How autistic are you? Autistic-like traits, language ability, and how a nasal voice shapes people's social judgements.

by

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Abstract

Autistic Spectrum Disorder (ASD) is thought to be the far end of a spectrum of behaviours that include individuals from the neurotypical population. Characteristics associated with ASD are autistic-like traits such as decreased social skill and acute attention to detail. Language difficulties, hypernasality, and a high degree of autistic-like traits are characteristic of ASD. People with ASD are also more likely to be assigned negative social judgements (Smerbeck, 2010). The following studies will determine whether language difficulties, hypernasality, and negative social judgements are characteristics present in the neurotypical population, and if these characteristics are related to the degree of autistic-like traits. In Study I, neurotypical adult males completed the Autism-Spectrum Quotient (ASQ, Baron-Cohen et al., 2001) to measure autistic-like traits. Receptive and productive language abilities were measured as well. Findings from this first study showed that language ability was not consistently related to autistic-like traits. The purpose of Study II was to determine whether nasality and negative social judgements are related to autistic-like traits. A group of assessors rated the 4 most nasal and 4 least nasal participants from Study I, and the participant with the highest and the lowest ASQ scores on positive and negative social attributes, on male- and female-oriented descriptive attributes, as well as on how young and typically-developing the participants are. Nasality and negative social judgements were not related to autistic-like traits. In this second study, nasal participants were more likely to be rated with negative social judgements. Nasal participants were also more likely to be rated with positive social judgements. The findings provide support for future exploration of nasality in explaining negative social judgements in people with ASD, with more research needed to determine why the positive social judgements associated with nasality are not observed in ASD.

Preface

This thesis is an original work by Robyn Enns. The research projects, of which this thesis is a part, received research ethics approval from the University of Alberta Research Ethics Board, Project Name "SOCIAL ENGAGEMENT AND COMMUNICATIVE STYLE", No. 00059541, OCTOBER 2015 and Project Name "NASALITY AS A MEDIATOR OF SOCIAL PERCEPTIONS", No. 00068603, NOVEMBER 2016.

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Chapter One: Introduction to Autistic Spectrum Disorder

Autistic Spectrum Disorder (ASD) is a developmental disorder that affects approximately 1 in 68 children (D. Christensen et al., 2016), and is characterized by difficulties in communication and social interaction. These can present as deficiencies in language ability (Eigsti, Bennetto, & Dadlani, 2007; Cleland, Gibbon, Peppé, O'Hare, & Rutherford, 2016; McFadden, Hepburn, Winterrowd, Schmidt, & Rojas, 2012; Mizuno et al., 2011; Kargas, López, Morris, & Reddy, 2016; Maljaars, Noens, Scholte, & van Berckelaer-Onnes, 2012) and abnormal speech quality (Smerbeck, 2010). These deficiencies could contribute to negative social perceptions attributed to people with ASD (Smerbeck, 2010), and contribute in turn to their difficulty in forming friendships (Birdwhistell, 2015). ASD's designation as a spectrum disorder is important to understanding how these difficulties vary in people with a diagnosis, as well as illuminate the possibility that people without a diagnosis can present with autistic-like behaviours.

Language Ability & Speech Quality

Language Ability. People with ASD show deficits in many aspects of language, such as syntactic delays (Eigsti et al., 2007) and difficulties with pronoun shifting, where the speaker refers to oneself using the pronoun "you" (Mizuno et al., 2011). Further difficulties in communication result from difficulties in processing language, which results in lower receptive vocabulary (Maljaars et al., 2012). The language used by people with ASD is less complex than their neurotypical peers. When looking at the storytelling of children with ASD, Losh and Capps (2003) found that children with ASD used less complex syntax when telling a story about a personal experience than typically-developing children. Banney, Harper-Hill and Arnott (2015) also showed that children with ASD used less complex syntax when telling a story using a storybook when compared to typically-developing children.

In addition to using qualitatively different language, people with ASD also use language less than neurotypical people. Capps, Losh and Thurber (2000) found that children told significantly shorter stories than the control group during a storybook retelling task. Similarly, Smith Gabig (2008) found that children with ASD's longest utterance lengths during a story retell task were significantly shorter than their neurotypical peers.

Speech Quality. Another characteristic associated with ASD is hypernasality (Smerbeck, 2010). Hypernasality is a condition where excess air travels through the nasal cavity when an individual speaks (Smerbeck, 2010). People with ASD who were rated as hypernasal were more likely to be rated with negative social perceptions (i.e. people see them as whiny, annoying, and irritating) and female-specific perceptions (i.e. people see them as feminine and weak, Smerbeck, 2010). Hypernasality was also correlated with the speaker being perceived as younger than a speaker who was not hypernasal (Smerbeck, 2010). These negative social perceptions could combine with other factors such as social deficits to contribute to people with ASD's difficulty in forming friendships (Birdwhistell, 2015; Williams, 2015).

In the studies of both language and speech, researchers have compared people with ASD to typically-developing people. This comparison implies that people with ASD are qualitatively different from typically-developing people. However, there is now acceptance for considering ASD a spectrum disorder, with people displaying more or fewer autistic-like traits.

Autism as a Spectrum

Early theories of what causes ASD were categorical, where if the person has or experiences some variable then that person will have ASD. Some of these theories involved failure of a parent to bond with the child (Bettelheim, 1969), and abnormal brain structure (Rimland, 1962; Moore & Shiek, 1971; Bower, 1986). Because researchers did not find a consistent common variable in people with ASD, theories that consider ASD as a spectrum have become the focus of research.

The emphasis on autism as a *spectrum* highlights the ways unique symptom combinations present in individuals with ASD. An example of how the American Psychiatric Association (APA) emphasized this variability can be observed from the following description of ASD in the diagnostic criteria from the DSM-5: "Deficits in social-emotional reciprocity, *ranging*, *for example, from* [emphasis added] abnormal social approach and failure of normal back-and-forth conversation; to reduced sharing of interests, emotions, or affect; to failure to initiate or respond to social interactions" (APA, 2013, p. 50). Two recent changes to the *Diagnostic Statistical Manual of Mental Disorders* (DSM; APA, 2013) have also emphasized the importance of looking at ASD as a spectrum instead of categorically. These changes were amalgamating the five autistic categories people had previously needed to fit into and renaming the umbrella term that had encompassed the five autistic categories from Pervasive Development Disorders (PDD) in the DSM-IV-TR (American Psychiatric Association, 2000) to Autistic Spectrum Disorders in the DSM-5 (APA, 2013). The wording of the diagnostic criteria and the two changes to the DSM highlight the unique variability of behaviours and social abilities of people with ASD. The rationale for ASD as a spectrum comes from two related lines of research: genetics and studies of family members of people with ASD.

Possessing common genetic variants that are both common in the neurotypical population and yet implicated in the development of ASD could increase the proportion of autistic-like traits a person has. It is therefore possible to possess many autistic-like traits without meeting the criteria for an ASD diagnosis. No one gene has been determined to *cause* ASD. Rather, ASD is thought to follow a multifactorial threshold model of development, such as the Quantitative Threshold Exposure hypothesis (Crawford, 2016), where both rare and common genetic variants are implicated in ASD's development. Other external factors are also included in the model, like age of the parents and prenatal health of the mother and child. The multifactorial model suggests that many of the genetic variations that contribute to ASD are common variants. These are variants that on their own are quite safe because they are very common in a healthy population. It is the accumulation of these variants that could additively combine to manifest as ASD.

Along with the understanding that ASD has a genetic component came investigation into the idea of a Broader Autism Phenotype (BAP), where having more genes that are associated with ASD leads to having more autistic-like traits and behaviours. Some of the research that investigated ASD as a spectrum showed that family members of a child with an ASD diagnosis display more autistic behaviours than families who do not have a child with ASD (L. Christensen et al., 2010). Differences have been found between younger siblings of children with ASD and matched controls as early as their first birthdays, such as having "reduced eye contact, … and delayed onset of gestures, speech, and play" (Ozonoff et al., 2014, p. 404). One study (L. Christensen et al., 2010) focused on the play behaviours of infant siblings of children with an ASD diagnosis who had not received an ASD diagnosis by three years of age. They found that the siblings of children with ASD more often engaged in play behaviours similar to those observed in ASD compared to the typically-developing children. A study by McFadden et al. (2012) also provided evidence for the validity of the BAP by showing that parents of children with an ASD diagnosis performed significantly worse on both a receptive vocabulary measure, and a phonology measure, than parents of typically-developing children. Gamma activity in the brain increases during language processing (Peña & Melloni, 2012), so the study also measured the amount of gamma activity in the brains of the parents on the premise that greater activity would suggest greater effort required. Parents of children with ASD had significantly higher gamma activity than parents of typically-developing children during the word recognition task. Evidence of the BAP in both siblings and parents of children with ASD supports the idea of ASD being the extreme end of a larger spectrum of behaviours that includes the neurotypical population. According to the reasoning behind the BAP, the families of children with ASD should still have displayed characteristics of the BAP before that child was born. This reasoning supports the idea that there are neurotypical people with BAP characteristics who do not have a family member with ASD.

Baron-Cohen (2004) pushed this idea further by suggesting that ASD is actually extreme male-oriented thinking, and that everyone lies on a continuum where their thinking is either more male-oriented or female-oriented. Baron-Cohen (2004) defined the two sides of gender-oriented thinking that allow people to excel at specific skills. On the female side, the average female excels at empathizing, meaning that a person can both discern another person's emotions and gives an appropriate emotional response, whereas on the male side, the average male excels at analyzing, exploring, and constructing systems (Baron-Cohen, 2004, p. 2-3). Baron-Cohen (2004) justified the idea that ASD is the extreme form of the male mind by suggesting that autism is an empathy disorder. The difficulty people diagnosed with ASD have both with reading and responding appropriately to the emotions of others is therefore attributed to a lack of female-oriented thinking. Baron-Cohen (2004) also justified this idea using the high male-to-female ratio, and that people with ASD are often adept at recognizing patterns, noting minute details, and other systemizing abilities attributed to male-oriented thinking. Asperger also suggested the possibility of ASD as extreme male-oriented thinking in his 1944 paper, "The autistic personality is an extreme variant of male intelligence. Even within the normal variation, we find typical sex differences in intelligence . . . In the autistic individual, the male pattern is exaggerated to the extreme" (Frith, 1991, p. 84-85). The theory of extreme male-oriented thinking promotes the idea of ASD being on a spectrum, where a person would be more likely to behave like someone with ASD when his or her mind is more male-oriented. Baron-Cohen, Wheelwright, Skinner, Martin and Clubley (2001) developed a scale called the Autism-Spectrum Quotient (ASQ) to measure autistic-like traits in the neurotypical population. This scale measures characteristics such as social skill and acute attention to detail, with a higher score meaning the person has more autistic-like traits. Baron-Cohen et al. (2001) found that students studying Science scored significantly higher on the ASQ than both students from Humanities and Social Sciences. Since science students should excel at the activities associated with male-oriented thinking, this finding supports the idea of ASD as extreme male-oriented thinking.

While ASD is now characterized as a spectrum disorder, autism research continues to separate participants into groups of those with a diagnosis of ASD and those without (L. Christensen et al., 2010; Losh & Capps, 2003; McFadden et al., 2012), as opposed to looking at participants on a scale. This dichotomous research design limits the fine detail that could be captured by exploring the disorder as a continuum. Meaningful information could be lost because of the variation present within the group of individuals with ASD. Research that studies autism as a spectrum allows for the possibility that ASD could be one end of a larger spectrum of traits and behaviours that includes people without an ASD diagnosis. This research would support the idea that people who are at the distal end of the spectrum from ASD are quantitatively but not qualitatively different than neurotypical individuals. There are several cognitive and social variables that could span the range of typical to disordered that can be used to explore the full spectrum, including language ability and speech quality. Study I will investigate ASD as a larger spectrum by determining whether language ability is related to autistic-like traits in the neurotypical population.

