ADHD Characteristics, Gender, and Their Relation to Sensory Profiles: A Dimensional Approach

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Master Thesis – Klinische Neuropsychologie

S2730464
July, 2022
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Abstract

Those who are diagnosed with attention-deficit/hyperactivity disorder (ADHD) have been found to also have deviations with regards to sensory stimulus processing. Issues with sensory stimulus processing relate to an atypical approach to different stimulus processing and is also a main characteristic of autism spectrum disorder (ASD), a disorder which shares a high level of comorbidity with ADHD but is often not controlled for when looking at ADHD specific populations. The current study aims to investigate to what extent characteristics of ADHD and differences in gender relate to different sensory profiles while controlling for autistic characteristics. The current study made use of a dimensional approach, in which members from the general population (N=224) were recruited to fill out a questionnaire. This questionnaire was created using the Autism Quotient questionnaire (AQ), the Connors' Adult ADHD Rating Scale (CAARS), and the Adolescent/Adult Sensory Profile-NL questionnaire (AASP-NL). The AASP-NL looks at four quadrants relating to one's sensory profile (sensory sensitivity, sensation seeking, sensation avoiding, and low registration). After analysis findings show that, while controlling for ASD characteristics, ADHD characteristics were significantly and positively related to sensory sensitivity, sensation seeking, and low registration, but not to sensation avoiding. When controlling for ASD, women were shown to score significantly higher than men on sensory sensitivity, sensation seeking, and sensation avoiding, with women also showing higher scores than men on all four quadrants. Based on the current study the implication can be made that ADHD characteristics and gender significantly affect sensory stimulus processing, independent from comorbid ASD characteristics.

Keywords: ADHD characteristics, Sensory Profiles, Gender, Sex differences, AASP-NL.

Introduction

Attention-deficit/hyperactivity disorder (ADHD) is estimated to be present in 3-7% of the child, and 4.4% of the adult population in the Netherlands (Michielsen et al., 2012), with a prevalence of 3.4% at a cross-national level (Fayyad et al., 2002). The core features of ADHD can be categorized as inattention and impulsivity/hyperactivity (American Psychiatric Association, 2013) with symptoms presenting heterogeneously across the clinical population, as well as being changeable throughout an individual's development. In addition to the variable characteristics of ADHD, the symptomatology of ADHD is now also increasingly seen as dimensional throughout the population, in contrast to the previous notion that it is a categorical disorder. The traits and characteristics associated with ADHD are increasingly viewed as dimensional, implying that these are present throughout the entire population in varying degrees (Panagiotidi et al., 2020). The notion that ADHD traits and characteristics are present throughout the population on a continuous scale allows for additional research on these characteristics within the general population. Those who suffer from a clinically high level of ADHD characteristics and can be diagnosed as having ADHD are likely to deal with functional deficits in daily life, leading to far reaching issues in many different domains (Biederman, 1998; Spencer et al., 2007), especially when an individual has not received a diagnosis or treatment (Asherson et al., 2016). For the adult population this can, for example, lead to difficulties in social and romantic relationships, or difficulties organizing one's daily life with regards to one's occupation, education, or social life (Michielsen et al., 2012).

The importance of diagnosis is thus apparent. However, due to the highly comorbid nature of ADHD and its related characteristics, it is not only important to understand the main characteristics of ADHD i.e., inattention and hyperactivity/impulsivity, but also the additional characteristics associated with ADHD. With regards to ASD and ADHD, subclinical traits regularly occur together within the population, with ADHD being associated with an increased prevalence of ASD and its related traits, as

well as an overlap in symptomatology (Taylor et al., 2013). Currently, ADHD is increasingly associated with deviations in sensory stimulus processing. Deviations in sensory stimulus processing appear to be a common feature of ASD and ADHD and are now also considered a core feature of ASD in the DSM-V (American Psychiatric Association, 2013). It is not yet clear whether deviations in sensory stimulus processing in the ADHD population are due to the high level of comorbidity with ASD, or whether these deviations are related to ADHD itself. Understanding how deviations in sensory stimulus processing relate to ADHD characteristics is important for the clinical population, a study on children found that children with ADHD show early sensory sensitivity even before the core symptoms of ADHD are distinct, emphasizing how recognition of sensory symptoms could lead to timely intervention (Ben-Sasson et al., 2017).

Sensory sensitivity

Sensory sensitivity relates to an atypical response to sensory modalities such as touch, vision, audition, taste, olfaction or the vestibular system and can present itself as either hyposensitivity which is a lowered responsiveness, or hypersensitivity which is a heightened responsiveness (Bijlenga et al., 2017). Sensory sensitivity is related to the way in which our nervous system deals with internal and external stimuli and has also been shown to influence daily functioning (Clince et al., 2016). In the current study the method used for measuring sensory sensitivity is based on Dunn's model of sensory processing (Dunn, 1997). This model forms the basis for the Adolescent/Adult Sensory Profile-NL (AASP-NL) questionnaire (Dunn, 1999). According to Dunn's model of sensory processing the capability of the nervous system for stimulus detection and the ability to respond to those stimuli exist on a continuum anchored on four quadrants (sensation seeking, sensory sensitivity, low registration, and sensation avoiding). Each quadrant has a different neurological threshold (personal range for noticing and responding) and behavioural response pattern (either passive or active strategies) which exist on a

continuum. Sensation seeking is seen as high threshold and active responding, sensory sensitivity as low threshold with passive responding, low registration as high threshold with passive responding, and sensation avoiding as low threshold for active responding (Dunn, 1997). In relation to this model, reference can also be made to hyper- and hyposensitivity, in which hypersensitivity relates to too much sensory information being perceived and transmitted to the brain, and hyposensitivity relates to too little sensory information being perceived. Experience of these thresholds is dependent on the individual, resulting in different overall and quadrant scores on the AASP-NL.

