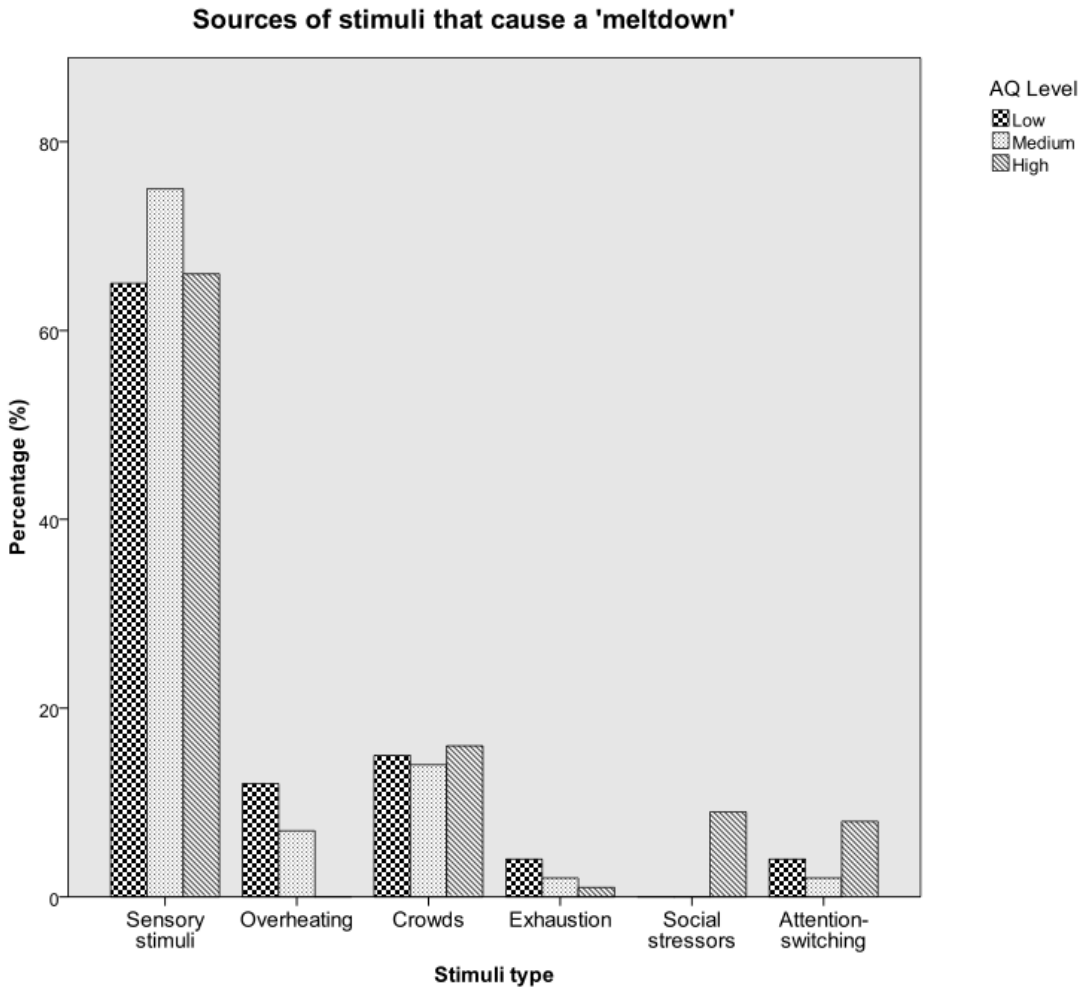
Sources of stimuli that cause a 'meltdown'
AQ Level
Low
Medium
High
Percentage (%)
0
20
40
60
80
Sensory stimuli
Overheating
Crowds
Exhaustion
Social stressors
Attention-switching
Stimuli type

Figure 3

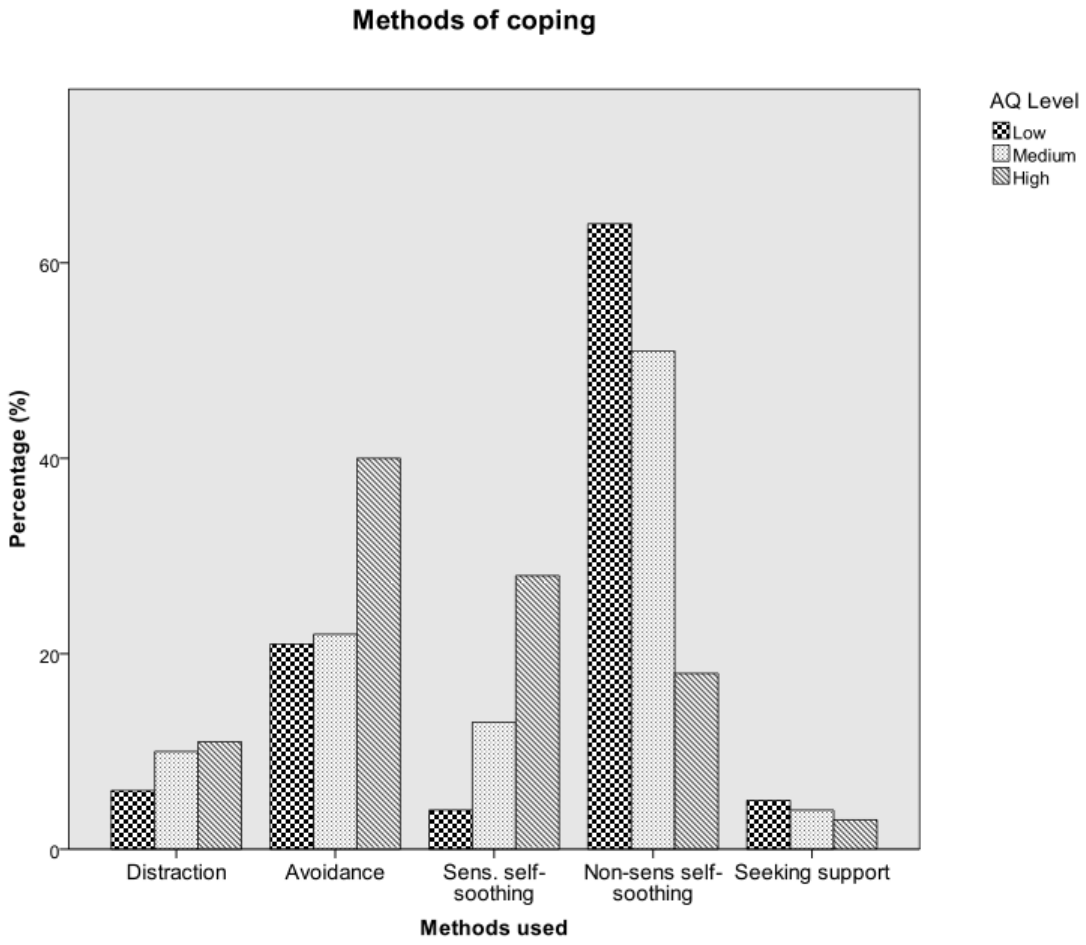
Methods of coping
AQ Level
Low
Medium
High
Percentage (%)
0
20
40
60
Distraction
Avoidance
Sens. self-soothing
Non-sens self-soothing
Seeking support
Methods used