Chapter Two: Study I

Because ASD is a spectrum of behaviours found both in people with and without a diagnosis, the degree of autistic-like traits in the neurotypical population should correlate with similar language use and language ability observed in people with ASD. This study investigated the relationship between scores from the self-administered Autism-Spectrum Questionnaire (ASQ; Baron-Cohen et al., 2001) and expressive and receptive language. The study also investigated how these relationships are different from or similar to the language ability of individuals with an ASD diagnosis in previous research. Adult males were chosen as the participants for this study. ASD is 4.5 times more prevalent in boys than in girls (D. Christensen et al., 2016), and despite ASD persisting into adulthood, there is a limited body of research that has looked at adolescent and adult populations.

Research Question 1: Do autistic-like traits relate to receptive language ability and expressive language use?

Hypothesis 1: people who score higher on the ASQ will have lower receptive vocabulary (Maljaars et al., 2012).

Hypothesis 2: having more autistic-like traits will correlate with producing both a lower total number of words (Paul, Chawarska, Cicchetti, & Volkmar, 2008; Smith, Mirenda, Zaidman-Zait, 2007; Capps et al., 2000) and distinct types of words when speaking (Perkins, Dobbinson, Boucher, Bol, & Bloom, 2006).

Hypothesis 3: the type of language used by people who score higher on the ASQ will be less complex (Banney et al., 2015; Losh & Capps, 2003) as assessed by measures of language complexity (i.e. Gunning Fog Index) and lexical richness (i.e. Guiraud Index).

Research Question 2: Will the complexity and level of social interaction in the video prompt alter the relationship between having autistic-like traits and language use?

Hypothesis 1: Capps et al. (2000) found that people with ASD provide simpler stories than the stories told by neurotypical people. Since people with ASD have difficulty inferring emotion and understanding complex social interactions, I hypothesized that the language used in the responses of people with more autistic-like traits will be simpler in a story with multiple characters with different goals and emotions than people who have fewer autistic-like traits.

Hypothesis 2: The responses in a question and answer task will decrease in complexity as ASQ scores increase, because the task is styled like a dialogue as opposed to a monologue-style in the storytelling task. Losh and Capps (2003) found that people with ASD provide simpler personal stories than neurotypical people. Because the question and answer task has personal questions asking how the participant experiences his life, people with more autistic-like traits may give less complex responses than people with fewer autistic-like traits.

Method

Participants. The sample consisted of 66 adult males (age: mean=19.39 years, S.D.=1.60). Seven participants were recruited via posters put up around the University of Alberta campus and the remaining 59 were recruited through the Department of Psychology's research participation pool.

Table 1

Means, Standard Deviations, and Ranges of the Age, ASQ Scores, and Raw PPVT Scores of the Participants in each Faculty

	Arts (*n*=18) *M (SD,* Range)	Science (*n*=43) *M (SD,* Range)	Other (*n*=5) *M (SD,* Range)	Total *M (SD,* Range)
Age	20.22 (1.99, 18-24)	19.07 (1.33, 18-24)	20.00 (1.73, 19-23)	19.45 (1.63, 18-24)
ASQ	18.44 (7.29, 10-35)	19.05 (5.98, 7-32)	17.20 (5.40, 12-26)	18.74 (6.25, 7-35)
PPVT	176.17 (12.16, 153-194)	181.28 (9.24, 159-199)	171.60 (12.86, 157-186)	179.15 (10.67, 153-199)

Note. ASQ=Autism Spectrum Quotient. PPVT=Peabody Picture Vocabulary Test.

Table 2

Means of Raw and Standardized PPVT Scores of Age Groups

Age	18 years (*n*=23)	19-20 years (*n*=31)	21-22 years (*n*=7)	23-24 years (n=5)
Raw PPVT	180.70	179.55	173.43	177.60
Std. PPVT	109-110	107-108	99-100	101-102

Note. Std.=Standardized. PPVT=Peabody Picture Vocabulary Test.

Materials. Demographic Questionnaire – This questionnaire was used to determine participants' status as a student, whether or not they were recruited from the research participation pool, age, and which languages the participant is able to speak. When tested as potential confounding factors, age and number of languages did not affect results.

Autism-Spectrum Quotient (ASQ) – This questionnaire was developed by Baron-Cohen et al. (2001) to measure autistic-like traits in people from a neurotypical population. The questionnaire consists of 50 questions with total scores ranging from 0-50. The available answers to the questions were the following: definitely agree, slightly agree, slightly disagree, and definitely disagree. Each ASQ answer that accompanied some autistic trait (25/50 answers agree, 25/50 answers disagree) was given a score of 1 regardless of whether the answer chosen was described as "slightly" or "definitely" (See Baron-Cohen et al., 2001 for full list of ASQ questions and scoring). The ASQ was chosen for this study because it is a self-report questionnaire that is brief and easily coded. Cronbach's alpha was calculated for the ASQ responses obtained in the present study and resulted in an overall reliability of 0.73.

Social Interaction Storytelling Task – This task used the following Pink Panther cartoon clip:

- "In the Pink of the Night" (The Clock Story; Lee & Davis, 1969a): This story was about the Pink Panther's new alarm clock and the driven cuckoo bird inside who attempts to wake up the Pink Panther. The Pink Panther does not want to wake up and tries to stop the alarm from going off. The story climaxes with the Pink Panther throwing the alarm clock and the cuckoo bird off a bridge. The Pink Panther then feels guilty, thinking he killed the cuckoo bird. While he searches for the bird and grieves over the bird's "death," the cuckoo bird brings the alarm clock back to the house. When the Pink Panther sees that the cuckoo bird is alive he is relieved, and the story ends with the Pink Panther and the cuckoo bird sleeping together. Then an alarm clock goes off and the cuckoo bird destroys the alarm. The video is approximately six minutes.

Single Character Storytelling Task – This task used the following Pink Panther cartoon clip:

- "Jet Pink" (Lee & Davis, 1969b): This story is about the Pink Panther wanting to fly an airplane, so he gets into one and takes off only to realize he does not know how to fly. He then panics, and the plane goes out of control. He flies into outer space, then into a city where he almost crashes into bystanders on the street. Then he flies into a tunnel into oncoming traffic. The Pink Panther tries pressing several buttons and is ejected from the plane. He starts flapping his arms to fly after the plane, but eventually he makes it to the ground and gives up trying to chase the plane. The plane then starts to chase the Pink Panther and he ends up back in the plane. The video ends with the Pink Panther reading the plane's owner's manual. The video is approximately five minutes long.

Question and Answer (Q&A) Task – This task used a predetermined list of interpersonal and objective questions.

The interpersonal questions were chosen to account for possible difficulties people with more autistic-like traits may have with the pronoun shifting involved in the questions that contain the word "you" (Mizuno et al., 2011). Examples of the interpersonal questions were: "How do you make a friend?" and "How do you know that two people are attracted to each other?"

Examples of the questions in the objective category were: "How does lightning work?" and "How does a plane get up in the air and stay there?". (See Appendix 1 for the full list of questions).

Peabody Picture Vocabulary Test-III-A (PPVT) – This test of comprehension vocabulary is standardized through to adulthood (Dunn & Dunn, 1997). The participant is told the target word and picks the corresponding image out of four pictures.

Measures & Procedure. Participants were asked to fill out the demographic questionnaire when they arrived for the experiment. Both Storytelling tasks and the Q&A task were videotaped and the order of the tasks was counterbalanced. For the Storytelling tasks, participants were told they would be watching two videos and that they would need to describe what they remember from each video to the best of their ability. In the Q&A task, the participants were told that they would "be asked a set of questions to explain various phenomena". They were also told that what was important was the style of explanation and not on whether the answers given were actually correct. The participants answered questions for a minimum of two minutes, unless all the questions were completed prior to this time. All participants were asked questions 1-7 (4 interpersonal and 3 objective, see Appendix 1 for full list of questions), and more questions were asked if the minimum time had not yet been reached. Then the ASQ was administered without fully disclosing its connection with Autistic Spectrum Disorder (ASD), as participants were told the ASQ was a Social Engagement Questionnaire. Participants were made aware of the ASQ's connection with ASD following the experiment. After completing the ASQ, participants completed the PPVT following the examiner's manual (Dunn & Dunn, 1997).

Coding & Analysis.

The videos were transcribed and the number of words counted for both the Q&A and the Storytelling tasks. The filler words "uh," "um," and "err" were excluded from the word count to focus on the words that were part of the story or answer being given.

Story length was measured using number of sentences, sentence length, and the total number of words. Lexical richness was measured using the number of different words and the Guiraud Index (quantifies the degree that the speaker uses a varied and large vocabulary, and is calculated by dividing the number of word types by the square root of the total number of words; Klatter-Folmer, Kolen, van Hout, & Verhoeven, 2006). Language complexity was measured using hard words and the Gunning Fog Index (uses a combination of average sentence length and the percentage of hard words; Scott, 2003). The text analyzer from the website www.usingenglish.com determined the following factors: number of sentences, sentence length, the total number of words, the number of different words, the number of hard words (words with 3 or more syllables), and Gunning Fog Index scores. Raw PPVT scores were used in the analysis because they show greater variability when comparing individuals. The standardized PPVT scores were determined as well to further describe the participants (see Table 2). Age and the number of languages the participant could speak were tested for correlation against all measured variables as potential confounding factors but were not found to be significantly correlated with any variable.

Preliminary Analysis. Prior to analysis, ASQ scores and raw PPVT scores were determined to be normally distributed using skewness (ASQ=0.535; PPVT=-0.396) and kurtosis values between -2 and 2 (ASQ=-0.368; PPVT=-0.173), as well as by inspecting their QQ plots. Residual plots of ASQ scores and the raw PPVT scores showed that the assumptions of linearity and homogeneity of variance were met as well.

Power Analysis. To analyze the statistical power for this study, a sensitivity analysis was conducted using G*Power software (Faul, Erdfelder, Buchner, & Lang, 2009). Given the sample size of 66 participants, this study has 80% power to detect a medium-sized correlation ($r \geq$ 0.331).

Results

The means and standard deviations were calculated for the variables measured from the Storytelling tasks and the Q&A task (see Table 3).

Table 3

The Means (M) and Standard Deviations (SD) for the Variables Measured in the Clock Story and Jet Pink Stories, and the Q&A Task

Categories	Variables	Clock Story (*M*)	Clock Story (*SD*)	Jet Pink (*M*)	Jet Pink (*SD*)	Q&A (*M*)	Q&A (*SD*)
Story Length	Num. of Sentences	15.20	8.57	13.11	7.53	18.88	8.40
	Sentence Length	17.10	3.49	15.02	3.71	13.17	4.44
	Num. of Words	270.6	179.28	204.73	154.12	263.59	170.03
Lexical Richness	Types of Words	107.1	51.53	91.24	50.01	128.80	57.83
	Guiraud Index	6.65	0.80	7.06	0.80	7.39	0.79
Language Complexity	Hard Words	7.86	7.41	6.85	8.17	18.86	14.07
	Gunning Fog Index	7.96	1.79	7.36	1.85	8.12	2.19

Table 4

Partial Correlations of ASQ Scores Compared with the Remaining Variables from the Clock Story, Jet Pink, and the Q&A Task After Controlling for Age and Number of Languages of the Participants

Categories	Variables	Correlations with ASQ		
		Clock Story	Jet Pink	Q&A
Story Length	Num. of Sentences	-0.054	0.004	-0.012
	Sentence Length	0.181	0.072	0.166
	Num. of Words	0.057	0.123	0.099
Lexical Richness	Types of Words	0.010	0.084	0.073
	Guiraud Index	-0.069	0.012	0.014
Language Complexity	Hard Words	0.062	0.274*	0.109
	Gunning Fog Index	0.134	0.132	0.136

Note. **Significant correlation with p-value<0.05. ASQ=Autism Spectrum Quotient.*

The average ASQ score was 18.74 with a standard deviation of 6.25, which is similar to Baron-Cohen et al.'s (2001) sample of male university students (n=454) whose average ASQ score was 18.60 with a standard deviation of 6.60. The average raw PPVT score was 179.15 with a standard deviation of 10.67.

Research Question 1: Do autistic-like traits relate to receptive language ability, and the expressive language used by the speaker?

Raw PPVT scores were found to trend toward a negative correlation with ASQ scores, $r(62)=-0.19$, p-value=0.13.