In relation to certain ADHD characteristics, research on adults showed a relationship between sensory sensitivity and increased inattention, as well as issues with auditory hypersensitivity (Micoulaud-Franchi et al., 2015; Kooij et al., 2015), and hypersensitivity to pain (Treister et al., 2015) as compared to norm groups. More specifically, a previous study investigated ADHD and sensory sensitivity in adults with ADHD from a Dutch sample using the AASP-NL while controlling for autistic symptoms (Bijlenga et al., 2017). Findings showed more hypo- and hypersensitivity in the ADHD group compared to the control group, indicating that sensory sensitivity is related to ADHD characteristics. Specifically, higher scores for the ADHD group were found for low registration and sensory sensitivity. These results are in line with findings by Clince et al. (2016) who also found higher scores on low registration and sensory sensitivity using the AASP-NL quadrants. Another study using the AASP found that adults with ADHD scored higher on the low registration, sensory sensitivity and sensation seeking quadrants of the AASP-NL (Kamath et al., 2020). In contrast to findings from a systematic review on children with ADHD (Ghanizadeh, 2011), studies show that deviations in sensory processing do not appear to be present for all quadrants on the AASP-NL for adults with ADHD (Bijlenga et al., 2017; Clince et al., 2016; Kamath et al., 2020). Reasons for these inconsistent findings are unclear but is likely due to differences in

participant selection and characteristics or could additionally point to the notion that deviations in sensory processing are a heterogenous characteristic.

So far, only two studies appear to have focused on the general population using a spectrum approach. These studies found high correlations between ADHD characteristics and sensory sensitivity in the general population, showing that an increased number of sensory difficulties were related to the severeness of ADHD characteristics (Panagiotidi et al., 2018; Panagiotidi et al., 2020). Overall, it appears that there is evidence to support the notion that ADHD characteristics both in the clinical and non-clinical population, for adults as well as children, relate to abnormal sensory sensitivity.

Gender Differences

Regarding the presentation of ADHD, studies have shown that this is far from universal, there are not only interpersonal differences with regard to symptom presentation and different comorbidity patterns, but also clear differences in the presentation and effect of ADHD between individuals, also with regard to gender (as summarized by Stibbe et al., 2020). In childhood, boys are more likely to be affected, or at least diagnosed than girls; this difference becomes smaller in adulthood, but the reason for these gender differences is still not properly understood (Stibbe et al., 2020). Suggestions have been made that it may be the disease persistence which varies based on gender, or that the gender differences are due to differential symptom presentations, with inattentiveness being more likely in women, and impulsivity-hyperactivity and combined symptoms more likely in men (Stibbe et al., 2020). This would be in line with findings that inattentive symptoms are more likely to persist into adulthood as compared to impulsive and hyperactive symptoms (Willcut, 2012, Li et al., 2019).

It is widely accepted that in the clinical population the presentation of ADHD characteristics is heterogenous and influenced by gender. However, the relation between cognitive differences and gender in the clinical population is still unclear. It can however be expected that due to the

heterogenous nature of ADHD and the different symptom presentation between men and women, there will also be noticeable differences in how ADHD characteristics and gender relate to sensory processing. As sensory processing forms the basis of cognitive processing (Pastor-Cerezuele et al., 2020), a better understanding of sensory processing in relation to ADHD and gender will allow for a better understanding of cognitive differences. An example of how different genders have different characteristics and symptom presentation in relation to ADHD can be seen in a previously conducted large population-based study including 40.000 adults with ADHD which found gender specific patterns of comorbidity, with women being more likely to suffer from internalizing disorders such as anxiety, depression, bipolar and personality disorders and men being more likely to deal with externalizing disorders, for example, substance use disorder or schizophrenia (Solberg et al., 2018). However, a study looking at the cognitive performance differences between men and women in a clinical ADHD sample using both self-report questionnaires and a computer-based test of attentional performance found no difference between the self-report scales regarding current ADHD related symptoms (Stibbe et al., 2020). These differential findings suggest that more research is needed into the issue of gender with regards to ADHD, which is in line with the notion that research regarding the gender differences with regard to ADHD symptom manifestation and impairment is still lacking (Fedele et al., 2012). Currently, a difference in sensory profiles between genders and its relation to ADHD in the clinical population has only been mentioned in one study. This study found that women with ADHD have a more dysregulated sensory profile than men with ADHD, showing both increased hypo-and hypersensitivity (Bijlenga et al., 2017). This finding raises questions as to whether sensory profiles in women as compared to men are different due to differences between gender, or whether this is due to differences related to the representation of ADHD traits.

