Comparing Self- and Parent Report: Sensory Features and Language In Autism

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PSY 4999: Honors Thesis

Spring 2024

Abstract

Background: No prior studies have compared self- and parent-reported questionnaires for autistic and non-autistic children. The relationship between self- and parent-report on core and related features of autism such as language also remains unclear. The purpose of this study was to examine differences in self- and parent-reported patterns of hyper- and hypo-responsivity in autistic and non-autistic children age 7-17 years. Differences in how both reports map onto expressive and receptive language were also examined between groups. Participants included seven autistic individuals and five non-autistic individuals. Self-reported hypo- and hyper-sensory constructs were assessed with the Glasgow Sensory Questionnaire (GSQ). Parent-reported hypo- and hyper- sensory constructs were assessed with the Sensory Experiences Questionnaire (SEQ). Expressive and receptive language were assessed using the Clinical Evaluation of Language Fundamentals-Fourth Edition (CELF-4). Kruskal Wallis Tests were conducted to determine if GSQ and SEQ hyper- and hypo- sensory constructs differed by diagnostic group. Correlations were also conducted to determine if there were associations between both reports and expressive and receptive communication skills.

Results: There was no significant difference between GSQ and SEQ scores or between the autistic and non-autistic group in either the hyper- and hypo-responsivity domains. However, there was a more robust relationship between SEQ hyper-responsivity and expressive language in both groups.

Conclusion: This study extends prior work to examine how self-report differs from parent-report when assessing sensory responsivities linked to language in older autistic children.

There are approximately 1 in 100 children who have autism spectrum disorder (ASD) worldwide (Zeidan et al., 2022). In the United States alone, the prevalence for ASD has tripled over the past 20 years with the current estimates indicating that ASD is prevalent among one in fifty-four children (Khachadourian et al., 2023).

ASD is a neurodevelopmental disorder characterized by differences in social communication and patterns of restricted interests and repetitive behaviors (American Psychiatric Association, 2013). According to the 5th edition of the Diagnostic and Statistical Manual of Mental Disorders, the sensory features of autism may include hyper-responsivity (i.e., exaggerated behavioral responses toward stimuli), hypo-responsivity (i.e., absent or reduced behavioral response to stimuli), and sensory-seeking (i.e. driven to engage in sensory-related experiences) (American Psychiatric Association, 2013; Lee et al., 2022). Importantly, sensory hyper- and hypo-responsivity and sensory seeking behaviors are all considered under the umbrella of restricted and repetitive behaviors.

Sensory measures have been widely used to assess differences in patterns of sensory responsivity in autistic and non-autistic children. Many studies have used parent-report to evaluate sensory characteristics (Baranek et al., 2006; Boyd et al., 2010; Chen et al., 2009; Feldman et al., 2020). For example, in the study of Feldman et al. (2020), a battery of sensory measures included the parent-reported Sensory Experiences Questionnaire (SEQ), which has been found to be reliable and valid in assessing sensory features in autistic and non-autistic children (Little et al., 2011). The SEQ assesses for hyper-responsivity, hypo-responsivity, and sensory-seeking. In Figure 1 referenced from Feldman et al.'s (2020) study with permission, parent-reported SEQ levels of hypo-responsivity, hyper-responsivity, and sensory-seeking were

significantly higher in autistic children compared to non-autistic children age 8–18 years. These types of sensory responsivities can be seen in the same children. Another example is Baranek et al.'s (2006) study, which also used the parent-reported SEQ. Baranek and colleagues (2006) found higher parent-reported hyper-responsivity and hypo-responsivity in autistic children compared to non-autistic children age 5-80 months (approximately 6 years). Both studies further reinforce how autistic individuals are more likely than non-autistic individuals to demonstrate atypical patterns of sensory responsiveness.

In addition to parent-report, other studies have used self-report to evaluate sensory characteristics in autism (Takayama et al., 2014; Ujiie et al., 2022). For example, Ujiie et al.'s study used The Glasgow Sensory Experiences Questionnaire (GSQ), which has also been found to be reliable and valid in assessing sensory features (Smees et al., 2023) and across various cultures (Kuiper et al., 2018). The GSQ sensory constructs are hyper-sensitivity (i.e., over-responsiveness) and hypo-sensitivity (i.e., under-responsiveness) (Ujiie et al., 2022). Ujiie and colleagues (2022) found higher self-reported levels of hypo- and hyper-sensitivity in autistic adults compared to non-autistic adults. More recent studies such as Smees et al. (2023) have used the parent-reported version of the GSQ to assess sensory characteristics in autistic and non-autistic children. Smees and colleagues (2023) had parents complete the GSQ to report their children's sensory sensitivities. They found higher parent-reported scores among autistic children compared to non-autistic children (Smees et al., 2023). Both examples suggest that the GSQ has been commonly used by adults whether for self-report or parent-reporting. However, there is an empirical gap in understanding the GSQ from a child-reporting perspective when evaluating sensory characteristics in autism. To our knowledge, there are also no previous studies that have compared how self-report among children and parent-report differ from one

another. By comparing the GSQ to the SEQ, this could provide additional insights in how parent-child reporting differs between autistic and non-autistic children.

Sensory measures have also been commonly used to explore differences in relations between patterns of sensory responsiveness and language (Feldman et al., 2020; Baranek et al., 2013). Language consists of visual and auditory cues. For example, an auditory cue is a speaker's voice, whereas a visual cue is their facial articulations. The vision of auditory and visual cues interacting with each other can dramatically shape speech perception (Wallace et al., 2020). Using sensory measures can be important for understanding changes in audiovisual processes that might have cascading effects on speech comprehension (Stevenson et al., 2017).

Prior studies have examined expressive and receptive language among autistic and non-autistic children. Expressive language involves the oral expression of language, which includes word structure, formulated sentences, and recalling sentences (Coret et al., 2015). Expressive language also involves body language (e.g., hand gestures) that can produce a behavioral response. Receptive language involves comprehension and listening, which includes sentence comprehension, word classes, and following directions (Coret et al., 2015). Receptive language is more focused on processing and perceiving sensory information compared to expressive language that is more focused on the behavioral expression of language.

The majority of studies have found lower expressive and receptive language scores among autistic children and adolescents (Feldman et al., 2020; Hojjati et al., 2014; Maljaars et al., 2012) and infants and toddlers whose parents used the Mullen Scales of Early Learning (MSEL) to report their expressive and receptive communication skills (Feldman et al., 2022; Riley et al., 2018; Kwok et al., 2015).

Studies have also assessed the relationship between sensory features in autism, and expressive and receptive language. For example, studies such as Feldman et al. (2020) used the SEQ and found that parent-reported SEQ hyper-responsivity and hypo-responsivity were associated with lower expressive and receptive language scores among autistic children age 8–18 years. Baranek et al.'s (2013) study also used the SEQ for hyper-responsivity and hypo-responsivity. Baranek and colleagues (2013) found that parent-reported hypo-responsiveness was associated with lower expressive and receptive language scores among autistic children age 11–105 months. Both studies have participants who are young autistic children and around 8 or older, which aligns with the current study's participant age range. The Feldman et al. (2020) and Baranek et al. (2013) studies only used the parent-reported SEQ; therefore, it remains unclear as to how self-reported patterns of sensory responsivities might be associated with expressive and receptive language in autistic and non-autistic children. Prior research has also found that the use of self-report is acceptable for autistic and non-autistic children age 8–17 years (Bakhtiari et al, 2021). Though it may be difficult for autistic individuals to self-report due to language impairment itself (Sturrock et al., 2020), there is still important sensory information to be gleaned from self-reported sensory measures.