Table 4 presents the correlations from the Clock Story, Jet Pink, and the Q&A session, where the only significant correlation with ASQ scores was a positive correlation with the number of hard words (words with 3 or more syllables) in Jet Pink, $r(62)=0.27$, p-value<0.05. There were no other significant correlations revealed between ASQ scores and the remaining variables.

Research Question 2: Will the complexity and level of social interaction in the video prompt alter the relationship between having autistic-like traits and language use?

Participants with more autistic-like traits did not display any significant relationships with language use during the more socially complex Clock Story (See Table 4).

Discussion

ASQ scores were only rarely correlated with the language measures. The absence of a significant relationship between autistic-like traits and receptive language ability could be because the ASQ is limited as a measure of the degree of autistic-like traits in the neurotypical population. For instance, Baron-Cohen et al. (2001) showed that people score themselves lower on the ASQ and therefore are considered to have fewer autistic-like traits than when their parents complete the ASQ on their behalf. This finding could mean that a portion of the participants in this study should have had more autistic-like traits than they reported, which may have led to finding a stronger relationship between autistic-like traits and language ability.

This absence could also be the result of investigating a university student population, where a delay in receptive language ability would have limited those students' chances of being admitted to and continuing on in postsecondary. However, it is important to note that the sample size of 66 participants only had statistical power to detect relationships with effect sizes that were medium or greater. Considering this study is investigating a subclinical population, it is possible that the true relationship between autistic-like traits and language ability has a smaller effect size (between 0.10 and 0.33). A third of the correlations reported in this study were in the small to medium range, which could suggest that there were small but meaningful relationships that I was unable to detect in this study. The correlation between receptive vocabulary and autistic-like traits was the strongest *nonsignificant* correlation of the relationships reported in this study ($r(62)=-0.19$, p-value=0.13). This negative trend between PPVT and ASQ scores is consistent with the findings from previous research where people with more autistic-like traits had a lower receptive vocabulary than other members of the typical population (McFadden et al., 2012). It is possible that this relationship would be statistically significant in future studies with a greater sample size.

There was a positive relationship between having more autistic-like traits and using more hard words (words with 3 or more syllables) in the Single Character Storytelling Task. A possible explanation for an increase in hard words during the Single Character Storytelling Task could be that people with more autistic-like traits have an easier time producing a more complex narrative when there are fewer instances of social interaction and emotional states to interpret

(Capps et al., 2000; Losh & Capps, 2003). Participants with more autistic-like traits did not display any significant relationships with language use during the complex tasks with social interaction, suggesting that the language use of people with more autistic-like traits does not differ from other neurotypical people on these complex tasks.

Thus, the results from Study I suggest that autistic-like traits are not consistently related to language ability in a neurotypical population. These results still allow for the possibility that speech quality could nonetheless be related to autistic-like traits, which will be the focus of Study II.

Chapter Three: Hypernasality and Study II

People are more likely to rate speakers with ASD as sounding nasal than typically-developing speakers (Smerbeck, 2010). Hypernasality could contribute to the negative social judgements experienced by people with ASD (Smerbeck, 2010). A study by Bloom, Moore-Schoenmakers and Masataka (1999) may provide a possible explanation for the negative social perceptions of people with a more nasal voice. The vocal tract is still in development from birth to three months of age, and these vocalizations were measured as being more nasal than vocalizations that come after three months, when the vocal tract has developed to allow for control of nasality (Bloom et al., 1999). This finding could mean that people who sound nasal are being perceived as sounding infantile by the listener, which Smerbeck (2010) supported with her finding that a hypernasal speaker was more likely to be rated as sounding younger than a speaker who did not sound nasal. Lorna Wing's (the psychiatrist who coined the term "Asperger's Syndrome"; Watts, 2014) description of people with Asperger's (High-Functioning ASD) as people "who give the impression of fragile vulnerability and a pathetic childishness, which some find infinitely touching and others merely exasperating" (Silverman, 2012, p. 51) could be in reference to nasality as the trait that perpetuates this childish perception.

Causes of Hypernasality

If hypernasality is related to negative social judgements, then it is important to understand why hypernasality may occur. Understanding why hypernasality occurs is necessary to developing interventions to help hypernasal speakers sound less nasal. Smerbeck (2010) posited multiple explanations for why people with ASD sound hypernasal. Children with ASD have been shown to have difficulties attending to speech (Whitehouse & Bishop, 2008), which means children with ASD may not recognize the difference between a more or less nasal voice. Difficulties with social learning could also contribute to being hypernasal, as children with ASD are known to be deficient at learning by observing others (MacDonald & Ahearn, 2015). Masataka and Bloom (1994) showed that parents attend more frequently to a child when that child uses fewer nasal utterances. This preference might not be observed by children with ASD and so they do not learn to limit nasal utterances. In both cases, hypernasality could be improved by training people to attend to a particular component of speech (i.e. hypernasality).

Study II Objectives

While language use and language ability did not correlate to the degree of autistic-like traits in Study I, the degree of nasality could still correlate to both the degree of autistic-like traits and with negative social judgements. This study will determine how having more autistic-like traits relates to the types of social judgements that are assigned to the speaker. The study will also determine whether being perceived as having a nasal voice mediates the types of social judgements that are assigned to the speaker (Smerbeck, 2010).

Research Question 1: Does having a more nasal voice accompany having more autistic-like traits?

Given the findings of Smerbeck's (2010) study showing that people with ASD are rated as significantly more nasal than those in the typically-developing comparison group, I hypothesized that neurotypical males who have a higher ASQ score will be rated as more nasal.

Research Question 2: Will having more autistic-like traits be associated with negative and feminine socially-relevant variables?

I hypothesized that people with more autistic-like traits would be rated higher on the negative socially-relevant adjectives and the female-specific adjectives, rated lower on the male-specific adjectives, and rated as being younger and less typically-developing than people with few autistic-like traits (Smerbeck, 2010).

Research Question 3: Will having a more nasal voice be associated with negative and feminine socially-relevant variables?

I expected to obtain similar results to Smerbeck's (2010) findings where the audio clips that were rated as being more nasal would also be described with negative socially-relevant adjectives. I also expected the male-specific adjectives to be negatively correlated with nasality, and for the female-specific adjectives to be positively correlated with nasality. I also investigated whether people will perceive more nasal speakers as being younger as well as less typically-developing.

Method

Participants. The sample of speakers used in the audio files consisted of the 4 most nasal and the 4 least nasal adult males from Study I, as well as the speaker with the highest and the speaker with the lowest ASQ score (age: mean=19.50 years, S.D.=1.67). A pilot study was conducted (see Appendix 2) and the ratings analyzed to determine the four participants with the highest nasal ratings and the lowest nasal ratings, who were chosen to fit into the study's one-hour time limit allotted for each rater. The average nasal rating of the 62 participants included (those of the 66 in Study I who produced the target words) was 2.95 with a standard deviation of 0.43. Using Smerbeck's (2010) definition of hypernasality (i.e., nasal ratings that are 1.0 standard deviation or higher than the average), 10 of the 62 participants (16.13%) were determined to be hypernasal, which is a similar percentage to the 5 hypernasal participants in Smerbeck's (2010) typically-developing control group of 29 children (17.24%).

The participants from the high nasal group were assigned the codes HN1, HN2, HN3, and HN4 (HN given to signify High Nasal), and had mean nasality ratings ≥3.68 on a 6-point Likert scale (see Table 5), with 6 being "very nasal." The participants from the low nasal group were assigned the codes LN1, LN2, LN3, and LN4 (LN signifying Low Nasal), and had mean nasality ratings of ≤2.62 (see Table 5), with 1 being "not nasal at all."

Table 5

Age, ASQ Scores, Faculty, and Mean Nasal Ratings of the 4 Highest-Rated Nasal Participants and the 4 Lowest-Rated Nasal Participants, Along with the Participant with the Highest and the Participant with the Lowest ASQ Scores

Participant	Age	ASQ	Faculty	Nasal Rating (*M*)
HN1	23	16	Arts	4.31
HN2	20	12	Arts	3.98
HN3	19	29	Arts	3.92
HN4	19	12	Other	3.68
LN1	21	18	Science	2.32
LN2	18	24	Science	2.36
LN3	18	16	Science	2.55
LN4	24	15	Science	2.62
HAQ	22	35	Arts	2.97
LAQ	18	7	Science	3.03

Note. ASQ=Autism Spectrum Quotient.

Table 6

Description of Word Options and the Number of Words Used Per Participant in the Nasality Judgement Audio Clips

Task	Clock Story	Jet Pink	Q&A – Personal	Q&A – Objective
Possible Words	Clock, Bird, Sleep, Wake	The, Air, Fly, Back	Other, You	That, Through, There
Num. of Words	2	2	1	1

Materials. Audio Clips – Six separate words were used from each participant (see Table 6 for the distribution across tasks). The segments were chosen based on words that the majority of participants used during each specific task from Study I. Two of four target words were selected from each cartoon (Clock Story – Clock, Bird, Wake, Sleep, Jet Pink – Fly, Air, The, Back), as well as one of three words from an objective question (That, There, Through) and one of two words from an interpersonal question (You, Other) from the Q&A task. Words were randomly chosen for each participant, unless the participant only said two of the target words for the Storytelling tasks, or one of the target words from the Q&A task, in which case the target words the participant said were selected. There were 31 instances of each of the target words from the Storytelling task and from the interpersonal question, and there were 18 instances of the word *There*, 21 instances of the word *Through*, and 23 instances of the word *That* from the objective question. When correlations were run with the words separated by task, the 6 words from each participant were highly correlated with one another at a p-value of >0.01, so the mean of the nasality ratings of the six words from each participant was used to test for a relationship with ASQ scores.

The average volume in decibels and the average length in seconds of the audio files were controlled for using partial correlations. A volunteer and I also listened to each audio file and came to an agreement about whether the participant in the audio file sounded like he had a foreign sounding accent (if no agreement could be reached a third person was called in to make the final judgement, which occurred four times in the 60 audio files). Whether or not the participant had a foreign accent was then controlled for using partial correlations as well. These variables were controlled for to ensure that nasality was the variable being rated.

The six audio files for each of the four most nasal and the four least nasal participants from Study I were used, as well as the 6 audio files from both the participant who scored the highest (HAQ, scored 35) and the lowest (LAQ, scored 7) on the ASQ in Study I, for a total of 60 audio files.

The Nasality Rater Training, the Nasality Judgement Task, and the Attributes Judgement Task were administered using Qualtrics survey software (Qualtrics, Provo, UT).

Measures & Procedure. A group of assessors were trained to rate the participants' nasality and were also asked to rate the participants using social and gender-specific adjectives.

Nasality Rater Training – Training involved completing the nasality discrimination task from the pilot study (see Appendix 3 for training procedure, and for full script used by experimenter).

Nasality Judgement Task – Each page displayed a word with its corresponding audio file and a 6-point Likert scale to rate nasality (1 being not nasal at all and 6 being very nasal). Once the participant chose to go to the next page, he or she could no longer return to the previous page. Each page had a 7-second countdown clock where reaching zero seconds switched to the next page (see Fig. 1). The Nasality Judgement Task was counterbalanced with the Attributes Judgement Task, and the order the questions appeared was randomized. The mean of the nasality ratings of the six words from each participant was used to test for the relationships between nasality and the other variables of interest (listed in Table 7, Results).