Current study

Based on these findings the current study will focus on the different sensory profiles in relation to ADHD characteristics in the general population, whilst controlling for autism characteristics if necessary. In addition to this, the current study will also focus on the differential presentation of ADHD characteristics and sensory processing based on gender. A better understanding of symptoms such as sensory processing, and to what extent and how this is different based on gender, is a step in the right direction to being able to properly understand the scope of ADHD related symptoms and their level of heterogeneity. Being able to identify and treat ADHD and ADHD related symptoms and characteristics is of immense public interest, as an improper understanding or diagnosis can lead to immense effects on one's functioning leading to measurable functional deficits in one's activities of daily living.

Specifically, this study will look at scores on the AASP-NL (Dunn, 1999) for each of the four quadrants and how these relate to gender and scores on the CAARS-DSM scale of the Connors' Adult ADHD Rating Scales (CAARS) questionnaire (Conners et al., 1999), while controlling for Autism characteristics using the Autism Quotient (AQ) questionnaire (Hoekstra et al., 2008). Additionally, this study will also look at to what extent the outcome on the inattention subscale (CAARS-E) and the impulsivity/hyperactivity subscale (CAARS-F) relate to differences in gender. Based on previous research it can be hypothesised that:

a. The level of ADHD characteristics will act as a predictor for certain sensory profiles, specifically low registration and sensory sensitivity, with higher levels of ADHD characteristics coinciding with higher levels of low registration and sensory sensitivity.
b. Gender will be a significant predictor for the different sensory profiles, with women showing higher scores on all sensory profiles as compared to men.
c. Men and women will show distinct differences with regard to the ADHD subscales of inattentiveness, and impulsivity/hyperactivity, with levels of inattentiveness being higher in

women, and levels of impulsivity/hyperactivity being higher in men.

The outcome of this research question and hypotheses will lead to a better understanding of the way in which ADHD characteristics and sensory sensitivity are related to each other. Additionally, the current study will also give more insight into the role of gender in the understanding of ADHD characteristics and sensory sensitivity.

Method

Participants

From initially 308 recruited participants only those participants who completed the questionnaire, were aged 18 or older, and took longer than 5 minutes to fill out the questionnaire were included in the statistical analyses. Additionally, those participants who filled out that their senses could be influenced in any way considered relevant to the researchers were removed from the data set As a result, the final sample consisted of 224 participants, of which 68 (30.36%) identified as male and 156 (69.64%) identified as female. Overall, participants had a mean age of 36.39 (range 18 to 71) with men (M = 37.71, SD = 16.69) being significantly older than women (M = 35.82, SD = 13.92), $t(222) = .876$, $p < 0.001$.

A poster was created and shared by the researchers through different social media platforms (Instagram and Facebook), at their places of work, and through social messaging groups. All participants gave informed consent prior to taking part in the study and did not receive any kind of compensation for their efforts.

Materials

The questionnaire used for this study was created by combining three prior existing questionnaires. Firstly, the AASP-NL which was developed in order to measure the different sensory profiles in adolescents/adults aged 11 - 65 (Dunn, 1999). The AASP-NL consists of a total of 60

statements each representing one of the four quadrants measured by the AASP-NL, namely, low registration, sensation seeking, sensory sensitivity and sensation avoiding. The total score for each quadrant can vary from 15 – 75. Each statement must be answered based on a 5-point Likert scale ranging between 1 = almost *never* and 5 = *almost always*, for example "*I add spices to my food*", which is an example of a statement relating to the sensation seeking quadrant. This questionnaire adheres to the expectations for test-retest reliability and internal validity (Brown et al., 2007).

Secondly, from the CAARS, which measures the presence and severity of ADHD symptoms and related issues, the subscales CAARS E and CAARS F (regarding the DSM-Inattention and DSM-hyperactivity-impulsivity scales respectively) were included, with the sum of both subscales making the CAARS-DSM. Each of these scales consisted of nine statements which could be answered based on a 4-point Likert scale ranging from 1 = *never* and 4 = *very often,* for example: "*I have trouble keeping my attention focused when working"* which is an example of a question related to inattention. Here the scores run from zero to three, meaning the maximum score for either of the subscales ranges between 0 - 27. The complete CAARS questionnaire shows sufficient construct validity for the use in a clinical and research setting (Connors, et al., 1999). It is unclear to what extent the subscales used for the current study adhere to the preferred standards of reliability and validity.

Lastly, the complete AQ was also included, which is designed to measure the expression of ASD traits in an individual. This questionnaire is based on 50 statements which must be answered on a 4-point Likert scale ranging from 1 = *definitely agree* to 4 = *definitely disagree*, for example: "*I am fascinated with years and dates*". The raw scores for this test run from 50 – 200. Internal consistency and test-retest reliability were considered satisfactory (Hoekstra et al., 2008).