Our Current Study

In the current study, the overarching question is how the GSQ and SEQ differ from one another when both are compared to assess hypo- and hyper-responsivities between autistic and non-autistic children. The current study is also interested in how these sensory constructs from both measures are linked to language. Specifically, the research aims to be examined are:

Research Aim #1: Determine if there is a difference between the self-reported GSQ scores and the parent-reported SEQ scores in the same individuals. Finally, evaluate if these parent-child reporting differences differ by group.

Hypothesis #1:

I hypothesized that there would be a difference in self- reported GSQ scores and the parent-reported SEQ scores. I expected that the GSQ would differ from the SEQ, in how the GSQ captures more of the individual's experience perceiving and processing sensory information. For example, in GSQ Question #18: "Do lights ever seem to flicker when you look at them? ('Flickering' in this question means appearing to turn on and off very quickly instead of appearing constant)" (**see Appendix A**), the child perceives and processes the light (Robertson & Simmons, 2013). However, the SEQ would capture responsivity. For example, in SEQ Question #8: "Is your child disturbed by too much light inside or brightness outside?" (**see Appendix B**), the child may respond by covering their eyes (Auderau & Baranek, 1999).

Another hypothesis was based on differences between parent- and self-reporting for hypo-responsivities and hyper-responsivities. I expected that both parent- and self-reporting would differ by group with both sensory constructs being much higher in autistic children compared to non-autistic children. I predicted this based on previous studies, which used the SEQ and found higher parent-reported patterns of hypo- and hyper-responsivity in autistic children (Feldman et al., 2020; Baranek et al., 2006; Boyd et al., 2010). I also predicted this based on Smees et al.'s (2023) paper, which found that parent-reported hypo- and hyper-sensitivity from the GSQ were much higher in autistic children compared to non-autistic children.

Research Aim #2: Determine whether self-reported and parent-reported hyper-responsivity and hypo-responsivity scores in autistic children/adolescents are associated with expressive and receptive communication skills.

Hypothesis #2:

I expected that the parent-reported SEQ would have a stronger association with expressive language than the GSQ, since expressive language involves producing a behavioral response (e.g., hand gestures) (Ausderau & Baranek, 1999). I also expected that the self-reported GSQ would have a stronger association with receptive language than the SEQ, since receptive language overlaps more with an individual's subjective experience of processing and perceiving sensory information (e.g., following directions).

Participants

Twelve participants (ASD = 7, TD = 5; see descriptive statistics in **Table 1** below). Experimental protocols were approved by Vanderbilt University's institutional review board. Participants were divided into two diagnostic groups: one with a confirmed ASD diagnosis (ASD group) and one without (TD) a confirmed ASD diagnosis. The ASD group included 7 individuals (7 males, mean age = 13.1, sd = 2.13, range = 10.79–15.87) and the TD group included 5 individuals (5 males, mean age = 12.44 years, sd = 2.64, range = 9.56–16.17). There were no significant group differences in sex, since all of the participants were male. There was also no significant difference in age ($p = 0.569$).

All participants had parent-reported normal hearing and normal or corrected-to-normal vision. Autistic individuals' diagnosis was confirmed through a clinician-administered Autism Diagnostic Observation Scale 2nd Ed. (ADOS-2); those without a recent ADOS-2 administration

were re-evaluated by a trained member of the research team at the first research visit. Non-autistic participants were screened for autism with the parent-reported Lifetime version of the Social Communication Questionnaire (SCQ) (Lord et al., 2012), and excluded if they scored above the threshold for an autism diagnosis. Non-autistic participants were also excluded if they had a first-degree relative with autism or if they had a history of current diagnosis of psychiatric illness. All participants received a $10 Visa gift card as compensation for every half hour for their participation. For the TD group, one participant was excluded from the final analyses for expressive and receptive language because their expressive and receptive language scores were not available when analyses were conducted. Therefore, a total of four TD participants were included. For the ASD group, 1 ASD participant was excluded from the final analyses for expressive and receptive language because their expressive and receptive language scores were not available when analyses were conducted. Therefore, 6 ASD individuals were included for the final analyses.

Materials

GSQ Questions

To capture hypo- and hyper-sensitivity, a version of Robertson & Simmons' (2013) self-reported GSQ was used and tailored to autistic and non-autistic participants' hypo-sensitivities and hyper-sensitivities. Participants completed 42 items of hyposensitivity (e.g., "Do you ever run your hand around the outside of an object before picking it up") and hypersensitivity (e.g., "Do bright lights ever hurt your eyes/cause a headache?") (**see Appendix A**) across seven sensory domains: auditory, visual, gustatory, olfactory, tactile, vestibular, proprioception

(Robertson & Simmons, 2013; Ujiie et al., 2022). Participants used a 5-point Likert Scale and rated their responses from "1 = never" to "5 = always" (Robertson & Simmons, 2013; Ujiie et al., 2022). Low scores indicated that participants experienced low levels of hypo- and hyper-sensitivities and high scores indicated high levels of hypo- and hyper- sensitivities.

SEQ Questions

The parent-reported SEQ by Ausderau & Baranek, (1999) was used to assess hypo-responsivity and hyperresponsivity among autistic and non-autistic children. Parent completed 18 items of hyperresponsivity (e.g., "Does your child show distress (startles, covers ears, etc.) during loud conversations or singing?") and hypo-responsivity ("Does your child ignore you when you call his/her name") (**see Appendix B)** across five sensory domains: sound, sight, touch, taste or smell, and movement (Ausderau & Baranek, 1999). Participants used a 5-point Likert Scale and rated their responses from "1 = Almost never" to "5 = Almost always" (Ausderau & Baranek, 1999). Low scores would indicate lower hypo/hyper responsivities and high scores would indicate higher hypo/hyper responsivities. Low scores indicated that participants experienced low levels of hypo- and hyper- responsivities and high scores indicated high levels of hypo- and hyper- responsivities.

Additional Clinical Evaluations

Additional clinical tests were used to assess for IQ and language function **(Table 2)** in line with standard procedures in the Wallace Lab. All clinical tests were administered to all participants, except the ADOS-2. The ADOS-2 was only administered to the autistic group if it was not performed in the last 5 years.

Experimental Procedures

Participants arrived to Vanderbilt University Medical Center for their scheduled appointment. Child participants received the GSQ and parents received the SEQ. The Clinical Evaluations Language Fundamentals 5 (CELF-5) was administered by a trained student/clinical fellow of our research team.

Data Analysis Plan

First, we calculated the summed sub scores for each sensory domain for the consistent use of the GSQ and SEQ. To answer the first aim, the Kruskal Wallis Test was conducted to determine whether parent-child reporting for hyper- and hypo-responsivities differed between autistic and non-autistic children. This test was appropriate to use, since the data was not normally distributed. Though the GSQ and SEQ both assess for hypo- and hyper-sensory constructs, the SEQ assesses for an additional construct: sensory-seeking behavior. Because the GSQ does not assess for sensory-seeking behavior, this sensory construct has been excluded from the final analyses.

For the second aim, zero-order correlations between hypo-responsivity and hyper-responsivity from both measures and expressive and receptive language were conducted. A zero-order correlation is an association between two variables without controlling for the potential influence of an additional variable (American Psychological Association, 2018). This test was appropriate, since we were interested in whether sensory constructs from both measures were associated with language. All analyses were conducted using R Studio coding.

Results

The Kruskal-Wallis Test was used in this study to determine whether parent-child reporting for hyper- and hypo-responsivities differed between autistic and non-autistic

children. There was not a significant difference in total GSQ scores and SEQ scores in the ASD condition ($\chi^2 = 6$, $p = 0.4232$). There was also not a significant difference in total GSQ scores and SEQ scores in the TD condition ($\chi^2 = 4$, $p = 0.406$). There were no significant differences in total GSQ scores and SEQ scores between ASD and TD groups ($\chi^2 = 4.2951$, $p = 0.7452$).