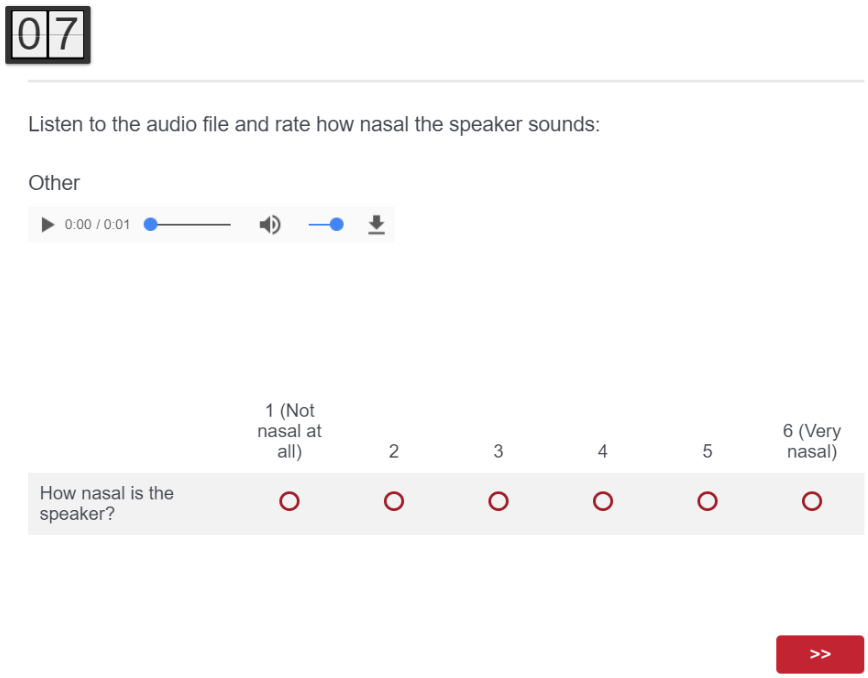

Fig. 1: Example question from Nasality Judgement Task using Qualtrics.com.

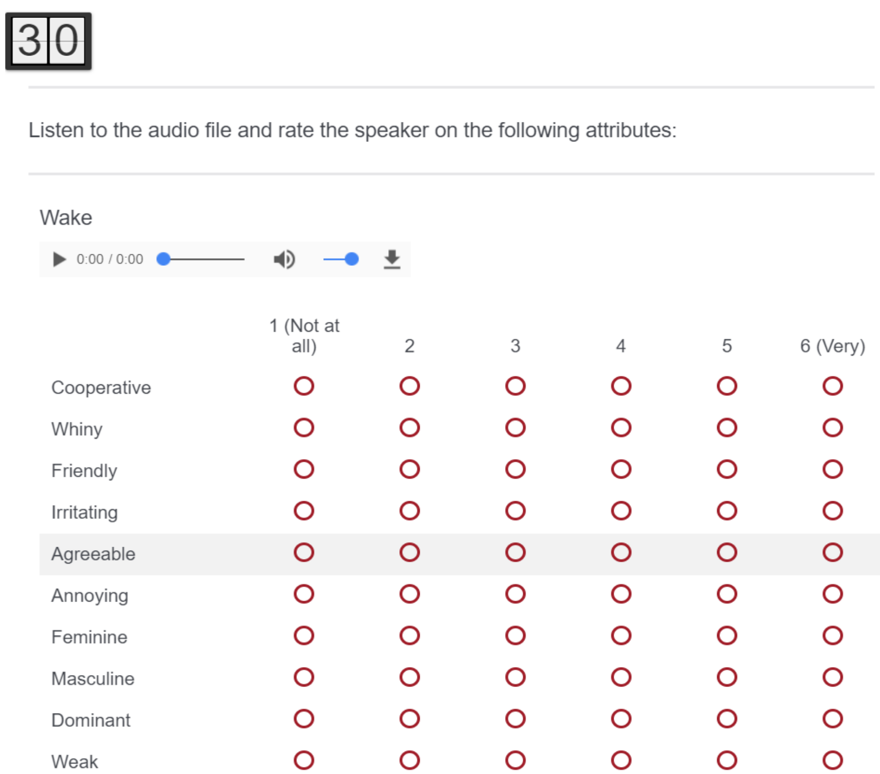

Fig. 2: Example question from Attributes Judgement Task using Qualtrics.com.

Attributes Judgement Task – The list of attributes (see Fig. 2 for the complete list of adjectives) was displayed on one page with their corresponding 6-point Likert scales. The attributes-rating questions were randomized. Once the participant chose to go to the next page, he or she could no longer return to the previous page. Each adjective page had a 30-second countdown clock where reaching zero seconds switched to the next page. The next page asked about the estimated age of the speaker, and had asked the participant to rate how typically-developing the speaker is on a 6-point Likert scale (with a score of 1 being psychologically abnormal and 6 being typically-developing, see Fig. 3). This page had a 10-second countdown clock.

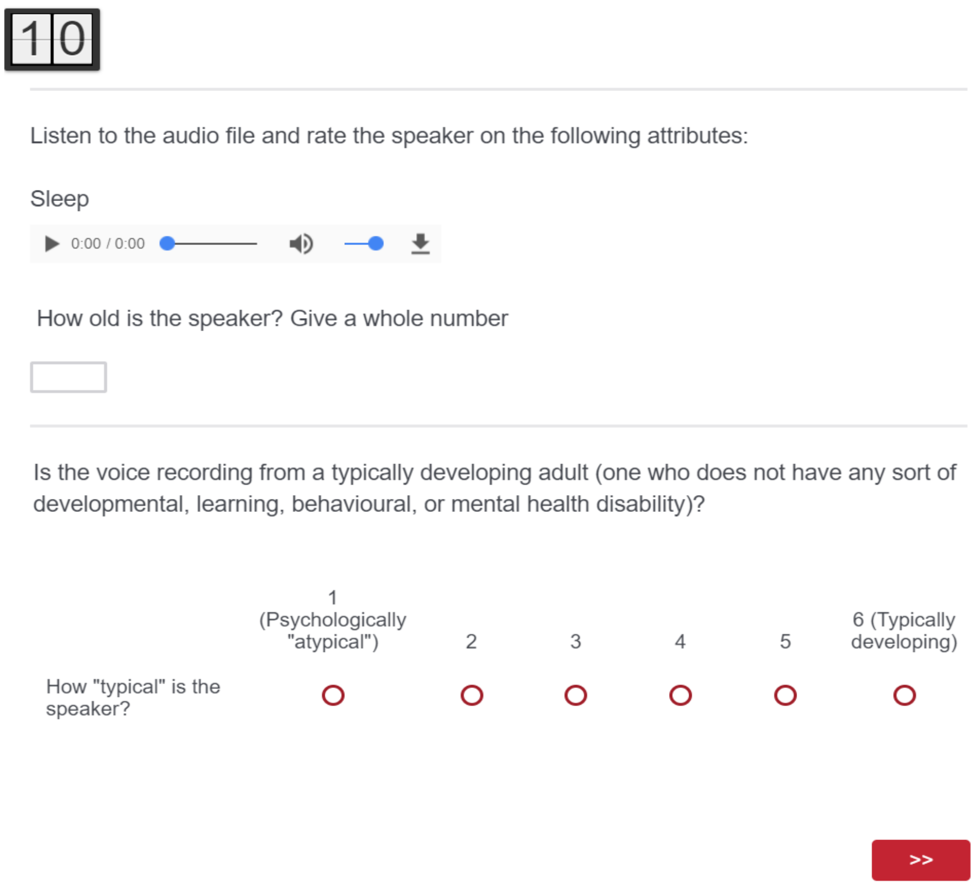

Fig. 3: Second example question from Attributes Judgement Task using Qualtrics.com.

Coding & Analysis. Out of 30,420 questions (780 questions per person, with a total of 39 people participating) 369 questions were left unanswered (1.21% missing data). The Multiple Imputation function in SPSS was used to estimate the missing values (20 imputations per missing value).

After finding the 6 words from each participant were significantly correlated with each other, I also ran Cronbach's alpha on the words from each participant using SPSS. Cronbach's alpha ranged from 0.993-0.998 for the ten participants. Because the words from each participant were consistently correlated with each other, the means of the 6 words were used in the analysis.

The mean of the ratings from each variable of three of the four speakers in the High Nasal Group and the mean of the ratings from each variable of the four speakers in the Low Nasal Group were used to test for possible correlations. After running preliminary analyses on the data, the fourth speaker (HN2) from the High Nasal Group was determined to be an outlier and was removed from the analysis. The nasality training was also compared with other training styles to determine the training's validity, and the ratings from the training styles did not differ significantly (See Appendix 4 for procedure used to test training validity and the results of this procedure).

Preliminary Analysis. Prior to analysis, ASQ scores and nasal ratings were determined to be normally distributed using skewness (ASQ=0.866; Nasal=0.682) and kurtosis values between -2 and 2 (ASQ=0.201; Nasal=-1.232), as well as by inspecting their QQ plots. Residual plots of ASQ scores and the nasal ratings showed that the assumptions of linearity and homogeneity of variance were met as well.

Power Analysis. To analyze the statistical power for this study, a sensitivity analysis was conducted using G*Power software (Faul et al., 2009). Given the sample size of 10 participants, this study has 80% power to detect a large-sized correlation ($r \geq 0.711$).

Results

The means and standard deviations of the nasal ratings and attributes were calculated for the High Nasal Group, the Low Nasal Group, and speakers HAQ and LAQ in all the variables tested (see Table 7). Correlations between all variables listed in Table 7 were calculated, as well as the speakers' ASQ scores (see Table 8).

Table 7

The Mean Ratings from 1 (Least Like the Speaker) to 6 (Most Like the Speaker) for the Descriptive Categories and the Mean Estimated Age for the High and Low Nasal Groups with Standard Deviations, as well as the Means for Participants HAQ and LAQ

Variables	High Nasal Group (*M*)	High Nasal Group (*SD*)	Low Nasal Group (*M*)	Low Nasal Group (*SD*)	HAQ (*M*)	LAQ (*M*)
Nasal	3.87	0.39	2.24	0.07	2.49	2.60
Cooperative	3.48	0.21	3.21	0.18	3.39	3.33
Friendly	3.60	0.28	3.09	0.16	3.60	3.28
Agreeable	3.37	0.22	3.15	0.21	3.40	3.32
Whiny	3.51	0.17	2.66	0.08	2.90	2.67
Irritating	3.47	0.18	2.93	0.18	2.99	2.96
Annoying	3.52	0.21	2.76	0.09	3.03	2.74
Masculine	4.05	0.08	4.40	0.18	4.37	4.63
Dominant	2.86	0.18	3.02	0.24	3.09	3.50
Feminine	2.18	0.05	1.79	0.07	2.03	1.72
Weak	3.43	0.21	3.21	0.15	3.15	3.05
TD	4.36	0.56	4.69	0.42	4.76	4.54
Est. Age	22.44	1.90	26.07	0.86	24.28	28.41

Note. HAQ=Participant with highest Autism Spectrum Quotient Score. LAQ=Participant with lowest Autism Spectrum Quotient Score. TD=Typically-Developing.

Table 8

Partial Correlations among Ratings, Controlling for Foreign Accent, Mean Volume and Length of Audio Files

Correlations	Nasal	Cooperative	Friendly	Agreeable	Whiny	Irritating	Annoying	Masculine	Dominant	Feminine	Weak	Age	TD
ASQ	.467	-.076	.289	-.224	.650	.623	.609	-.753	-.661	.737	.603	-.679	.334
Nasal	--	.642	.810*	.132	.944**	.828*	.926**	-.764*	-.793*	.877**	.715	-.818*	-.034
Cooperative		--	.905**	.597	.390	.162	.322	-.147	-.163	.471	.171	-.526	.125
Friendly			--	.597	.657	.427	.591	-.519	-.431	.781*	.364	-.821*	.249
Agreeable				--	.016	-.210	-.029	.010	.255	.265	-.458	-.321	.127
Whiny					--	.897**	.991**	-.868*	-.841*	.927**	.713	-.836*	-.045
Irritating						--	.934**	-.874**	-.977**	.788*	.824*	-.613	-.249
Annoying							--	-.881**	-.874**	.891**	.729	-.781*	-.124
Masculine								--	.888**	-.874**	-.764*	.834*	-.177
Dominant									--	-.760*	-.902**	.620	.115
Feminine										--	.803	-.969**	.768
Weak											--	-.562	.132
Age												--	-.448

Note. *Significant correlation with p-value<0.05. **Significant correlation with p-value≤0.01. ASQ=Autism Spectrum Quotient. TD=Typically-Developing.*

Research Question 1: Does having a more nasal voice accompany having more autistic-like traits?