Procedure

The questionnaire was created in an online survey platform Qualtrics (Qualtrics, Provo, UT, 2005), and following the approval of the Ethics Committee of the Behavioural and Social Sciences department at the University of Groningen the questionnaire was shared to be filled out online. At the start of the questionnaire participants were given the relevant information pertaining to the current study and were told that the questionnaire was about personality and sensory sensitivity. Participants were then asked to fill out an informed consent form before being able to continue to the questionnaire. It was stated that the questionnaire would take no longer than 30 minutes to fill out. The questionnaire started with descriptive questions about the participant regarding their age, gender, and whether they experience any sensory issues. The questionnaire then went on to the CAARS-DSM, AQ, and AASP-NL respectively. At the end of the questionnaire participants were debriefed, and informed that in reality the personality questions were about ADHD- and ASD- characteristics. Data collection took place from the 5th until the 28th of January 2022, during a period of 24 days.

Statistical Analysis and Design

For the current study there were no serious violations of the assumptions for a parametric test. In order to see to what extent gender and ADHD characteristics play a role on the sensory profile scores the zero-order correlations were inspected. Based on these observations it was decided to conduct a two-stage hierarchical multiple regression for each of the four quadrants of the AASP-NL, using the four quadrants as dependent variables. The AQ was used in step one in order to control for ASD characteristics, following this the Z-scores of the total score on the CAARS-DSM and the gender variable were added at stage two. It was decided to combine the subscales of the CAARS-E and CAARS-F as no significant difference was found between the two subscales in the MANOVA. Effect size was calculated using F-squared, with 0.02 indicating a small effect, 0.15 indicating a medium effect, and 0.35 indicating a large effect.

To examine whether women and men significantly differ with regards to inattentive and/or hyperactive/impulsive symptoms, a one-way multivariate analysis of variance (MANOVA) was conducted with the CAARS-E and CAARS-F as dependent variables and gender as the independent variables. To test whether adults show more inattentive than hyperactive/impulsive symptoms an explorative paired t-test was performed across gender. Here an effect size was calculated using Cohen's D, where 0.20 indicated a small effect, 0.50 indicates a medium effect, and 0.80 indicates a large effect. A significance level of 5% was upheld throughout all analyses.

Results

An overview of the mean and standard deviation for the AQ, CAARS-E, CAARS-F, CAARS-DSM, and SP scores on the questionnaire separated by gender can be found in Table 1.

Table 1

Mean and standard deviation for each test measure for men, women, and total score.

	Men M (SD)	Women	Total
AQ	99.07 (12.44)	97.22 (13.44)	97.81 (13.13)
CAARS-E	17.33 (4.93)	16.45 (4.67)	16.73 (4.76)
CAARS-F	8.66 (4.01)	9.03 (4.45)	8.91 (4.31)
CAARS-DSM	25.99 (7.88)	25.48 (7.94)	25.64 (7.91)
AASP-NL	136.39 (19.60)	145.00 (19.98)	143.34 (20.21)

Sensory Processing

A zero-order correlation was performed, these results can be viewed in Table A1 in the Appendix. Most noticeable and relevant for the current analysis is the fact that although the AQ is not correlated to the AASP-NL it does show correlations with each of the individual quadrants. Furthermore, the table gives an additional insight into the relationship between the different quadrants, and the way in which these relate to the other variables. Following this analysis, the two-step hierarchical multiple

regression was performed for each of the sensory profiles from the SP, results of all four analyses can be seen in Table 2.

Table 2

Summary of Hierarchical Regression Analysis for Variables Predicting all four Quadrants of the Sensory Profile Questionnaire.

	B(SE)	β	*t*	*p*	sr	R^2_{adj}	ΔR^2
Sensation Seeking							
Step 1						.08	.08***
Autism Quotient (AQ)	-0.16(0.04)	-.29	-4.26**	.000	-.29		
Step 2						.23	.15***
Autism Quotient (AQ)	-0.19(0.04)	-.34	-5.38***	.000	-.34		
CAARS Total	2.66(0.46)	.37	5.84***	.000	.36		
Gender	2.40(0.99)	.15	2.43*	.016	.15		
Sensation Avoiding							
Step 1						.26	.26***
Autism Quotient (AQ)	0.29(0.04)	.51	8.33***	.000	.51		
Step 2							
Autism Quotient (AQ)	0.29(0.04)	.50	8.23***	.000	.49	.28	.03**
CAARS Total	0.83(0.45)	.11	1.83	.069	.11		
Gender	2.49(0.98)	.15	2.54*	.012	.15		
Low Registration							
Step 1						.12	.13***
Autism Quotient (AQ)	0.19(0.04)	.34	5.37***	.000	.36		
Step 2						.33	.21***
Autism Quotient (AQ)	0.15(0.03)	.29	4.86***	.000	.28		
CAARS Total	3.14(0.40)	.46	7.85***	.000	.45		
Gender	1.31(0.87)	.09	1.52	.131	.09		
Sensory Sensitivity							
Step 1						.12	.13***