I compared SEQ and GSQ scores by categorizing them based on sensory construct and diagnostic group. Specifically, the SEQ hypo-responsivity scores were compared with the GSQ hypo-responsivity scores, and the SEQ hyper-responsivity scores were compared with the GSQ hyper-responsivity scores for both groups. Next, different number of GSQ and SEQ hypo- and hyper questions were compared across different sensory domains including: visual, auditory, olfactory, and tactile. The different number of questions from both instruments were compared in how similarly they asked about a particular topic. For example, in the previous example above, I compared GSQ hyper-sensitivity Question #8: ("Do bright lights ever hurt your eyes/cause a headache?") (Robertson & Simmons, 2013) (**see Appendix A**) with SEQ hyper-responsivity Question #8: ("Is your child disturbed by too much light inside or brightness outside?") (Ausderau & Baranek, 1999) (**see Appendix B**) because both similarly ask about whether the brightness of light impacts the child participants. Questions like these can further contribute to the overarching issue of whether one measure is more sensitive than another and provide additional insights from a child and parent perspective. Another example is having to compare GSQ hypo-sensitivity Question #16: ("Do you notice that you have hurt yourself but did not feel pain?") (Robertson & Simmons, 2013; Ujiie et al., 2022) (**see Appendix A**) and SEQ hypo-sensitivity Question #19: ("Does your child seem slow to react to pain? (For example: he/she isn't bothered by bumps, scrapes, cuts, or falls") (Ausderau & Baranek, 1999) (**see Appendix B**), which both ask about how child participants respond to pain. Comparing both questions with

each other and from both instruments can be important toward addressing psychological and physical safety, particularly among ASD participants.

Additionally, the Kruskal-Wallis test showed that there was no statistically significant difference in self-reported GSQ hypo-sensitivity scores and parent-reported SEQ hypo-responsivity scores for ASD participants ($\chi^2 = 6$, $p = 0.423$) (**Figure 2A**). There was also no significant difference in self-reported GSQ hyper-sensitivity and parent-reported SEQ hyper-responsivity scores for ASD participants ($\chi^2 = 5.57$, $p = 0.234$) (**Figure 2B**).

In addition to ASD participants, the Kruskal-Wallis test showed that there was no statistically significant difference in self-reported GSQ hypo-sensitivity scores and parent-reported SEQ hypo-responsivity scores for TD participants ($\chi^2 = 3.80$, $p = 0.284$) (**Figure 2C**). When compared with Figure 2A, parent-reported SEQ hypo-responsivity within the ASD condition is much higher than parent-reported SEQ hypo-responsivity within the TD condition. This finding is consistent with previous literature such as Feldman et al.'s (2020), which found that parent-reported SEQ hyper-responsivity is much higher in autistic children than non-autistic children. There was also no significant difference in self-reported GSQ hyper-sensitivity and parent-reported SEQ hyper-responsivity scores ($\chi^2 = 0.63$, $p = 0.729$) (**Figure 2D**). When compared with Figure 2B, parent-reported SEQ hyper-responsivity in the ASD condition is much higher than parent-reported SEQ hyper-responsivity in the TD condition. This is consistent with Feldman et al.'s (2020) study in which they found that parent-reported SEQ hyper-responsivity was much higher in the ASD condition than the TD condition.

Zero-order associations were conducted in the study to determine if self-reported GSQ and parent-reported SEQ measures are associated with expressive and receptive communication skills. There was an overall trend of weak associations in the ASD condition

between self-reported hypo-sensitivity and CELF expressive language scores (r = 0.16) **(Figure 3A),** parent-reported hypo-responsivity and CELF expressive language scores (r = -0.17) **(Figure 3C),** self-reported hypo-sensitivity and CELF receptive language scores (r = -0.11) **(Figure 4A),** and parent-reported hypo-responsivity and CELF receptive language scores (r = 0.09) **(Figure 4C).** This also holds true in the ASD condition between self-reported hyper-sensitivity and CELF expressive language (r = 0.04) **(Figure 3B),** self-reported hyper-sensitivity and CELF receptive language (r = 0.09) (**Figure 4B**), and parent-reported hyper-responsivity and CELF receptive language (r = 0.12) (**Figure 4D**). Though the majority of the associations are very weak, the association between parent-reported hyper-responsivity and CELF expressive language (r = -0.26) was the most robust relationship, since it has a moderate negative association (**Figure 3D**).

The correlations for both measures and expressive language in the TD condition had differing correlations compared to the ASD group. There was a moderate negative association between self-reported hypo-sensitivity and CELF expressive language (r = -0.41) (**Figure 5A)**, moderate positive association between parent-reported hypo-responsivity and CELF expressive language (r = 0.45) **(Figure 5C),** a very weak positive association between self-reported GSQ hyper-sensitivity and CELF expressive language (r = 0.06) (**Figure 5B**), and a strong positive association between parent-reported hyper-responsivity and CELF expressive language (r = 0.68) (**Figure 5D**). Correlations for both measures and receptive language in the TD condition suggested a moderate negative association between self-reported hypo-sensitivity and CELF receptive language (r = -0.50) (**Figure 6A**), a moderate positive

association between parent-reported hypo-responsivity and CELF receptive language (r = 0.43) (**Figure 6C**), a very weak positive association between self-reported GSQ hyper-sensitivity and CELF receptive language (r = 0.08) (**Figure 6B**), and a moderate positive association between parent-reported hyperresponsivity and CELF receptive language (r = 0.42) (**Figure 6D**).

Discussion

The present study sought to examine how the GSQ and SEQ differ from each other when both are compared to assess hypo- and hyper-responsivities , and linked to expressive and receptive language. The SEQ assessed for hypo- and hyper-responsivities and the GSQ assessed for hyper- and hypo-sensitivities.

Parent- and self-reported measures of sensory responsivities are comparable in autistic and non-autistic children, but there were no differences. This may have been due to the limited sample sizes that resulted in underpowered analyses. There were also minimal differences because the sample may not have significantly differed from the broader autism population. Perhaps, if the sample was more heterogenous or larger, we would expect more profound differences between groups (Lombardo et al., 2019).

While there was little relationship between sensory measures and language outcomes in the autism group, a moderate and strong positive relationship was evident between SEQ hyper-sensitivity and expressive and receptive language, respectively. This may suggest that, within normal limits of sensory sensitivity, increased responsivity to the sensory environment may have a beneficial impact on language. However, more data is required to evaluate this hypothesis. Because of the presumptive relationship between sensory processing and language outcomes in autism, the correlations would be expected to strengthen as more participant data is

acquired. Specifically, we would expect stronger negative relationships to emerge between hyper- and hypo-sensitivity constructs in autism because differences in sensory responsiveness produce a cascading effect contributing toward core and related features of autism such as language (Feldman et al., 2020).

There were several limitations to the current study. One limitation were the small sample sizes, which resulted in underpowered analyses. A second limitation was that the current study only used hypo- and hyper-sensory constructs. Therefore, we were unable to quantify the relationship that other sensory constructs like sensory-seeking have with expressive and receptive language. The study was also unable to compare sensory-seeking across measures, since the GSQ does not have this sensory construct. A third limitation often includes heterogeneity of autism (Lenroot & Yeung, 2013), which restricts generalizability for the study's results. Specifically, all participants in this study were verbal autistic participants, but results might not be generalizable for, perhaps non-verbal participants. There is uncertainty as to how non-verbal participants would self-report (Patten et al., 2013). There may also be difficulty, which builds upon my previous point above about how it may be difficult for autistic individuals to self-report, perhaps due to language impairment itself. Both reports also have limited diversity, since they only use standardized English.