The correlation between ASQ scores and nasality ratings was nonsignificant, r(5)=0.467, p-value=0.785. Table 7 shows the minimal difference between the mean nasal ratings of HAQ and LAQ. Analysis of the relationship between ASQ scores and nasality ratings of all 62 participants from the pilot study supports this nonsignificant correlation (r(60)=0.035, p-value=0.785, see Appendix 2).

Research Question 2: Will having more autistic-like traits be associated with specific socially-relevant variables?

ASQ Scores were not correlated with any social judgements (Table 8).

Research Question 3: Will having a more nasal voice be associated with specific socially-relevant variables?

As predicted, the negative social adjectives significantly increase as nasal ratings increase (Table 8). The Friendly ratings form a significant positive relationship with nasal ratings, with a larger positive trend observed between the Cooperative ratings and nasal ratings as well (Table 8).

The Feminine adjective was positively correlated with nasal ratings and both male-oriented adjectives were negatively correlated with nasal ratings (Table 8).

The nasal ratings were found to be negatively correlated with the estimated age of the speaker (Table 8). Typically-Developing ratings were not found to be significantly correlated with the other variables.

Discussion

Study II showed that having more autistic-like traits was not significantly correlated with nasality, any of the social or gender-oriented adjectives, the estimated age of the participants, or whether the participants were typically-developing. It is important to note that the sample size of 10 participants only had adequate statistical power to detect relationships with very large effect sizes. Considering this study is investigating a subclinical population, it is probable that the relationship between autistic-like traits and hypernasality would have a smaller effect size than this study is able to detect ($r \geq 0.711$). When comparing the correlation between autistic-like traits and hypernasality in Study II with the correlation between the 62 participants from the pilot study, autistic-like traits and hypernasality in Study II had a large nonsignificant correlation (r(5)=0.467, p-value=0.785), whereas the correlation from the pilot study was lower than a small effect size of $r = 0.10$ (see Appendix 2). A possible explanation for why the relationship between autistic-like traits and hypernasality from the pilot study and Study II were so different is that one of the four most nasal participants also had the third highest degree of autistic-like traits, which could have biased the results. Therefore, using the results from the 62 participants in the pilot study (Appendix 2), I conclude that autistic-like traits and hypernasality are not correlated. It is possible that some of the relationships between autistic-like traits and negative social and female-oriented adjectives would be significant in future studies with a greater sample size, considering the effect size needed to find significant correlations in this study was quite large. These findings suggest that autistic-like traits alone do not explain why people with ASD are rated with negative social adjectives and female-oriented adjectives. It is also important to note that because hypernasality is not correlated with autistic-like traits, Study II can investigate hypernasality's relationship with social perceptions independently from its connection with ASD.

People who were rated as sounding more nasal were rated as being whinier, more irritating, and more annoying, which supports Smerbeck's (2010) findings. However, people who were rated as sounding more nasal were also rated as being friendlier, and were marginally more likely to be rated as more cooperative, which contradicts the previous findings. Smerbeck (2010) indirectly provided an explanation for the lack of a relationship between hypernasality and positive social adjectives when she stated that "…most raters were likely aware that the study was supervised by a group of researchers who specialize in autism spectrum disorders and that the research would involve this population in some way" (p. 40). Because the raters most likely knew the research was related to a social communication disorder, they may have avoided providing strong ratings to the positive socially-relevant adjectives compared to the less nasal group.

The strong ratings between nasality and both the positive and negative socially-relevant adjectives could be that a nasal voice reminds the listener of a particular personality stereotype that includes the characteristic extroversion. Extraversion is characterized as being "sociable, fun-loving, affectionate, friendly, and talkative" (McCrae & Costa, 1987, p.87), which was supported by the friendly and positively trending cooperative ratings of the nasal participants in this study. However, people who score higher on extraversion have also been described as more likely to "[s]how [o]ff and [b]oast or be [i]nfantile and [d]isruptive" (Stewart et al., 1979, p. 19), which was supported by the negative social ratings as well as the lower estimated ages of the nasal participants in this study. Previous research has shown that people are able to attribute extraversion consistently to others with little information (Stewart, Powell, & Chetwynd, 1979,

p. 12), supporting the possibility that the raters consistently attributed adjectives associated with this extraverted stereotype to the nasal participants. This extraverted personality stereotype is perpetuated by popular cultural examples, such as Fran from *The Nanny* (Drescher & Jacobson, 1993), Janice from *Friends* (Bright, Kauffman, & Crane, 1994), and Steve Urkel, who was the example of a hypernasal speaker used in both Smerbeck (2010) and Study II. Contemporary popular culture characters that fit this stereotype can also be found on websites like YouTube, such as Miranda Sings (n.d.) and FЯED (n.d.). These popular cultural examples of hypernasal speakers are typically extraverted females or less masculine males, making it more likely for people to associate hypernasality with the characteristics of extraversion, and with more feminine- and less masculine-oriented adjectives. The existence of an extroverted cultural stereotype is supported by the findings of nasal participants being rated with both negative and positive socially-relevant adjectives, as well as being rated as more feminine, less masculine, and less dominant.

Chapter Four: Conclusions & Limitations

Conclusions

The main question driving these studies is whether having autistic-like traits in people from a neurotypical population is related to using and processing language, as well as the quality of their speech, in a similar way to people with ASD. Studies I and II showed that having more autistic-like traits, as measured by the ASQ, did not relate to receptive or expressive language ability, language complexity or hypernasality in a neurotypical population.

One possibility for why autistic-like traits were not related to language ability or hypernasality could be because the ASQ is limited as a measure of the degree of autistic-like traits in the neurotypical population. Baron-Cohen et al.'s (2001) finding that people score themselves lower on the ASQ than when their parents complete the ASQ on their behalf suggests that a portion of the participants in this study might have had more autistic-like traits than they reported. Measures of autistic-like traits like the Social Responsiveness Scale (Constantino & Gruber, 2005), where someone close to the participant gives the participant a score for his or her degree of autistic-like traits may be a more accurate way of measuring autistic-like traits than the ASQ. However, because of the difficulty associated with procuring these scores from the parents of this study's sample, the ASQ's self-reportability was necessary for this study.

A likely possibility for why autistic-like traits were not found to be related to the variables measured in these studies is that the participants from Studies I and II were primarily university students. While this research seems to cast doubt on ASD's spectrum designation, university students with more autistic-like traits are more likely to use and process language like their neurotypical peers than like people with an ASD diagnosis, as significant differences in language ability could restrict a person from both attending and completing postsecondary education. It is important to study ASD as a spectrum to determine what ASD-associated traits could contribute to the dysfunction experienced by having Autistic Spectrum Disorder, as well as whether these traits could negatively affect neurotypical individuals with these traits.

A strength of these studies is the focus on studying ASD as a spectrum. Using materials like the ASQ, as well as statistical methods that allow measuring autistic-like traits on a scale, is important to demonstrating how research could study the spectrum of ASD more accurately. Investigating ASD as a larger spectrum that includes neurotypical individuals with autistic-like traits also helps form a better understanding of what is contributing to ASD as a disorder. By highlighting when autistic-like traits and behaviours shift from individual differences to personal dysfunction, research can inform better interventions as well as prevention strategies that help people avoid experiencing the dysfunction associated with ASD.

One surprising finding from these studies is that people who are perceived as being more nasal are not only more likely to be assigned negative social judgements, but are also more likely to be perceived as being friendlier. This combination of positive and negative social perceptions could be the result of a cultural personality stereotype that incorporates the perception of a nasal voice. People who are perceived as being more nasal are also perceived as being more feminine and in turn less masculine, as well as being younger, which also adheres to the idea of a cultural personality stereotype.

Limitations & Future Directions

The biggest limitation of this study is that there are concerns about the ASQ as a measure of autistic-like traits in the general population (Kloosterman, Keefer, Kelley, Summerfeldt, & Parker, 2011; Lundquist & Lindner, 2017). This limitation was unavoidable because of the lack of research available to guide the spectrum perspective adopted in this study. Because the majority of ASD research uses a categorical diagnosis-no diagnosis framework, there are limited resources (i.e. measures, study designs) to inform investigating ASD as a full spectrum. While Baron-Cohen et al.'s (2001) ASQ is one measure being used to correct this issue, more research focusing on ASD as a spectrum is necessary for future researchers to emulate and expand on. Further research in this area would allow for a more complete understanding of how autistic-like traits present in neurotypical individuals, and would contribute to both the general knowledge of ASD as well as potential innovations in intervention.

One question regarding the ASQ is whether it is truly measuring autistic-like traits. Baron-Cohen et al.'s (2001) study tested the validity of the ASQ on hundreds of neurotypical participants and compared them with the ASQ scores of participants with ASD, and concluded that the ASQ was a valid measure of autistic-like traits in the neurotypical population. Kose et al. (2013) replicated the validity of the ASQ in the neurotypical population as well. However, some studies have shown that certain items from the ASQ do not seem to be contributing to the measurement of autistic-like traits. For instance, Kloosterman et al. (2011) suggested in their study that only 28 of the 50 items should be used, while Lundquist and Lindner (2017) suggested only 12 of the items need to be used. Future studies could use one of these revised scales to determine whether these scales provide a more accurate representation of the degree of autistic-like traits in the neurotypical population.

Another limitation of both studies in this thesis is the low statistical power due to small sample size. Future studies should include more participants to increase the statistical power and make it possible to determine if the nonsignificant relationships between autistic-like traits and language ability should be significant small relationships. To detect correlations with effect sizes of $r = 0.30$ and greater, future studies would need 82 participants to detect significant relationships 80% of the time. Future studies would need 84 if controlling for number of languages and age as was done in Study I, and 85 if controlling for foreign accent, and average length and volume of the audio files as was done in Study II.

Only using male participants is another limitation in Studies I and II. Even though females generally score lower than males on the ASQ (Baron-Cohen et al., 2001), it is important to have the lower end of a spectrum when measuring autistic-like traits and relationships from a spectrum perspective so that the study is able to reveal the complete picture behind these traits and relationships. It would be interesting to see if having more autistic-like traits would influence the responses of females in some way. Having females participate would also be useful because the sample of participants would be more representative of the spectrum of autistic-like traits in the typical population.

People with ASD are only rated with negative socially-relevant adjectives when compared to other speakers (Smerbeck, 2010), and not with the positive socially-relevant adjectives as observed in this study. It would be interesting for future research to investigate what it is about ASD that limits the positive socially-relevant perceptions observed in hypernasal speakers. Further research into the viability of a cultural stereotype that incorporates having a hypernasal voice would also be useful to both replicate and expand on findings from Study II.

References

American Psychiatric Association (2000). *Diagnostic and statistical manual of mental disorders* (4th ed., text rev.). Washington, DC: American Psychiatric Association.

American Psychiatric Association (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.). Arlington, VA: American Psychiatric Publishing.

Banney, R.M., Harper-Hill, K., & Arnott, W.L. (2015). The Autism Diagnostic Observation Schedule and narrative assessment: Evidence for specific narrative impairments in autism spectrum disorders. *International Journal of Speech-Language Pathology, 17,* 159-171.

Baron-Cohen, S. (2004). *The essential difference: Male and female brains and the truth about autism.* New York: The Perseus Books Group.

Baron-Cohen, S., Wheelwright, S., Skinner, R., Martin, J., & Clubley, E. (2001). The Autism-Spectrum Quotient (AQ): Evidence from Asperger syndrome/high functioning autism, males and females, scientists and mathematicians. *Journal of Autism and Developmental Disorders, 31,* 5-17.

Beattie, G., & Shovelton, H. (1999). Mapping the range of information contained in the iconic hand gestures that accompany spontaneous speech. *Journal of Language and Social Psychology, 18,* 438-462.

Bettelheim, B. (1967). *The empty fortress: Infantile autism and the birth of the self.* New York: Free Press.

Birdwhistell, J.L. (2016). Friendship and autism: A multiple case study ecological exploration of student, teacher, and peer factors relating to the social network and feelings of loneliness of students with Autism Spectrum Disorder in general education elementary classrooms (Doctoral dissertation). Retrieved from ProQuest dissertations & theses global. (3718285)

Bloom, K., Moore-Schoenmakers, K., & Masataka, N. (1999). Nasality of infant vocalizations determine gender bias in adult favorability ratings. *Journal of Nonverbal Behavior, 23,* 219-236.