Autism Quotient (AQ)	0.21(0.04)	.36	5.42***	.000	.36		
Step 2						.27	.15***
Autism Quotient (AQ)	0.19(0.04)	.32	5.21***	.087	.31		
CAARS Total	2.47(0.47)	.32	5.30***	.000	.32		
Gender	3.83(1.01)	.23	3.79***	.000	.23		

Note. *p < .05, **p < .01, ***p< .001

Sensation seeking: For the sensation seeking quadrant the hierarchical multiple regression analysis showed that introducing the CAARS and gender significantly explained 15.3% in addition to the AQ, (F (3, 197) = 19.69, p < .001). The CAARS uniquely explains 13.2% of the variance of sensation seeking, with a medium effect size (F^2 = 0.15) and gender uniquely explains 2.3% of the variance of sensation seeking with a small effect size (F^2 = 0.02). This suggests that adults with a higher level of ADHD characteristics and women as compared to men show a higher level of sensation seeking.

Sensation Avoiding: The CAARS and gender significantly explained an additional 3.4% in addition to the AQ, (F (3, 197) = 4.78, p < .001). Here the CAARS is not a significant predictor for sensation avoiding and has a small effect size (F^2 = 0.01) whereas gender uniquely explains 2.3% of the variance of sensation avoiding with a small effect size (F^2 = 0.02). This suggests that there is no relationship between adults with higher levels of ADHD characteristics and sensation avoiding, but that women do show a higher level of sensation avoiding as compared to men.

Low Registration: For Low Registration the CAARS and gender significantly explained an additional 21.2% in addition to the AQ, (F(3,197)=32.66, p<.001). Here the CAARS is a significant predictor and uniquely explains 20.6% of the variance of low registration with a medium effect size (F^2 = 0.25), whereas gender is not a significant predictor with a small effect size (F^2 = 0.01). There is no relationship between gender and low registration, but adults with higher levels of ADHD characteristics show a higher level of low registration.

Sensory Sensitivity: Regarding Sensory Sensitivity, the CAARS and gender significantly explained 15.2% in addition to the AQ, (F(3.197) = 20.76, p<.001). Here the CAARS is a significant predictor and uniquely explains 10.2% of the variance with a small effect size (F^2 = 0.11), gender is also a significant predictor and uniquely explains 5.2% of the variance with a small effect size F^2 = 0.06). This implies that adults with higher levels of ADHD characteristics will show higher levels of sensory sensitivity and that women show a higher level of sensory sensitivity as compared to men.

ADHD characteristics and gender

The MANOVA showed no significant differences between males and females on the CAARS-E, or on the CAARS-F with both showing small effect sizes (d = 0.09; d = 0.18 respectively), (Pillais' Trace = .017, F(2, 206) = 1.81, p = .167). To summarize, these results showed that the level of inattentiveness and hyperactivity/impulsivity does not differ between genders. Irrespective of gender, participants scored significant higher on the CAARS-E as compared to the CAARS-F, (t(204) = 24.71, p = <.001, d = 1.72).

Discussion

The main aim of the current study has been to further investigate the extent to which ADHD characteristics and differences in gender relate to the different sensory profiles in the general population. This was done using a cross-sectional design in which responses from the general population on the AQ, CAARS-DSM, and AASP-NL were collected and analyzed. Results show that both ADHD characteristics gender are significantly related to the explanation of the variance for different sensory sensitivity profiles after accounting for ASD characteristics. Furthermore, both men and women show a noticeable difference in the total scores of the individual scales of the CAARS.

It was expected that the level of overall ADHD characteristics would act as a predictor for certain sensory profiles, specifically low registration, and sensory sensitivity. Indeed, the findings from the

general population showed that after controlling for ASD characteristics the level of ADHD characteristics is a significant positive predictor for sensory sensitivity, sensation seeking, and low registration, but not for sensation avoiding. Here the strongest relationship appears to be between ADHD and low registration, whereas the other quadrants show less strength. These findings are in line with a previous study which focused on the clinical population (Kamath et al., 2020), whereas other studies focusing on the clinical population only found a significant relationship between ADHD characteristics and sensory sensitivity and low registration (Bijlenga et al., 2016; Clince et al., 2017). Previous studies focusing on the general population found support for the relationship between ADHD characteristics and sensory sensitivity (Panagiotidi et al., 2018, Panagiotidi et al., 2020). Based on the current results and previous research it can be suggested that higher scores on ADHD characteristics, regardless of whether you are part of the clinical population, will also result in higher scores on the sensory profiles, specifically for low registration, sensory sensitivity, and sensation seeking. This implies that those who show higher levels of ADHD characteristics are more likely to have a low neurological threshold with passive responding and thus be sensitive to sensory input, have a high threshold with passive responding and thus show low registration on incoming sensations, or have a high neurological threshold and active responding and as a result go in search for sensations. These actions can be linked to the different ADHD characteristics, for example sensation seeking and impulsiveness, as well as inattentiveness due to low or high levels of registration. This is in line with the notion that higher levels of sensory sensitivity lead to increased inattention scores, and deficits in filtering out information (Micoulaud-Franchi et al., 2015), both common characteristics of ADHD according to the DSM-V (American Psychiatric Association, 2013).