One future direction for the study is to consider evidence-based comparison across other sensory reports such as the parent-reported Sensory Profile Questionnaire (SP). The SP accounts for sensitivity with similar questions to the GSQ (e.g., SP Question #14: "Is bothered by bright lights after others have adapted to the light") (Williams et al., 2018). Comparing the SP and GSQ could be meaningful toward further understanding sensitivity from a parent-child reporting perspective. Another future direction is the consideration of examining how self- and parent-

reported measures differ when linked to other language outcomes. For example, in the study of Watson et al. (2011), the SEQ was used to assess hypo- and hyper-responsiveness and their relation with social-communicative symptom severity. Watson and colleagues (2011) found that parent-reported hypo-responsiveness shared a positive association with social-communicative symptom severity, but there was no association between hyper-responsiveness and social-communicative symptom severity. Perhaps, the inclusion of self-report like the GSQ could be compared to the SEQ for social-communicative symptom severity and build upon Watson et al.'s (2011) study.

Overall, results from these questions highlight the importance of both measures in assessing sensory features of autism. Both have the potential to further improve current ASD-related interventions like the Big Red Safety Box. The Big Red Safety Box is a toolkit that helps prevent autistic children from wandering off from safe to potentially dangerous environments (National Autism Association, 2003). The toolkit provides resources such as a caregiver checklist and emotion identification cards. There is, however, no self-report checklist for autistic individuals. The results from the first question can inspire policymakers to add a self-report checklist, particularly for autistic children and adolescents to communicate how they feel. This also ties in with Keith et al.'s (2019) and Hyland et al.'s (2022) studies where both reports are effective at predicting subjective experience during adolescence. The implementation of both measures could further be beneficial across contexts, allowing autistic individuals to have more accessible ways to communicate and perceive their natural environment.

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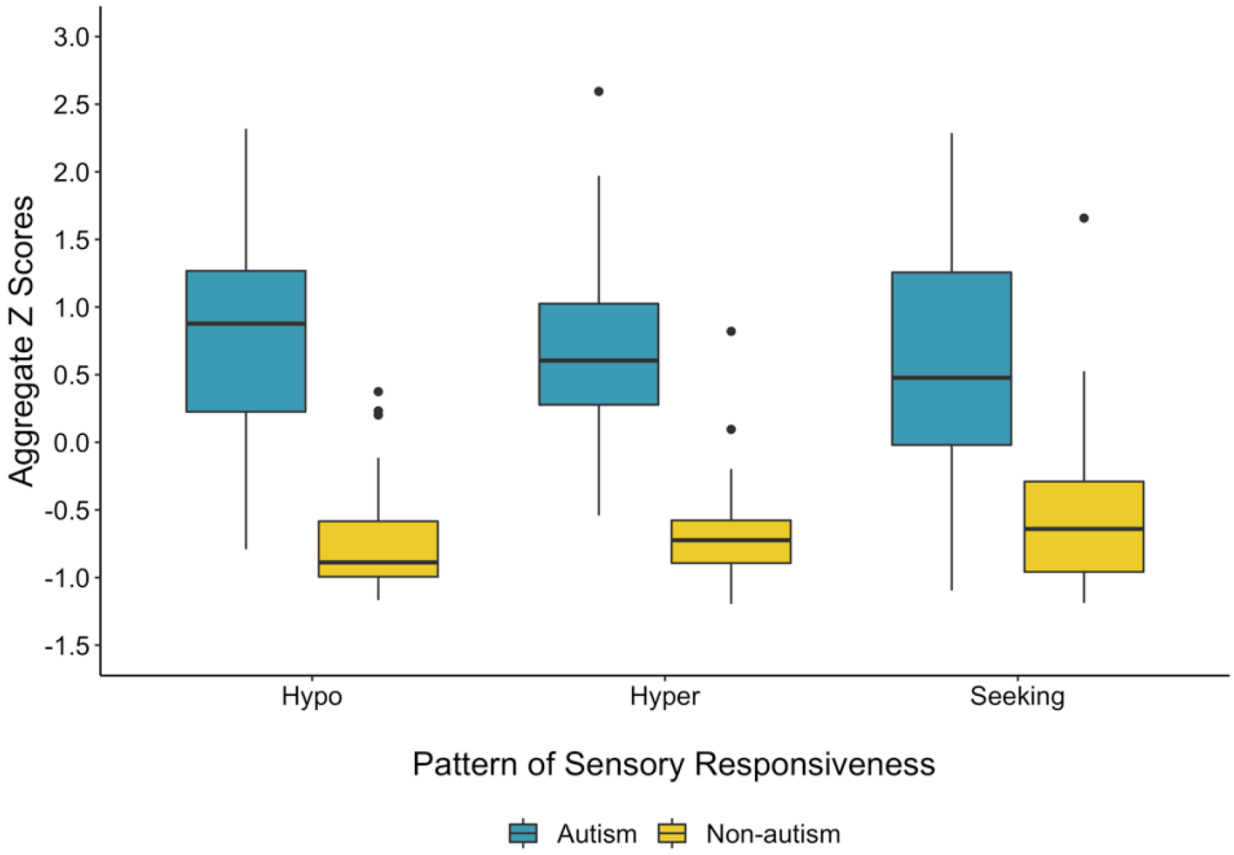


Figure 1 referenced from Feldman et al.'s (2020) study with permission:

As shown in Figure 1 referenced from Feldman et al.'s (2020) study with permission, parents reported significantly higher levels across all three behaviors (hypo-responsiveness, hyper-responsiveness, and sensory-seeking) in autistic children compared to non-autistic children age 8–18 years.

Table 1: Descriptive statistics sensory of overall sample and split by diagnostic condition experienced

	Full sample N = 12			ASD N = 7			TD N = 5			p-value
	Mean	SD	Range	Mean	SD	Range	Mean	SD	Range	
Self-Reported GSQ hypo-sensitivity	23.3	10.04	6-39	25.71	11.86	6-39	20	6.52	14-28	0.193
Self-Reported GSQ hyper-sensitivity	26	12.10	8-49	31.43	11.59	18-49	12.4	4.39	9-20	0.290
Parent-Reported SEQ hypo-responsivity	12.75	4.35	8-21	14.28	5.22	8-21	12.6	3.65	10-19	0.463
Parent-Reported SEQ hyper-responsivity	28.92	10.13	20-56	35.14	11.36	23-56	22.2	3.83	20-29	0.012
CELF Expressive	94.9	29.69	47-130	81.5	31.41	47-122	115	10.13	108-130	0.088
CELF Receptive	98.2	26.65	50-131	84.33	25.73	50-112	119	8.16	113-131	0.011

Figure 2: Self-reported sensory responsivities are comparable to parent-reported sensory responsivities