Bower, B. (1986). Inside the autistic brain. *Science News, 130,* np.

Bright, K.S., Kauffman, M., & Crane, D. (Producers). (1994). *Friends* [Television series]. Burbank, CA: National Broadcasting Company.

Capps, L., Losh, M., & Thurber, C. (2000). "The frog ate the bug and made his mouth sad": Narrative competence in children with autism. *Journal of Abnormal Child Psychology, 28,* 193-204.

Christensen, D.L., Baio, J., Van Naarden Braun, K., Bilder, D., Charles, J., Constantino, J.N., … Yeargin-Allsopp, M. (2016). Prevalence and characteristics of Autism Spectrum Disorder among children aged 8 years — Autism and Developmental Disabilities Monitoring Network, 11 Sites, United States, 2012. *Surveillance Summaries, Morbidity and Mortality Weekly Report.* Centers for Disease Control and Prevention

Christensen, L., Hutman, T., Rozga, A., Young, G.S., Ozonoff, S., Rogers, S.J., … Sigman, M. (2010). Play and developmental outcomes in infant siblings of children with autism. *Journal of Autism and Developmental Disorders, 40,* 946-957.

Cleland, J., Gibbon, F.E., Peppé, S.J.E, O'Hare, A., & Rutherford, M. (2010). Phonetic and phonological errors in children with high functioning autism and Asperger syndrome. *International Journal of Speech-Language Pathology, 12,* 69-76.

Constantino, J.N., & Gruber, C.P. (2005). Social responsiveness scale: Manual. Los Angeles, CA: Western Psychological Services.

Crawford, S. (2016). Increased autism incidence: Is there a single cause? *Journal of Child & Adolescent Behavior, 4,* 1-6.

Drescher, F. & Jacobson, P.M. (Producers). (1993). *The Nanny* [Television series]. Culver City, CA: Columbia Broadcasting System.

Dunn, L.M., & Dunn, I.M. (1997). Peabody Picture Vocabulary Test, Third Edition. *Journal of Psychoeducational Assessment, 16,* 334-338.

Eigsti, I., Bennetto, L., & Dadlani, M. (2007). Beyond pragmatics: Morphosyntactic development in autism. *Journal of Autism and Developmental Disorders, 37,* 1007-1023.

Faul, F., Erdfelder, E., Buchner, A., & Lang, A.-G. (2009). Statistical power analyses using G*Power 3.1: Tests for correlation and regression analyses. *Behavior Research Methods*, *41*, 1149-1160.

FЯED (n.d.). Home [YouTube channel]. Retrieved from https://www.youtube.com/user/Fred

Frith, U. (1991). *Autism and Asperger syndrome*. Cambridge: Cambridge University Press.

Kargas, N., López, B., Morris, P., & Reddy, V. (2016). Relations among detection of syllable stress, speech abnormalities, and communicative ability in adults with Autism Spectrum Disorders. *Journal of Speech, Language & Hearing Research, 59,* 206-215.

Klatter-Folmer, J., Kolen, E., van Hout, R., & Verhoeven, L. (2006). Language development in deaf children's interactions with deaf and hearing adults: A Dutch longitudinal study. *Journal of Deaf Studies and Deaf Education, 11,* 238-251.

Kloosterman, P.H., Keefer, K.V., Kelley, E.A., Summerfeldt L.J., & Parker, J.D.A. (2011). Evaluation of the factor structure of the Autism-Spectrum Quotient. *Personality and Individual Differences, 50,* 310-314.

Kose, S., Bora, E., Erermis, S., Özbaran, B., Bildik, T., & Aydin, C. (2013). *Psychiatry & Clinical Neurosciences, 67,* 20-27.

Lee, M. (Writer), & Davis, A. (Director). (1969a). In the pink of the night [Television series episode]. In D.H. DePatie & F. Freleng (Producers), The pink panther show. Burbank, CA: DePatie-Freleng Enterprises.

Lee, M. (Writer), & Davis, A. (Director). (1969b). Jet pink [Television series episode]. In D.H. DePatie & F. Freleng (Producers), The pink panther show. Burbank, CA: DePatie-Freleng Enterprises.

Losh, M., & Capps, L. (2003). Narrative ability in high-functioning children with autism or Asperger's Syndrome. *Journal of Autism and Developmental Disorders, 33,* 239-251.

Lundquist, L., & Lindner, H. (2017). Is the Autism-Spectrum Quotient a valid measure of traits associated with the autism spectrum? A Rasch validation in adults with and without autism spectrum disorders. *Journal of Autism and Developmental Disorders, 47,* 2080-2091.

MacDonald, J., & Ahearn, W.H. (2015). Teaching observational learning to children with autism. *Journal of Applied Behavior Analysis, 48,* 800-816.

Maljaars, J., Noens, I., Scholte, E., & van Berckelaer-Onnes, I. (2012). Language in low-functioning children with Autistic Disorder: Differences between receptive and expressive skills and concurrent predictors of language. *Journal of Autism & Developmental Disorders, 42,* 2181-2191.

Masataka, N., & Bloom, K. (1994). Acoustic properities that determine adults' preferences for 3-month-old infant vocalizations. *Infant Behavior and Development, 17,* 461-464.

McCrae, R.R., & Costa, P.T. (1987). Validation of the five-factor model of personality across instruments and observers. *Journal of Personality and Social Psychology, 52,* 81-90.

McFadden, K., Hepburn, S., Winterrowd, E., Schmidt, G., & Rojas, D. (2012). Abnormalities in gamma-band responses to language stimuli in first-degree relatives of children with Autism Spectrum Disorder: An MEG study. *BMC Psychiatry, 12,* 213-230.

Miller, T.L., Boyett, R.L., Bickley, W., Warren, M., & Duclon, D.W. (Producers). (1989-1998). *Family matters* [Television series]. Culver City & Burbank, CA: American Broadcasting Company & Columbia Broadcasting System.

Miranda Sings (n.d.). Home [YouTube channel]. Retrieved from https://www.youtube.com/user/mirandasings08

Mizuno, A., Liu, Y., Williams, D.L., Keller, T.A., Minshew, N.J., & Just, M.A. (2011). The neural basis of deictic shifting in linguistic perspective-taking in high functioning autism. *Brain: A Journal of Neurology, 134,* 2422-2435.

Moore, D.J., & Shiek, D.A. (1971). Toward a theory of early infantile autism. *Psychological Review, 78,* 451-456.

Ozonoff, S., Young, G.S., Belding, A., Hill, M., Hill, A., Hutman, T., … & Iosif, A. (2014). The broader autism phenotype in infancy: When does it emerge? *Journal of the American Academy of Child & Adolescent Psychiatry, 53,* 398-407.

Paul, R., Chawarska, K., Cicchetti, D., & Volkmar, F. (2008). Language outcomes of toddlers with Autism Spectrum Disorders: A two year follow-up. *Autism Research, 1,* 97-107.

Peña, M., & Melloni, L. (2012). Brain oscillations during spoken sentence processing. *Journal of Cognitive Neuroscience, 24,* 1149-1164.

Perkins, M.R., Dobbinson, S., Boucher, J., Bol, S., & Bloom, P. (2006). Lexical knowledge and lexical use in autism. *Journal of Autism & Developmental Disorders, 36,* 795-805.

Qualtrics (2005). Qualtrics (Version Jan-Aug 2017) [Software]. Utah: Provo. Available from www.qualtrics.com

Rimland, B. (1964). *Infantile autism: The syndrome and its implications for a neural theory of behavior.* New York: Appleton-Century-Crofts.

Scott, B. (2003). *The Gunning's Fog Index (or FOG) Readability Formula*. Retrieved from www.ReadabilityFormulas.com

Silverman, C. (2012). *Understanding autism: Patients, doctors, and the history of a disorder*. Princeton: Princeton University Press

Smerbeck, A.M. (2010). Voice abnormality in boys with high-functioning Autism Spectrum Disorders: Diagnostic and psychosocial implications (Doctoral dissertation). Retrieved from ProQuest dissertations & theses. (3423524)

Smith, V., Mirenda, P., & Zaidman-Zait, A. (2007). Predictors of expressive vocabulary growth in children with autism. *Journal of Speech, Language, and Hearing Research, 50,* 149-160.

Smith Gabig, C. (2008). Verbal working memory and story retelling in school-age children with autism. *Language, Speech, and Hearing Services in Schools, 39,* 498-511.

Stewart, R.A., Powell, G.E., & Chetwynd, S.J. (1979). *Person perception and stereotyping.* England: Saxon House.

Watts, G. (2014). Lorna Wing. *The Lancet, 384,* 658.

Whitehouse, A.J.O., & Bishop, D.V.M. (2008). Do children with autism 'switch off' to speech sounds? An investigation using event-related potentials. *Developmental Science, 11,* 516-524.

Williams, B.L. (2015). Propinquity as a barrier to friendship development for children with autism (Doctoral dissertation). Retrieved from ProQuest dissertations & theses global. (3722640)

Appendix 1

Abstract Phenomena Q&A Task-Questions

1. How do you make a friend?
2. How does lightning work?
3. How do we have access to Internet?
4. How do you know that two people are attracted to each other?
5. How does a plane get up in the air and stay there?
6. How would you prepare for a job interview?
7. Have you ever thought you were just about to die? What happened?
8. How does a clock work?
9. When you meet someone first time, how would you decide how introverted or extroverted they are?
10. Has someone ever been really angry with you? What did you do?
11. How does a pen work?
12. Where does wind come from?
13. If you met a roomful of strangers for the first time, how would you remember their names?
14. How does the metric system work?
15. If one of your friends was in a romantic relationship with someone who was really not good for them, how could you tell them?
16. How do you study to ace a test?
17. Have you ever been treated unfairly? What happened?
18. Is there something you like to cook? How do you prepare it?

Appendix 2

Experimental Procedure & Script – Pilot Study

Methods

Participants. The sample of speakers used in the audio files consisted of 62 of the 66 adult males from Study I (age: mean=19.50 years, S.D.=1.67). Four of the males were excluded for not saying any of the target words used from Study I's tasks.

Table 9

Means, Standard Deviations, and Ranges of the Age, ASQ Scores, and Nasality Ratings of the Participants in each Faculty

	Arts (*n*=16) *M* (*SD*, Range)	Science (*n*=42) *M* (*SD*, Range)	Other (*n*=4) *M* (*SD*, Range)	Total *M* (*SD*, Range)
Age	20.44 (2.00, 18-24)	19.07 (1.35, 18-24)	20.25 (1.89, 19-23)	19.50 (1.67, 18-24)
ASQ	18.31 (7.74, 10-35)	18.88 (5.95, 7-32)	15.00 (2.58, 12-18)	18.48 (6.31, 7-35)
Nasality	3.11 (0.59, 2.18-4.31)	2.86 (0.31, 2.30-3.56)	3.27 (0.49, 2.56-3.68)	2.95 (0.43, 2.18-4.31)

Note. *ASQ=Autism Spectrum Quotient*

Materials. Nasal Training Sentences – The following four sentences were chosen using guidelines from Smerbeck (2010), which were to avoid using n's and m's and to keep the semantic meaning of the sentences neutral. The first sentence was the example sentence listed by Smerbeck (2010) in her paper.

– The shirt was blue.

– The dog walked up the block.

– The flower grew tall.

– The cat licked its paw.

Nasality Training Audio Clips – Four male volunteers, who were acquaintances of the experimenter, were each recorded saying 10 different words for a total of 40 distinct words. They said each word three times and were asked to make one of the recordings using a nasal voice, and to make the other two recordings distinct from one another without being more or less nasal in either of them. This distinction was made to avoid the other two recordings from sounding identical. The 40 words were then sorted into four sets, while ensuring that words from the same speaker did not appear consecutively, and that there were at least two words from each speaker in each set. Words chosen for the nasal discrimination task were chosen because they were either semantically neutral (e.g. circle) or dichotomous (e.g. hot/cold) and did not contain any *n*'s or *m*'s (see Appendix 5 for full list and order in which training words appeared to each participant).