With regards to gender, it was hypothesized that gender would be a significant predictor of scores on the sensory profiles and that women would likely show higher scores after controlling for ASD

characteristics. In line with this hypothesis the results showed that gender is a significant predictor for three of the four sensory profiles, and that women showed significant higher scores, specifically on: sensory sensitivity, sensation seeking, and sensation avoiding, but not low registration Here the relationship between sensory sensitivity and gender is strong, with the other significant quadrants showing a medium relationship. It must be noted that these findings are not caused by a possible relationship between gender and ADHD characteristics, as no relationship was found between these two variables. This is in line with a previous study using a similar method but applying this to a clinical ADHD sample, here women showed higher levels of hypo and hypersensitivity as compared to males in the same study (Bijlenga et al., 2017). These findings show that high scores on the sensory profiles are not necessarily a core symptom or characteristic of ADHD specifically for women, as proposed by Bijlenga et al. (2017), as women also show higher scores on the sensory profiles as compared to men in the non-clinical population. The reason for gender effects with regards to sensory responsivity has not been previously clarified, it is possible that differences in neurological functioning or hormonal differences play a role in this discrepancy between men and women, but further investigation is clearly still needed (Bijlenga etal., 2017).

Regarding the relationship between ADHD characteristics and gender, the results do not show a significant difference between the scores on the different ADHD characteristics for men and women. This is in contrast to previous research which lead to the assumption that women would show higher overall scores with regards to inattentiveness, and men would show overall higher scores on impulsivity/hyperactivity, due to the proposition of differential symptom presentation (as summarized by Stibbe et al., 2020). The fact that no significant difference was found between men and women from the general population regarding ADHD characteristics compares to similar findings in the clinical population (Stibbe et al., 2020). The fact that no difference has been found in both the general and

clinical population draws into questions the notion that symptomology is dependent on/or related to gender. Based on the current and previous findings it appears that there is increasing indication that symptom presentation may not be the leading cause of the clear gender differences when it comes to diagnosis of clinical levels of ADHD characteristics.

There was however a significant difference between the subscales of inattention and impulsivity/hyperactivity, suggesting that within the general population levels of inattention are significantly higher than levels of impulsivity/hyperactivity. A possible explanation for this could be the perseverance of inattentive characteristics into adulthood as compared to hyperactivity-impulsivity which appears to fade throughout childhood (Wilcut, 2012; Li et al., 2019). However, the fact that the general population shows significantly higher scores on inattention as compared to impulsivity/hyperactivity may also suggest that inattention simply has an overall higher base rate than impulsivity/hyperactivity. In order to properly understand the relationship between inattention and impulsivity/hyperactivity these characteristics would have to be mapped throughout the developmental stages and measured to a greater and more expansive extent than the current study allows for.

Limitations

Despite these interesting findings it must be noted that the current study has some room for improvement. Although the goal of this study was to take samples from the general population, the only descriptive statistics asked in the questionnaire were gender and age. With only this data it is impossible to check whether the sample represents the general population, especially when considering that the researchers shared the questionnaire within their own social circles. It would have been beneficial to include questions such as level of education or place of birth to gain more insight into the sample. Furthermore, it would have been beneficial to have a more even differentiation of men and women in the sample, as now there are double the number of women as compared to men which could skew the

results. Additionally, though the number of participants was more than what the researchers were aiming for, it would have still been beneficial to have performed a power analysis, especially when taking into consideration that the sample was split based on gender. Regarding the questionnaire, upon analyzing the results it was found that some questions were missing. This was an accidental oversight by the researchers and should have been resolved before the questionnaire was sent out. Although this will not have had a large effect on the current results as the oversight only concerned a limited number of questions, it is something to take into consideration when looking at the current results, and also for future possible replications. Future studies using the same methodology may also benefit from including control questions to test whether a participant is taking the time to properly read and answer the questions. Additionally, the current questionnaire ordered the questions based on each sub-questionnaire, it may also be useful to present the questions in a more randomized fashion so as to make it less obvious what is being asked of the participant, reducing the chance of different forms of response bias such as social desirability bias. The use of self-report measures for this study was the only possible way to garner the necessary information within the scope of the current research project, however the use of self-report data does bring with it certain methodological limitations as it can lead to more socially acceptable answers, depend on one's introspective ability, and response and sampling bias.

Future directions

Despite these limitations the current study sheds additional light on an aspect of ADHD characteristics and sensory sensitivity research within the general population, as well as adding a still somewhat novel aspect of gender, an avenue which has so far been underrepresented in the literature. In light of the new findings new questions come to light regarding possible future research avenues. It would, for example, be interesting to replicate this study using children from the general population,