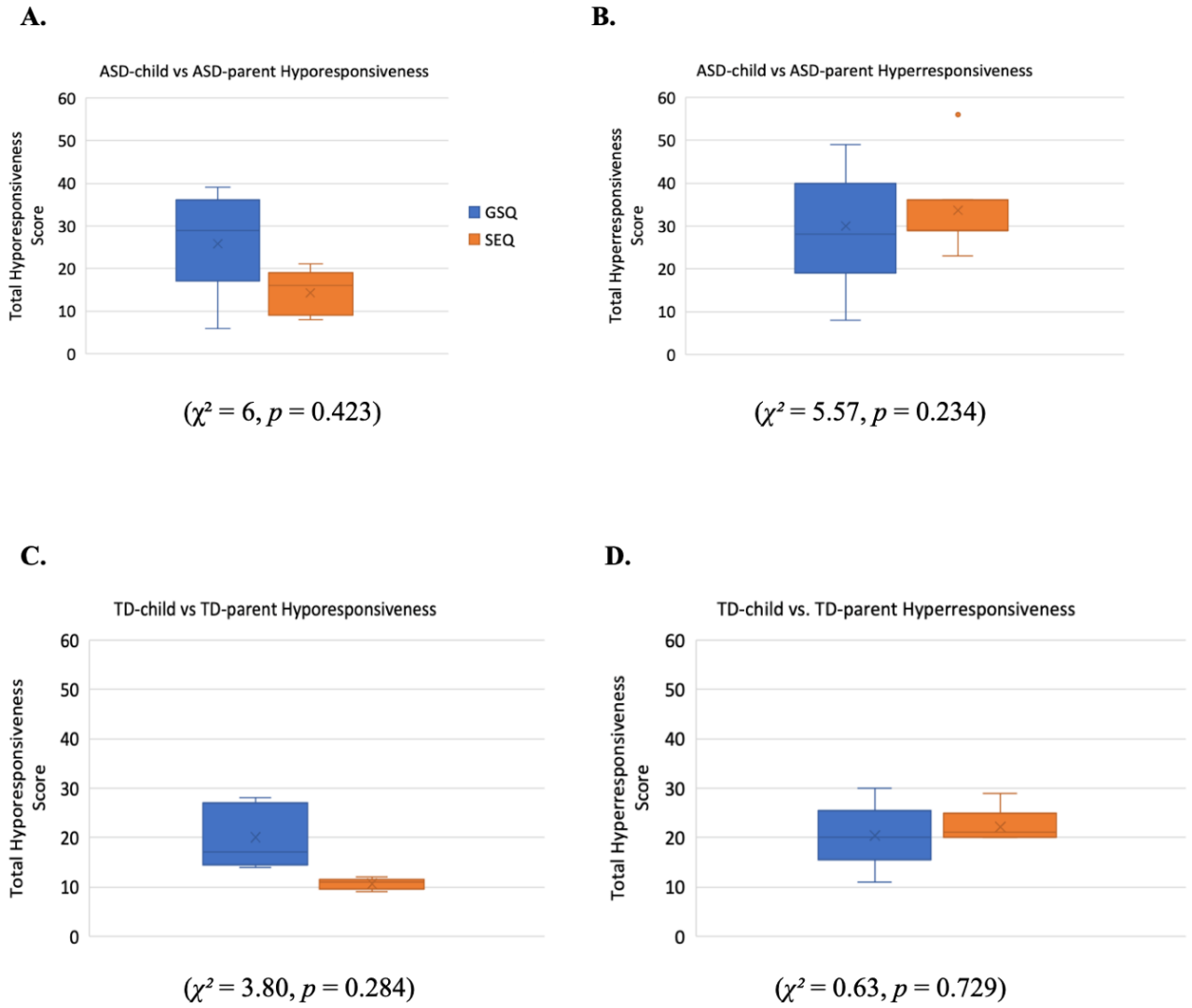


Table 2. Clinical Assessments

Assessment	*Domain*	*Assessment Type*
ADOS-2[87]	Autism	Observational
Leiter Test of Nonverbal Intelligence, 3rd Ed.[88]	IQ	Observational
Social Communication Questionnaire (SCQ)	Language	Parent-reported
Clinical Evaluation of Language Fundamentals, 4th Ed.[89]	Language	Observational
Glasgow Sensory Experience Questionnaire	Sensory	Self-reported
Sensory Experiences Questionnaire[93]	Sensory	Parent-reported

Figure 3: Parent-reported sensory hyper-responsivity predicts lower expressive language outcomes