Measures & Procedures. We recruited 22 adults (63.6% female, mean=18.9 years) from the undergraduate research participation pool to rate the nasality of the participants from Study I. The raters were native English speakers. The raters were randomly assigned to one of two nasality rating groups. Eleven raters (72.7% female) rated 40 of the 62 participants in the First Rater Group, and the other eleven raters (54.5% female) rated the remaining 22 participants, as well as 18 of the same participants from the first group in the Interrater Group to determine interrater reliability of both groups separately (of 22 participants) and together (of the 18 participants).

Nasality Rater Training – The training task took at most fifteen minutes to ensure the study adhered to the one-hour time-slot allotted to each rater, with the first few minutes being used to expose the raters to examples of nasality. Raters were asked if they had heard of hypernasality before, with following script used to explain hypernasality: “You know how your voice can sound different when you are stuffed up or if you plug your nose and try talking? The difference in your voice is caused by excess air in the nasal cavity, which causes your voice to sound more nasal. People who sound nasal all the time without having a plugged nose are considered to be hypernasal” (See Pilot Study Script for full script used by experimenter). The two nasality rating groups followed the same training procedure as in Smerbeck (2010). They were introduced to a hypernasal speaker using a video compilation of Steve Urkel from *Family Matters* (F, Boyett, Bickley, Warren, & Duclon, 1989-1998). Then the trainer said the Nasal Training Sentences using a nasal voice, and the rater said these sentences using nasal voice as well.

The remainder of the training involved completing a nasality discrimination task. Each question from the nasality discrimination task had three of the same words on a screen (Fig. 4), and when the play button underneath the word was clicked the corresponding nasality training audio clip would play. The rater’s task was to choose which of the three words was the nasalized word within a 15-second time limit, which was implemented in order to ensure the training did not take longer than 15 minutes. Each question had a 15 second countdown clock to familiarize the raters to the format of the Nasality Judgement Task. There were four sets of ten questions, and the nasal audio files from each word were randomly assigned as either Word 1, Word 2, or Word 3 (with Word being replaced by the word said in the audio file). If the rater scored 90% or higher on the first set, then the rater's training ended and he or she continued to the Nasality Judgement Task. If the rater scored lower than 90%, then he or she continued to the second set. The rater continued completing the four training sets until he or she had either attained an overall average of ≥90% accuracy or until all four sets were completed. The scores and the number of sets completed were recorded for each rater. Once raters completed training they completed the Nasality Judgement Task.

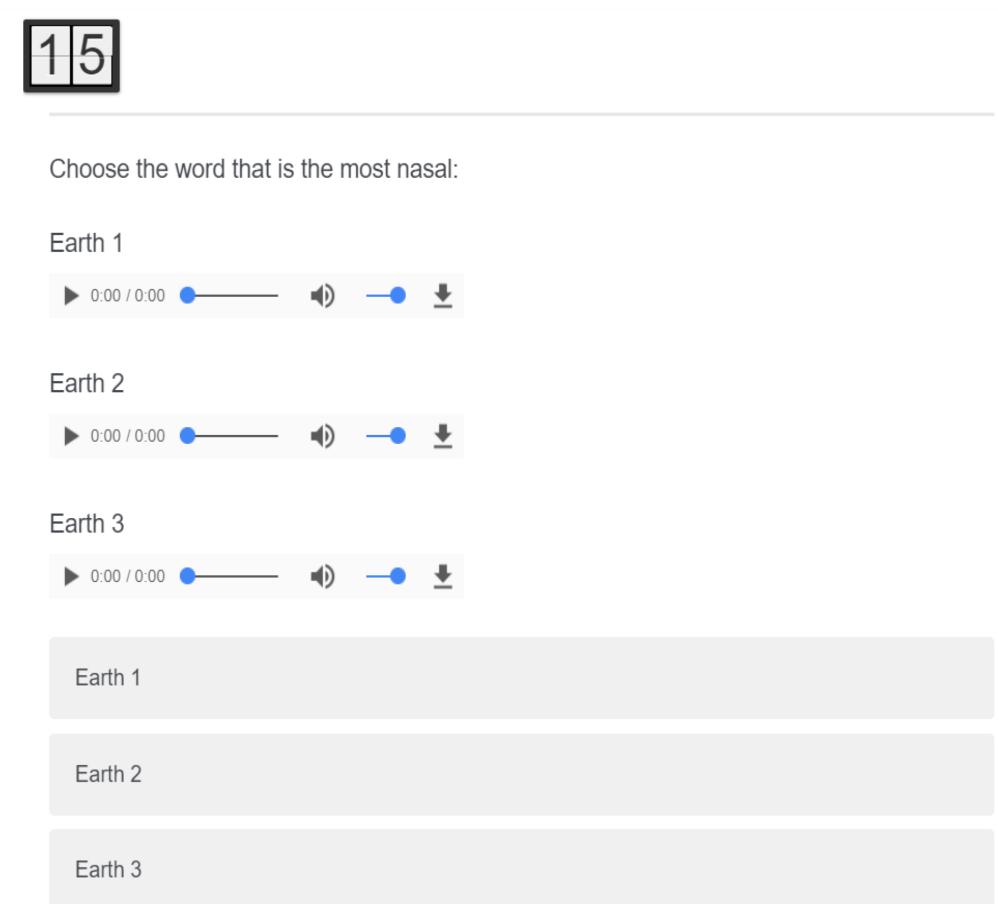

Fig. 4: Question taken from Nasality Training Task 1 using Qualtrics.com.

Nasality Judgement Task – Each page displayed a word with its corresponding audio file and a 6-point Likert scale to rate nasality (1 being not nasal at all and 6 being very nasal). Once the rater chose to go to the next page, he or she could no longer return to the previous page. Each page had a 7-second countdown clock where reaching zero seconds switched to the next page (see Fig. 1).

The Nasality Rater Training and the Nasality Judgement Task were administered using Qualtrics survey software (Qualtrics, Provo, UT).

Coding & Analysis. Out of 5040 rating scales (240 scales per person, with a total of 21 people participating) 29 questions were left unanswered (0.58% missing data). The Multiple Imputation function in SPSS was used to estimate the missing values. Twenty imputations were generated and the estimations pooled to determine the average nasal rating for each participant.

Interrater reliability was first calculated separately between the First Rater Group and the Interrater Group using the One-Way Random Consistency Intraclass Correlations in SPSS. The First Rater Group had a Cronbach's alpha of 0.976, and the Interrater Group had an alpha of 0.984. The ratings for the 18 speakers rated by both groups were then tested using the Two-way Random Consistency Intraclass Correlations in SPSS, which had an alpha of 0.96.

Preliminary Analysis. Prior to analysis, ASQ scores and nasal ratings were determined to be normally distributed using skewness (ASQ=0.631; Nasal=1.037) and kurtosis values between -2 and 2 (ASQ=-0.252; Nasal=1.564), as well as by inspecting their QQ plots. Residual plots of ASQ scores and the nasal ratings showed that the assumptions of linearity and homogeneity of variance were met as well.

Power Analysis. To analyze the statistical power for this study, a sensitivity analysis was conducted using G*Power software (Faul et al., 2009). Given the sample size of 62 participants, this study has 80% power to detect a medium-sized correlation ($r \geq 0.340$).

Results

ASQ scores and nasal ratings were not significantly correlated (r(60)=0.035, p-value=0.785).

Pilot Study Script

- Ask the student to read and sign the consent form
- Have the student fill out the demographic questionnaire (you will assign them their participant code here)
- Open document with links to Qualtrics questionnaires and training materials
- **Nasality Training Session**

Experimenter: Today we are going to be listening to audio files to determine how nasal people sound. Have you heard about hypernasality before?

If answers yes, kind of, maybe some sort of affirmative: Excellent, we will have you watch a short video of someone speaking with a hypernasal voice so that it is fresh in your mind for the next activity.

If answers no, I don't know, some sort of noncommittal response: That's fine. You know how your voice can sound different when you are stuffed up or if you plug your nose and try talking? The difference in your voice is caused by excess air in the nasal cavity, which causes your voice to sound more nasal. People who sound nasal all the time without having a plugged nose are considered to be hypernasal. (Now continue with what is written for the "yes" answer)

After the video I will say some sentences in a hypernasal voice, and I'd like you to repeat them after me as nasally as you can. If you can hear and feel how your own voice sounds when speaking nasally, it should help to further familiarize yourself with how a nasal voice should sound when you are rating the audio files. Does that sound alright to you?

If yes, continue by clicking the link underneath "Nasality Training Video". If no, then ask if they want to continue with just the experimenter saying the sentences or if they would rather not participate. If they say experimenter only, then say the sentences without having the rater repeat back (but make sure you mark this on their demographic questionnaire so that we know they did not participate in this part of the training!). If they say they would rather not participate then tell them you have an alternative assignment they can work on for the research credit.

- **Sentences to Produce in a Nasal Voice**

1. The shirt was blue.
2. The dog walked up the block.
3. The flower grew tall.
4. The cat licked its paw.

- **Nasality Training Task**

1. Click link underneath "Nasality Training Task 1"
2. Explain to rater that there will be ten questions each with three audio files of a word, and they need to choose which word is the most nasal. Tell them there will be a 15-second countdown timer, so they need to answer as quickly as they can. Also tell them once the "see experimenter" page appears to come get you from the other room.
3. Once rater comes to collect you, press the next button on the screen (make sure the rater cannot see the screen). The rater's score will appear.

4. If the rater scores 9/10 or more move on to the link underneath “Nasality Study Task 1” (or if the previous person completed “Nasality Study Task 1” than choose “Nasality Study Task 2”, make sure to write whether the person did Task 1 or 2 on their demographic questionnaire!). If they score less than proceed to Nasality Training Task 2 and explain that this will be the same format as the previous task.
5. After the rater has completed the second training task, check their score and add it to their previous score. If the total score is 18/20 or more than move on to Nasality Study Task. If the score is still lower, then move on to Nasality Training Task 3.
6. If score is 27/30 or more than move on to Nasality Study Task. If not, then move to Nasality Training Task 4.
7. If score is 36/40, move on to Nasality Study Task. If it is lower, write the total score out of 40 on the back of the rater’s demographic questionnaire and continue to the Nasality Study Task.

- **Nasality Study Task 1 (or 2**)

1. Click link underneath “Nasality Study Task 1” (or “Nasality Study Task 2” if previous rater completed “Nasality Study Task 1”)
2. Explain to rater that their will be a number of questions with an audio file and a scale rating how nasal the speaker sounds scored from 1 to 6, with 1 being not nasal at all and 6 being very nasal. Let them know that there will be a 7 second timer, so we are only looking for their first “gut instinct” and to make sure they answer before the time runs out. Also let them know there will be a progress bar visible for them to see their overall progress, and to come and get the experimenter when the “see experimenter” page appears.

3. When the rater comes to collect you, you will give them the debrief form to read and sign. If they have any questions, direct them to email me (my email is on the form).
4. If the rater wants to stop before the test is over then let the test cycle through and it will give a non-response for the remaining questions (make sure to mark this on the back of the demographic questionnaire).

Appendix 3

Experimental Procedure & Script – Study II

Method

Measures & Procedures. We recruited 39 adults (48.7% female, mean=20.8 years) from the undergraduate research participation pool to be raters of nasality and the social and gender-specific adjectives. The raters were native English speakers. Raters were randomly assigned to one of three nasality training conditions (Video Condition N=15, Audio Condition N=14, Sentences Only Condition N=10, see Appendix 4).

Nasality Rater Training – The training task took at most fifteen minutes, with the first few minutes being used to expose the raters to examples of hypernasal speakers. The same explanation of hypernasality from Study I was used in the training for Study II (See Appendix 2 for full script used by experimenter):

Coding & Analysis. Sex of the rater, and the order the two tasks were completed by the raters were controlled for as possible confounding variables by ensuring that as close to half of the raters were from each sex, and by counter-balancing the order of the two tasks.