rather than adults, in order to map out the developmental changes which take place within the different variables studied, and how these relate to each other. It could, for example, be the case that children from the general population show different patterns regarding inattention and impulsiveness/hyperactivity than adults due to the natural development of these variables also found in the clinical population (Stibbe et al., 2020). Furthermore, it would also be interesting to expand the current study, using age as an additional variable, to see whether the maturation of the participants has an effect on both the outcome of the ADHD characteristics and the sensory profiles. Here it would be insightful to perform a cohort-study by grouping different age levels from the general population, in order to make some inference as to the natural changes in the general population of both ADHD characteristics and sensory sensitivity during aging. This information would also more clearly show whether there is in fact no difference between gender on the ADHD subscales, as was found in the current study, or whether the current findings are due to the sample used. If it was found that in the different age groups the level of sensory sensitivity and ADHD characteristics does not differ between genders, this would provide a clear insight into the true difference between men and women on these aspects, opening the doors to even more extensive research and understanding of the underlying mechanisms. Another interesting avenue of research would be to look at a possible relationship between ADHD characteristics, daily functioning, and scores on the sensory profiles. This would be beneficial for a better understanding as to what extent characteristics related to ADHD such as deviations in sensory stimulus processing may also influence ones functioning and development of functional deficits (Biederman, 1998; Spencer et al., 2007). Here gender could also be taken into consideration, looking at the internalizing and externalizing disorders in women and men respectively as suggested by Solberg et al. (2018).

To summarize, the current study shows that a higher level of ADHD characteristics is significantly related to sensory sensitivity, sensation seeking, and low registration on the AASP-NL, and that gender significantly predicts sensory sensitivity, sensation seeking, and sensation avoiding on the AASP-NL, showing a stronger relationship between the AASP-NL and women than men. Furthermore, this study shows that in the current sample there did not appear to be a significant difference in gender when it came to the ADHD subscales of inattentiveness and impulsivity/hyperactivity, instead the results showed that both genders show similar scores on both subscales with inattentiveness being significantly higher. These findings give additional insight into the way in which the different sensory profiles are related to ADHD characteristics and the role of gender with regards to both ADHD characteristics and the sensory profiles in the general population, thus raising interesting questions and paving the path for more extensive and in-depth research on this topic.

References

American Psychiatric Association. *Diagnostic and statistical manual of mental disorders (DSM-5)*, 5th ed., Washington DC: American Psychiatric Association; 2013.

Ben-Sasson, A., Soto, T. W., Heberle, A. E., Carter, A. S., & Briggs-Gowan, M. J. (2017). Early and concurrent features of adhd and sensory over-responsivity symptom clusters. *Journal of Attention Disorders*, *21*(10), 835–845. https://doi.org/10.1177/1087054714543495

Biederman, J. (1998). Attention-deficit/hyperactivity disorder: a life-span perspective. *The Journal of Clinical Psychiatry*, *59*, 4–16.

Bijlenga, D., Tjon-Ka-Jie, J. Y. M., Schuijers, F., Kooij, J. J. S. (2017). Atypical sensory profiles as core features of adult adhd, irrespective of autistic symptoms. *European Psychiatry*, *43*, 51–57.

Brown, C. E., Dunn, W. (2007) *Adolescent/Adult Sensory Profile-NL: Handleiding*. Pearson.

Clince, M., Connolly L., Nolan, C. (2016). Comparing and exploring the sensory processing patterns of higher education students with attention deficit hyperactivity disorder and autism spectrum disorder. *American Journal of Occupational Therapy, 70*(2), 7002250010p7002250011–7002250010p7002250019.

Conners, K. C., Erhardt, D., Sparrow, E. P. (1999) *Connors' Adult ADHD Rating Scales (CAARS); Technical Manual.* Multi-Health Systems.

Dunn, W. (1997). The impact of sensory processing abilities on the daily lives of young children and their families: A conceptual model. *Infants and young children*, *9*, 23-35.

Dunn, W. (1999). *Sensory Profile: User's manual.* San Antonio TX: Psychological Corporation.

Fayyad, J, de Graaf R, Kessler R, Alonso J, Angermeyer M, Demyttenaere K, et al. (2002)

Cross-national prevalence and correlates of adult attention-deficit hyperactivity disorder. *Br J Psychiatry, 190*, 402–29.

Fedele, D. A., Lefler, E. K., Hartung, C. M., Canu, W. H. (2012). Sex differences in the manifestation of ADHD in emerging adults. *Journal of Attention Disorders*, *16*(2), 109–17. https://doi.org/10.1177/1087054710374596

Ghanizadeh, A. (2011). Sensory processing problems in children with adhd, a systematic review. *Psychiatry Investigation*, *8*(2), 89–94. https://doi.org/10.4306/pi.2011.8.2.89

Hoekstra, R. A., Bartels, M., Cath, D. C., & Boomsma, D. I. (2008). Factor structure, reliability and criterion validity of the Autism-Spectrum Quotient (AQ): a study in Dutch population and patient groups. *Journal of autism and developmental disorders, 38*(8), 1555-1566.

Li, T., Mota, N. R., Galesloot, T. E., Bralten, J., Buitelaar, J. K., et al. (2019) ADHD symptoms in the adult general population are associated with factors linked to ADHD in adult patients. *European neuropsychopharmacology: the journal of the European College of Neuropsychopharmacology 29* (10): 1117–1126.