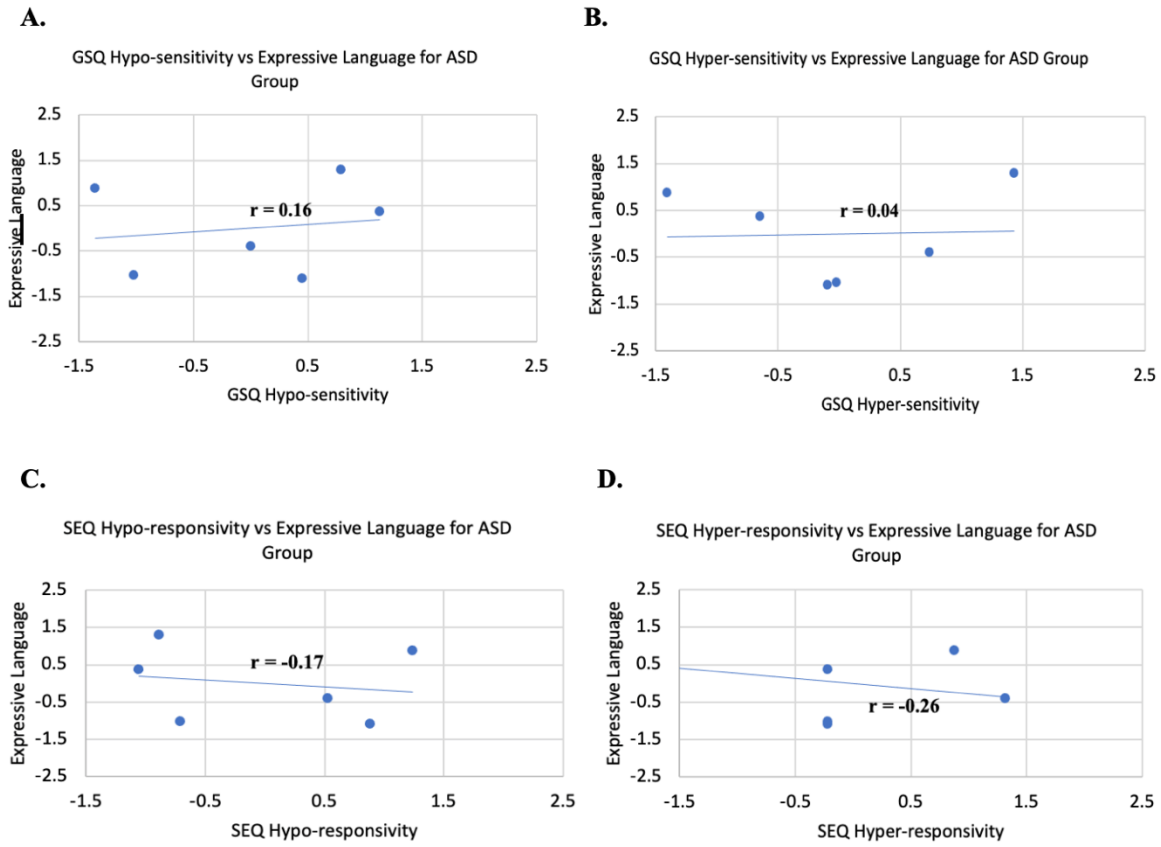


Figure 4: No relationship between sensory responsivity and receptive language

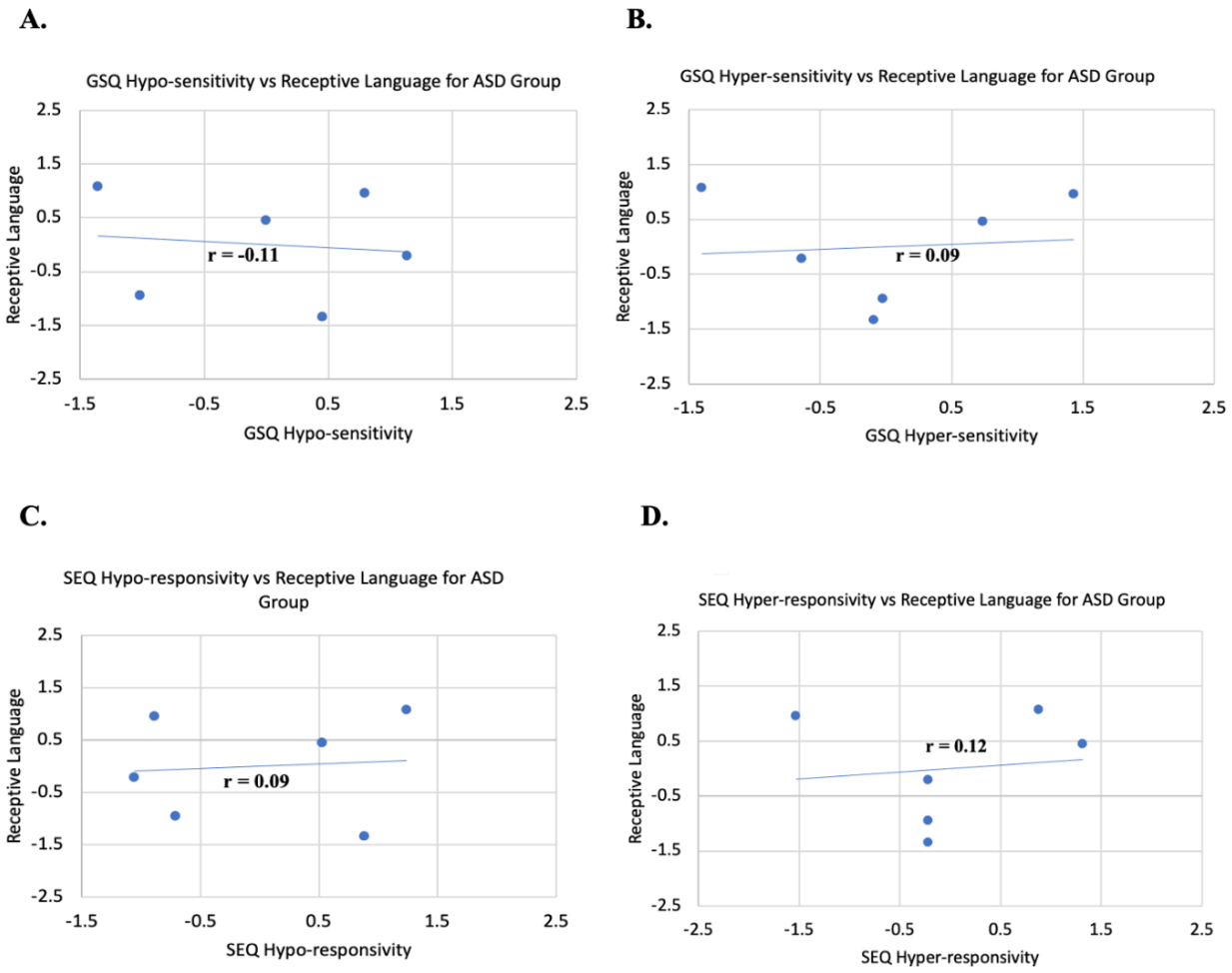


Figure 5: Parent-reported sensory responsivity predicts increased expressive language outcomes in non-autistic children

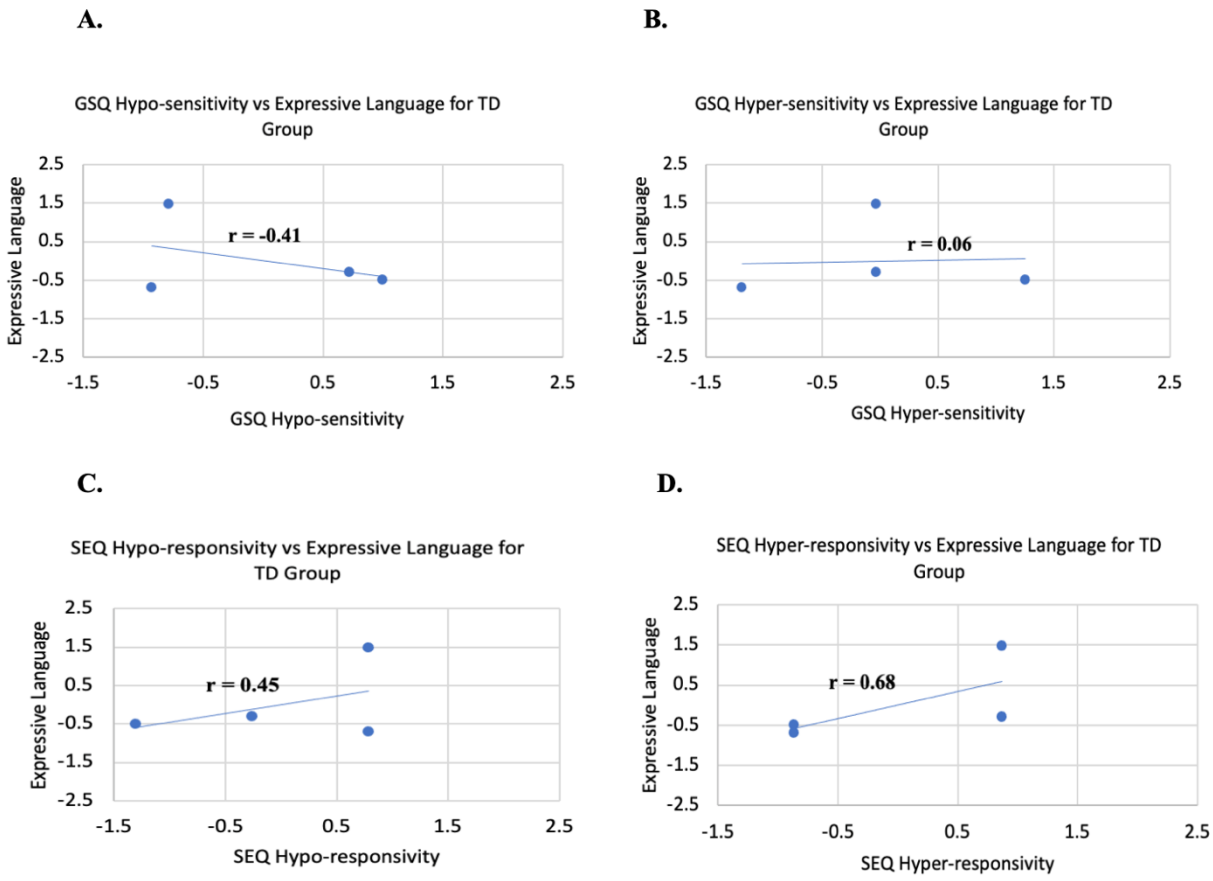
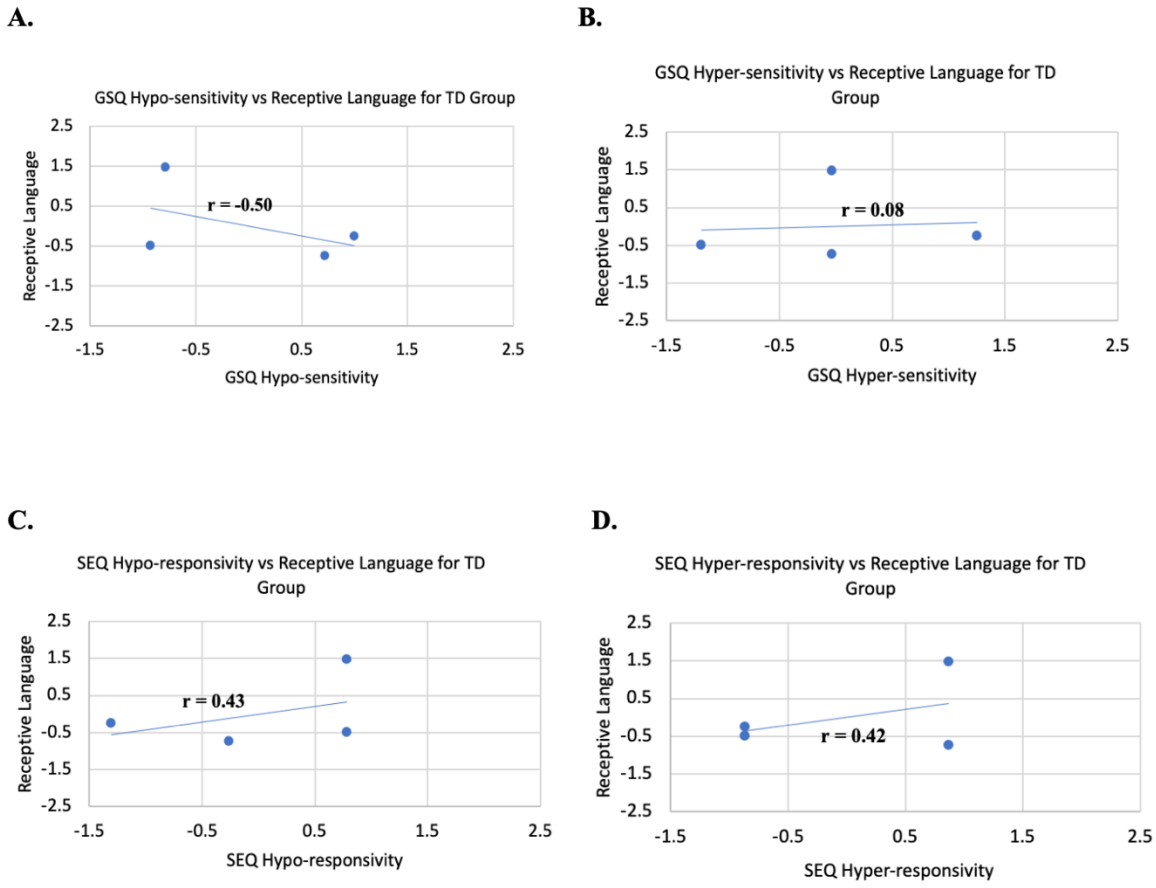