Figure 4

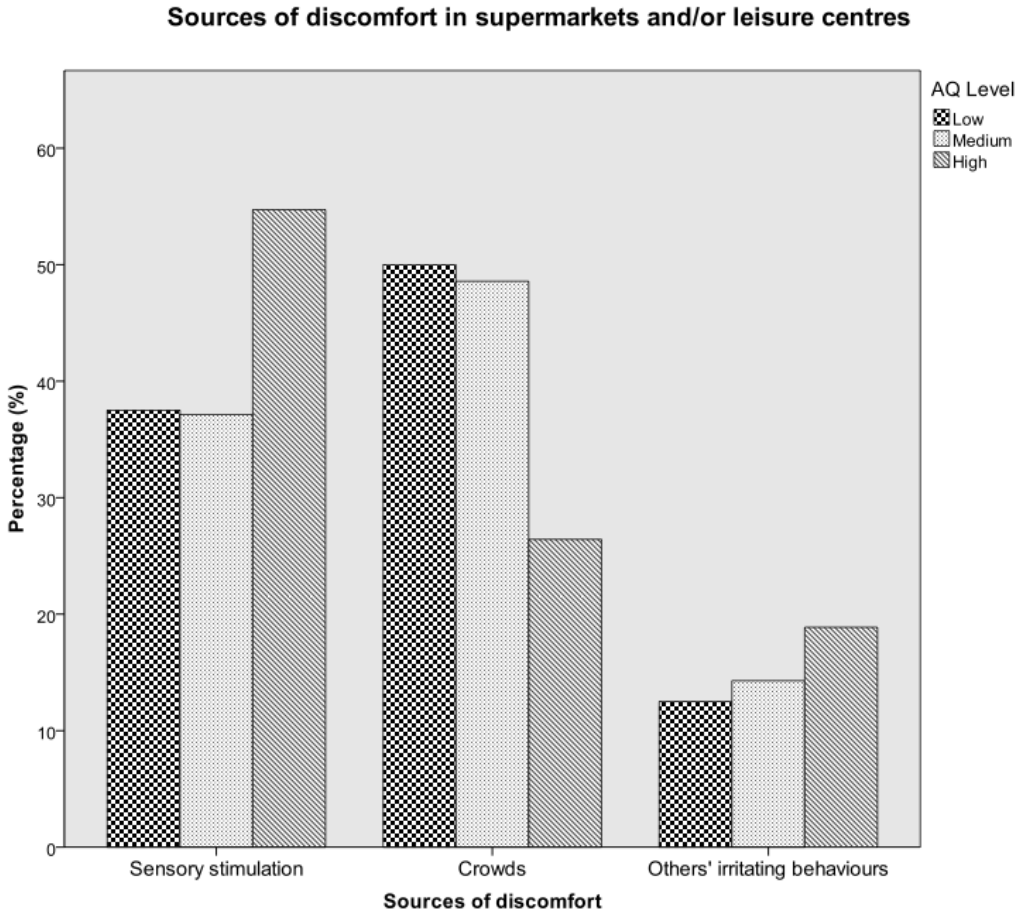
Sources of discomfort in supermarkets and/or leisure centres
AQ Level
Low
Medium
High
Percentage (%)
0
10
20
30
40
50
60
Sensory stimulation
Crowds
Others' irritating behaviours
Sources of discomfort

Figure Captions

Figure 1 – The main causes of panic and discomfort reported by participants. Responses are grouped by level of AQ score (high, medium and low).

Figure 2 – The main sources of stimuli that can cause a 'meltdown'

Figure 3 – The main techniques that people in the sample use to cope with stressful situations. Responses are grouped by level of AQ score (high, medium and low).

Figure 4 – The main sources of discomfort experienced in supermarkets and leisure centres. Responses are grouped by level of AQ score (high, medium and low).