Michielsen, M., Semeijn, E., Comijs, H. C., van, de V. P., Beekman, A. T., Deeg, D. J., Kooij, J. J. (2012). Prevalence of attention-deficit hyperactivity disorder in older adults in the netherlands. *The British Journal of Psychiatry : The Journal of Mental Science, 201*(4), 298–305. https://doi.org/10.1192/bjp.bp.111.101196

Kamath, M. S., Dahm, C. R., Tucker, J. R., Huang-Pollock, C. L., Etter, N. M., & Neely, K. A. (2020). Sensory profiles in adults with and without adhd. *Research in Developmental Disabilities*, *104*. https://doi.org/10.1016/j.ridd.2020.103696

Kooij, J. J., Aeckerlin, L. P., & Buitelaar, J. K. (2001). Functioneren, comorbiditeit en behandeling

van 141 volwassenen met aandachtstekort-hyperactiviteitstoornis (adhd) op een algemene polikliniek psychiatrie. *Nederlands Tijdschrift Voor Geneeskunde*, *145*(31), 1498–501.

Micoulaud-Franchi JA, Lopez R, Vaillant F, Richieri R, El-Kaim A, Bioulac S, et al. (2015) Perceptual abnormalities related to sensory gating deficit are core symptoms in adults with ADHD. *Psychiatry Research, 230*, 357–63.

Panagiotidi, M., Overton, P. G., & Stafford, T. (2018). The relationship between adhd traits and sensory sensitivity in the general population. *Comprehensive Psychiatry, 80*, 179–185. https://doi.org/10.1016/j.comppsych.2017.10.008

Panagiotidi, M., Overton, P. G., Stafford, T. (2020). The relationship between sensory processing sensitivity and attention deficit hyperactivity disorder traits: a spectrum approach*. Psychiatry Research, 293*, 113477–113477. https://doi.org/10.1016/j.psychres.2020.113477

Pastor-Cerezuela, G,. Fernandez-Andres, M.I, Sanz-Cervera, P., Marin-Suelves, D. (2020). The impact of sensory processing on executive and cognitive functions in children with autism spectrum disorder in the school context. *Research in Developmental Disabilities, 96*, 1-10. https://doi.org/10.1016/j.ridd.2019.103540

Spencer, T. J., Biederman, J., & Mick, E. (2007). Attention-deficit/hyperactivity disorder: diagnosis, lifespan, comorbidities, and neurobiology. *Journal of Pediatric Psychology*, *32*(6), 631–642. https://doi.org/10.1093/jpepsy/jsm005

Stibbe, T., Huang, J., Paucke, M., Ulke, C., Strauss, M., & Rodríguez Celestino. (2020). Gender differences in adult adhd: cognitive function assessed by the test of attentional performance. *Plos One*, *15*(10), 0240810. https://doi.org/10.1371/journal.pone.0240810

Solberg, B. S., Halmøy, A., Engeland, A., Igland, J., Haavik, J., & Klungsøyr, K. (2018). Gender

differences in psychiatric comorbidity: a population-based study of 40 000 adults with attention deficit hyperactivity disorder. *Acta Psychiatrica Scandinavica*, *137*(3), 176–186. https://doi.org/10.1111/acps.12845

Taylor, M. J., Charman, T., Robinson, E. B., Plomin, R., Happé, F., Asherson, P., & Ronald, A. (2013). Developmental associations between traits of autism spectrum disorder and attention deficit hyperactivity disorder: a genetically informative, longitudinal twin study. *Psychological Medicine*, *43*(8), 1735–46. https://doi.org/10.1017/S003329171200253X

Treister, R., Eisenberg, E., Demeter, N., Pud, D. (2015). Alterations in pain response are partially reversed by methylphenidate (Ritalin) in adults with attention deficit hyperactivity disorder (ADHD). *Pain Pract 15*, 4–11.

Willcutt, E. G. (2012). The prevalence of DSM-IV attention-deficit/hyperactivity disorder. A meta-analytic review. *Neurotherapeutics: the journal of the American Society for Experimental NeuroTherapeutics 9*(3): 490–499.

Qualtrics (2005) *Copyright year:2022*, Provo, Utah, USA. Available at: https://www.qualtrics.com

Appendix

Table A1

Overview of the Means, Standard deviations, and zero-order correlations for all variables.

Variable	*M(SD)*	1.	2.	3.	4.	5.	6.	7.	8.	9.
1. AQ	97.8(13.1)	-	.198**	.087	.167*	.345	-.289**	.509**	.356**	.359**
2. CAARS-E	16.7(4.8)		-	.517**	.884**	.457**	.190**	.215**	.485**	.371**
3. CAARS-F	8.9(4.3)			-	.857**	.410**	.358**	.109	.395**	.271**
4. CAARS-DSM	25.6(7.9)				-	.496**	.308**	.188**	.505**	.369**
5. AASP-NL	142.3(20.2)					-	.369**	.759**	.767	.836**
6. Sensation Seeking	47.5(7.3)						-	-.131	.153*	.008
7. Sensation Avoiding	31.6(7.6)							-	.452**	.725**
8. Low Registration	31.2(6.9)								-	.525**
9. Sensory Sensitivity	32.1(7.7)									-

Notes. ** Correlation is significant at the .01 level, * Correlation is significant at the .05 level (2 -tailed