Figure 6: Parent-reported sensory hyper-responsivity predicts increased receptive language outcomes in non-autistic children



Appendix A:

Glasgow Sensory Questionnaire

SAMPLE QUESTIONS (please read to make sure you know how to answer the questionnaire but **do not answer** these sample questions).

These sample questions (and answers) have been included to make it as easy as possible for you to fill out the questionnaire.

A. Do you find it difficult to concentrate on visual information (for example, reading a book) when there are noises in the background?

In this question, an example is given which helps to explain the question further. Examples are only given to help prompt you (if needed).

Sample answer to question A:

If I experience problems (most of the time) in concentrating while watching a movie when there is background noise, I would answer '*Often*'. This would be regardless of whether I experienced the exact issue detailed by the example.

Never *Rarely* *Sometimes* (*Often*) *Always*

B. Do you find it difficult to look people in the eyes?

It can be hard to answer questions like this as the amount that eye contact (or something else) is a problem for you is likely to have varied throughout your life-time. For this reason, we ask that you choose the option that corresponds best with your experience over the last 12 months.

Sample answer to B:

If I found it difficult to have eye contact with someone all of the time at the age of 7, but as an adult I find it easy <u>most</u> of the time, I would answer 'Rarely'.

Never *Rarely* *Sometimes* *Often* *Always*

1. Do you dislike the **physical** sensation you get when people hug you?

Never *Rarely* *Sometimes* *Often* *Always*

2. Do you gag when you are eating certain foods, perhaps feeling as if you are going to be sick)?

Never Rarely Sometimes Often Always

3. Do you find it difficult to manipulate your hands when completing a delicate task (for example, picking up small objects or transferring objects from one hand to the other)?

Never *Rarely* *Sometimes* *Often* *Always*

4. Do you ever run your hand around the outside of an object before picking it up?

Never Rarely Sometimes Often Always

5. Do you stand very close (for example, less than 1 metre/3 feet away) or very far (for example, more than 3 metres/9 feet away) when you are talking to someone?

Never *Rarely* *Sometimes* *Often* *Always*

6. Do you find certain noises/pitches of sound annoying?

Never *Rarely* *Sometimes* *Often* *Always*

7. Do you smell your food before you eat it?

Never *Rarely* *Sometimes* *Often* *Always*

8. Do bright lights ever hurt your eyes/cause a headache?

Never *Rarely* *Sometimes* *Often* *Always*

9. Do you like to listen to the same piece of music/part of a DVD over and over again?

Never *Rarely* *Sometimes* *Often* *Always*

10. Do you feel ill/dizzy/peculiar if you have to reach up high or bend down low for something?

Never *Rarely* *Sometimes* *Often* *Always*

11. Do you find yourself fascinated by small particles (for example, little 'bits' of dust in the air)?

Never *Rarely* *Sometimes* *Often* *Always*

12. Do you like to spin yourself round and round?

Never *Rarely* *Sometimes* *Often* *Always*

13. Do you ever feel ill just from smelling a certain odour?

Never *Rarely* *Sometimes* *Often* *Always*

14. Do you find it difficult to hear what people are saying?

Never *Rarely* *Sometimes* *Often* *Always*

15. Do you dislike having a haircut (for example, because little bits of hair go down your back)?

Never *Rarely* *Sometimes* *Often* *Always*

16. Do you notice that you have hurt yourself but did not feel any pain?

Never *Rarely* *Sometimes* *Often* *Always*

17. Are you ever told by others that you wear too much perfume/after-shave?

Never Rarely Sometimes Often Always

18. Do lights ever seem to flicker when you look at them? ('Flickering' in this question means appearing to turn on and off very quickly instead of appearing constant).

Never Rarely Sometimes Often Always

19. Do you like lining objects up?

Never Rarely Sometimes Often Always

20. Do you rock yourself backwards and forwards?

Never Rarely Sometimes Often Always

21. Do you find it difficult to go into a strong-smelling shop (for example "Lush" and "The Body Shop")?

Never Rarely Sometimes Often Always

22. Do you cut the labels out of your clothes?

Never Rarely Sometimes Often Always

23. Do you hate the feel or texture of certain foods in your mouth?

Never Rarely Sometimes Often Always

24. Do you avoid going to restaurants because you can smell a certain odour?

Never Rarely Sometimes Often Always

25. Do you dislike loud noises?

Never Rarely Sometimes Often Always

26. Do you use the tip of your tongue to taste your food before eating it?

Never Rarely Sometimes Often Always

27. Does your body ever feel 'numb' - like you can't feel anything against your skin?

Never Rarely Sometimes Often Always

28. Do you think you have a weak sense of taste? One example of this would be if most food taste of 'nothing'?

Never Rarely Sometimes Often Always

29. Do you find that you are unaware of your body's signals (for example, don't often feel hungry/tired/thirsty)?

Never Rarely Sometimes Often Always

30. Do you ever feel dizzy/ill when playing fast-paced sports, for example basketball or football?

Never Rarely Sometimes Often Always

31. Do you react very strongly when you hear an unexpected sound?

Never Rarely Sometimes Often Always

32. Do you dislike walking on uneven surfaces?

Never Rarely Sometimes Often Always

33. Do you really like listening to certain sounds (for example, the sound of paper rustling)?

Never Rarely Sometimes Often Always

34. Do you like to run about – perhaps up and down in straight lines or round in circles?

Never Rarely Sometimes Often Always

35. Do you chew and lick objects that aren't food (for example pen lids or bottle tops) because you like the way they feel in your mouth?

Never *Rarely* *Sometimes* *Often* *Always*

36. Do you enjoy wearing very strong perfumes/after-shaves?

Never Rarely Sometimes Often Always

37. Do you find that you position your body in a way that is different to most people (for example, lie on your back on a sofa with your legs straight up in the air at a 90° angle)?

Never *Rarely* *Sometimes* *Often* *Always*

38. Do you find it difficult to tie your shoelaces or button up your clothes?

Never Rarely Sometimes Often Always

39. Do you find that you are able to go outside without a coat or a jacket when other people think that it is too cold?

Never *Rarely* *Sometimes* *Often* *Always*

40. Do you eat the same foods most of the time?

Never Rarely Sometimes Often Always

41. Do you like to wear something/hold something (for example, a hat or a pencil) so that you know where your body 'ends'?

Never *Rarely* *Sometimes* *Often* *Always*

42. Do you flick your fingers in front of your eyes?

Never Rarely Sometimes Often Always

Appendix B

SENSORY EXPERIENCES QUESTIONNAIRE (SEQ)
Short Form

(Note: for wei-ly knowui as the Sensory Supplement Questionnaire - SSQ)

Child's ID #: _____ Date: _____ Child's Birthdate: _____Gender: F D M D

Person completing form (check one):

Mother O Father O Both Parents D Teacher O Other O (describe:

Directions

The following are some brief questions about how your child uses his/her senses (for example hearing, vision, touch, etc.) to experience the world. No two children are alike. This questionnaire asks about behaviors that make your child unique. Consider your child's usual responses to these situations or activities. The questions ask how often your child responds or behaves in a certain wav. Check the box that fits best (almost never, once in a while, sometimes, frequently, almost always). Answer all questions completely.

Experiences with Sound:

1. Does your child react sensitively or startle easily to unexpected or loud sounds? (For example: covers ears when hearing a vacuum, baby cry, door close, etc.)

Almost Never *Once in a While* *Sometimes* *Frequently* *Almost Always*

☐ ☐ ☐ ☐ ☐

2. Does your child enjoy listening to music?

Almost Never *Once in a While* *Sometimes* *Frequently* *Almost Always*

☐ ☐ ☐ ☐ ☐

3. Does your child ignore you when you call his/her name?

Almost Never *Once in a While* *Sometimes* *Frequently* *Almost Always*

☐ ☐ ☐ ☐ ☐

4. Does your child seem to ignore or tune-out loud noises? (For example: no reaction when alarms go off, vacuum tunes on or object falls to the floor.)

Almost Never *Once in a While* *Sometimes* *Frequently* *Almost Always*

☐ ☐ ☐ ☐ ☐

5. Does your child notice sounds in the environment (such as planes, trains, faucets dripping, lights buzzing, etc.) before other people do?

Almost Never *Once in a While* *Sometimes* *Frequently* *Almost Always*

☐ ☐ ☐ ☐ ☐

6. Does your child show distress (stanles, covers ears, etc.) during loud conversations or singing?

Almost Never *Once in a While* *Sometimes* *Frequently* *Almost Always*

☐ ☐ ☐ ☐ ☐

Experiences with Sight:

7. Does your child enjoy looking at picture books?

Almost Never *Once in a While* *Sometimes* *Frequently* *Almost Always*

☐ ☐ ☐ ☐ ☐

8. Is your child disturbed by too much light inside or brightness outside?

Almost Never *Once in a While* *Sometimes* *Frequently* *Almost Always*

☐ ☐ ☐ ☐ ☐

9. Does your child stare at lights or objects that spin or move?

Almost Never *Once in a While* *Sometimes* *Frequently* *Almost Always*

☐ ☐ ☐ ☐ ☐

10. Is your child slow to notice new objects or toys in the room, or slow to look at objects that are placed or held near him/her?

Almost Never *Once in a While* *Sometimes* *Frequently* *Almost Always*

☐ ☐ ☐ ☐ ☐

11. Does your child avoid looking at your face during social games/play?

Almost Never *Once in a While* *Sometimes* *Frequently* *Almost Always*

☐ ☐ ☐ ☐ ☐

12. Does your child seem to ignore (doesn't notice) when someone new or different enters the rooms?

Almost Never *Once in a While* *Sometimes* *Frequently* *Almost Always*

☐ ☐ ☐ ☐ ☐

13. Does your child enjoy watching children's videos or TV programs?

Almost Never *Once in a While* *Sometimes* *Frequently* *Almost Always*

☐ ☐ ☐ ☐ ☐

Experiences with Touch:

14. Does your child dislike cuddling or being held?

Almost Never *Once in a While* *Sometimes* *Frequently* *Almost Always*

☐ ☐ ☐ ☐ ☐

15. Does your child show distress during grooming? (For example, cries or fusses during face washing, hair combing, fingernail cutting, or teeth brushing)?

Almost Never *Once in a While* *Sometimes* *Frequently* *Almost Always*

☐ ☐ ☐ ☐ ☐

16. Does your child avoid touching certain textures (such as fuzzy or squishy toys) or playing with messy materials (such as sand, lotion)?

Almost Never *Once in a While* *Sometimes* *Frequently* *Almost Always*

☐ ☐ ☐ ☐ ☐

17. Does your child react negatively or pull away when touched by a person? For' example: pulls away when head is patted.).

Almost Never *Once in a While* *Sometimes* *Frequently* *Almost Always*

☐ ☐ ☐ ☐ ☐

18. Does your child have trouble adjusting to the water temperature during bath time or does he/she dislike being in water?

Almost Never *Once in a While* *Sometimes* *Frequently* *Almost Always*

☐ ☐ ☐ ☐ ☐

19. Does your child seem slow to react to pain? (For example: he/she isn't bothered by bumps scrapes, cuts, or falls.)

Almost Never *Once in a While* *Sometimes* *Frequently* *Almost Always*

☐ ☐ ☐ ☐ ☐

20. Does your child dislike being tickled?

Almost Never *Once in a While* *Sometimes* *Frequently* *Almost Always*

☐ ☐ ☐ ☐ ☐

21. Does your child ignore you (doesn't notice) when you tap him/her on the shoulder for attention?

Almost Never *Once in a While* *Sometimes* *Frequently* *Almost Always*

☐ ☐ ☐ ☐ ☐

Experiences with Taste or Smell:

22. Does your child refuse to try new foods or avoid certain tastes, smells, or textures (consistencies) of food?

Almost Never *Once in a While* *Sometimes* *Frequently* *Almost Always*

☐ ☐ ☐ ☐ ☐

23. Does your child smell objects or toys during play or other activities?

Almost Never *Once in a While* *Sometimes* *Frequently* *Almost Always*

☐ ☐ ☐ ☐ ☐

24. Does your child seem interested in the way people smell? (For example: smells hair, breath.)

Almost Never *Once in a While* *Sometimes* *Frequently* *Almost Always*

☐ ☐ ☐ ☐ ☐

25. Does your child put objects, toys, or other non-food items in his/her mouth to lick, suck, or explore?

Almost Never *Once in a While* *Sometimes* *Frequently* *Almost Always*

☐ ☐ ☐ ☐ ☐

Experiences with Movement:

26. Does your child enjoy riding in a car?

Almost Never	*Once in a While*	*Sometimes*	*Frequently*	*Almost Always*
☐	☐	☐	☐	☐

27. Does your child like to jump up/down, rock back/forth, or spin in circles?

Almost Never	*Once in a While*	*Sometimes*	*Frequently*	*Almost Always*
☐	☐	☐	☐	☐

28. Does your child seek out physical rough- housing play? (For example: craves being tossed in the air or spun around.)

Almost Never	*Once in a While*	*Sometimes*	*Frequently*	*Almost Always*
☐	☐	☐	☐	☐

29. Does your child seem uneasy or become dizzy when moving on a swing or rocking chair, for example?

Almost Never	*Once in a While*	*Sometimes*	*Frequently*	*Almost Always*
☐	☐	☐	☐	☐

30. Does your child flap his/her arms or hands repeatedly, particularly when excited?

Almost Never	*Once in a While*	*Sometimes*	*Frequently*	*Almost Always*
☐	☐	☐	☐	☐