Sex of the rater was not found to be a significant confounding factor (N=19 Females, 20 Males). However, there were significant differences between the ratings of male and female raters for specific categories. The ratings between males and females for the *Masculine* adjective rating were significantly different for the audio files of all ten participants. Women were more likely to give the participants a higher *Masculine* rating. The ratings between males and females for the *Feminine* adjective rating were significantly different for the audio files of five of the ten participants. Women were more likely to give the participants a less feminine rating than men. The estimated *Age* rating was significantly different for the audio files of three of the ten participants as well, with women being more likely to estimate the three participants as being older.

The task to be completed first by the rater was counterbalanced to account for any possible confounding effects (Nasality Task N=19, Attributes Task N=20). Correlating task order and using partial correlations that treated task order as a confounding variable revealed the task completed first was no a significant confounding factor.

Out of 30,420 questions (780 questions per person, with a total of 39 people participating) 369 questions were left unanswered (1.21% missing data). The Multiple Imputation function in SPSS was used to estimate the missing values. Twenty imputations were generated and the estimations pooled to determine the mean rating of each adjective and the mean estimated age for each participant.

Study II Script

- Ask the student to read and sign the consent form
- Have the student fill out the demographic questionnaire (you will assign them their rater code here)

Alternate equally between Conditions 1, 2, and 3. Make sure to include the condition number on the back of the rater's demographic questionnaire. Also alternate equally between doing the Nasality Training and Study Tasks first and the Attributes Task first, and include which task was completed first on the back of the demographic questionnaire.

- **Nasality Training Condition 1**

Experimenter: Today we are going to be listening to audio files to determine how nasal people sound ("Now, you will be listening to the same audio files as before, only this time you will be rating the speakers on how nasal they sound" if this is after Attributes Task). Have you heard about hypernasality before?

If answers yes, kind of, maybe some sort of affirmative: Excellent, we will have you watch a short video of someone speaking with a hypernasal voice so that it is fresh in your mind for the next activity.

If answers no, I don't know, some sort of noncommittal response: That's fine. You know how your voice can sound different when you are stuffed up or if you plug your nose and try talking? The difference in your voice is caused by excess air in the nasal cavity, which causes your voice to sound more nasal. People who sound nasal all the time without having a plugged nose are considered to be hypernasal. (Now continue with what is written for the "yes" answer)

After the video I will say some sentences in a hypernasal voice, and I'd like you to repeat them after me as nasally as you can. If you can hear and feel how your own voice sounds when speaking nasally, it should help to further familiarize yourself with how a nasal voice should sound when you are rating the audio files. Does that sound alright to you?

If yes, continue by clicking the link underneath "Nasality Training Video". If no, then ask if they want to continue with just the experimenter saying the sentences or if they would rather not participate. If they say experimenter only then say the sentences without having the rater repeat back (but make sure you mark this on their demographic questionnaire so that we know they did not participate in this part of the training!). If they say they would rather not participate then tell them you have an alternative assignment they can work on for the research credit.

- **Nasality Training Condition 2**

Experimenter: Today ("Now" if this is after Attributes Task) we are going to be listening to audio files to determine how nasal people sound. Have you heard about hypernasality before?

If answers yes, kind of, maybe some sort of affirmative: Excellent, we will have you listen to a short audio clip of someone speaking with a hypernasal voice so that it is fresh in your mind for the next activity.

If answers no, I don't know, some sort of noncommittal response: That's fine. You know how your voice can sound different when you are stuffed up or if you plug your nose and try talking? The difference in your voice is caused by excess air in the nasal cavity, which causes your voice to sound more nasal. People who sound nasal all the time without having a plugged nose are considered to be hypernasal. (Now continue with what is written for the "yes" answer)

After the audio clip I will say some sentences in a hypernasal voice, and I'd like you to repeat them after me as nasally as you can. If you can hear and feel how your own voice sounds when speaking nasally, it should help to further familiarize yourself with how a nasal voice should sound when you are rating the audio files. Does that sound alright to you?

If yes, continue by clicking the link underneath "Nasality Training Audio Clip". If no, then ask if they want to continue with just the experimenter saying the sentences or if they would rather not participate. If they say experimenter only then say the sentences without having the rater repeat back (but make sure you mark this on their demographic questionnaire so that we know they did not participate in this part of the training!). If they say they would rather not participate then tell them you have an alternative assignment they can work on for the research credit.

- **Nasality Training Condition 3**

Experimenter: Today ("Now" if this is after Attributes Task) we are going to be listening to audio files to determine how nasal people sound. Have you heard about hypernasality before?

If answers yes, kind of, maybe some sort of affirmative: Excellent, I am going to say some sentences in a hypernasal voice so that it is fresh in your mind for the next activity. I'd also like you to repeat them after me as nasally as you can. If you can hear and feel how your own voice sounds when speaking nasally, it should help to further familiarize yourself with how a nasal voice should sound when you are rating the audio files. Does that sound alright to you?

If answers no, I don't know, some sort of noncommittal response: That's fine. You know how your voice can sound different when you are stuffed up or if you plug your nose and try talking? The difference in your voice is caused by excess air in the nasal cavity, which causes your voice to sound more nasal. People who sound nasal all the time without having a plugged nose are considered to be hypernasal. (Now continue with what is written for the "yes" answer)

If yes, continue. If no, then ask if they want to continue with just the experimenter saying the sentences or if they would rather not participate. If they say experimenter only then say the sentences without having the rater repeat back (but make sure you mark this on their demographic questionnaire so that we know they did not participate in this part of the training!). If they say they would rather not participate then tell them you have an alternative assignment they can work on for the research credit.

- **Sentences to Produce in a Nasal Voice**

1. The shirt was blue.
2. The dog walked up the block.
3. The flower grew tall.
4. The cat licked its paw.

See **Nasality Study Task 1 (or 2)** for the procedure for Part 2.

Attributes Study Task

Experimenter: For the first task, you will be listening to some audio files and rating the speaker on a variety of traits ("For the second task, you will be listening to the same audio files, only this time you will be rating the speaker on a variety of traits." if after Nasality Study Task). The rating scales will be from 1 to 6, with 1 being not like the speaker at all and 6 being very much like the speaker.

Let them know that there will be a 30-second timer, so we are only looking for their first "gut instinct" and to make sure they answer before the time runs out. Also let them know there will be a progress bar visible for them to see their overall progress, and to come and get the experimenter when the "see experimenter" page appears.

If they seem concerned about "judging" the speaker, assure them that their responses will not reflect on them, but that we are looking for gut instincts based on different vocal characteristics.

Appendix 4

Effect of Training Style

Research has shown that people's accuracy in perception of events improves when receiving both visual and auditory input as opposed to auditory input alone (Beattie & Shovelton, 1999). This effect could have helped increase the interrater reliability in Smerbeck's (2010) study, where during the nasal training the raters were introduced to the hypernasal speaker Steve Urkel from *Family Matters* (Miller et al., 1989-1998), and Smerbeck's final nasality ratings were found to be highly reliable across raters. The purpose of this study was to determine if the modality used to introduce listeners to a hypernasal speaker influences the accuracy and social judgements the listener makes when rating subsequent nasal speakers.

Research Question: Does the type of training change nasality and attributes judgements?

In Study I raters watched a video compilation of Steve Urkel as an example of a hypernasal speaker. I hypothesized that people who receive both visual and auditory input of a hypernasal speaker will be able to discern highly nasal speakers more reliably than people who only receive auditory input. Beattie and Shovelton's (1999) findings suggest that visual input could be an important factor to the success of the nasality training in this study, as supported by Smerbeck's (2010) highly reliable nasality ratings across raters. Using a video clip of Steve Urkel, I hypothesized that people in the training group that includes the video will have higher interrater reliability than either the group with only the audio from the Steve Urkel video or the group who is not exposed to either the video or the audio, who will act as the control group. For this study I also investigated whether giving the participant both visual (how the speaker looks, behaves) and auditory cues (the nasal voice) during the training session will relate to people's social perception judgements of highly nasal speakers. Because of the stereotyping of Steve Urkel's character, I expected that people who watched the training video will have rated the nasal speakers with more negative social attributes than the other two training groups, as well as more female-stereotyped and fewer male-stereotyped attributes, and that the people who only listened to the audio from the training video will have rated the nasal speakers with more negative social attributes and female-stereotyped attributes, and fewer male-stereotyped attributes than the training group who are not exposed to either the video or audio clip.

Methods

Participants. We recruited 39 adults (48.7% female, mean=20.8 years) from the undergraduate research participation pool to be raters of nasality and the social and gender-specific adjectives. The raters were native English speakers. Raters were randomly assigned to one of three nasality training conditions (Video Condition N=15, Audio Condition N=14, Sentences Only Condition N=10).

Materials. Audio Clips – See Study II for explanation of audio clips.

Nasal Training Sentences – The same four sentences that were used in Study I and in all three nasal training conditions in Study II.

The Nasality Rater Training, the Nasality Judgement Task, and the Attributes Judgement Task were administered using Qualtrics survey software (Qualtrics, Provo, UT).

Measures & Procedures. The procedure used in Study III is identical to Study II, as the data used for both studies was collected during Study II. These data are discussed separately to account for the shift from the speakers as the participants under observation to the raters as the new participants (see Study II & Appendix 3 for full description of the procedure):

- Video Condition: The first group of 15 participants followed the same training procedure as in Smerbeck (2010) and Study I; they watched a video clip of a hypernasal speaker

(Steve Urkel from *Family Matters*, Miller et al., 1989-1998). Then the trainer said the Nasal Training Sentences using a nasal voice, and the participant said these sentences using nasal voice as well:

- Audio Condition: The second group of 14 participants listened to the audio clip of the video from Video Condition. The trainer said the Nasal Training Sentences using a nasal voice, and the participant attempted these sentences using nasal voice as well.
- Sentences Only Condition: The third group of 10 participants only completed the training portion where the trainer said the Nasal Training Sentences using a nasal voice, and the participant attempted these sentences using nasal voice as well.

Coding & Analysis. Interrater reliability for each of the three training conditions was calculated using Two-Way Random Consistency Intraclass Correlations in SPSS. The average measures Intraclass correlation coefficient provided by this model was then multiplied by 100 to determine the percentage of interrater reliability.

Results

Training Conditions. The reliability of the nasality ratings differed slightly by training condition, with the Video Condition's average reliability at 86.8%, the Audio Condition at 88.6%, and the Sentences Only Condition at 90.4%.

The means and standard deviations were calculated for each variable in each of the three training conditions (Table 10).

Table 10

The Mean Ratings from 1 (Least Like the Speaker) to 6 (Most Like the Speaker) for the Descriptive Categories, and the Mean Estimated Age from each Training Condition.

Conditions	Video	Audio	Sentences
Nasal	2.90	2.97	2.99
Cooperative	3.05	3.20	3.58
Friendly	3.22	3.23	3.28
Agreeable	3.08	3.22	3.20
Whiny	3.12	2.89	2.94
Irritating	3.19	2.95	3.14
Annoying	3.16	2.96	3.06
Masculine	4.50	4.08	4.06
Dominant	3.11	2.78	2.87
Feminine	1.71	1.92	1.57
Weak	2.93	2.90	2.74
TD	4.31	4.12	4.50
Est. Age	26.71	28.26	26.69

Note. TD=Typically-Developing

Research Question: Does the type of training change nasality and attributes judgements?

The ratings of the participants from the three conditions were compared using ANOVAs (Table 9) to determine whether or not the training methods would influence participant ratings. While the training condition was not found to influence nasality ratings or attributes ratings, when separate ANOVAs were done for each speaker in each category one participants from the Sentences Only Condition were more likely to rate speaker LN3 as being more cooperative than participants in the Audio Condition.

Discussion

Interrater reliability differed slightly by training condition, with the participants who were not exposed to either the training video or audio clip being more reliable than the participants from either the Audio or Video Condition, and the participants from the Audio Condition being more reliable than the participants from the Video Condition. However, all training conditions had high interrater reliability (≥86.8%). The only significant difference observed between training conditions regarding the descriptive adjectives was from the cooperative ratings of speaker LN3, where participants in the condition that were not exposed to either the training video or audio clip were more likely to rate those speakers as being more cooperative than the participants who listened to the training audio clip. These differences are not convincing findings, as only one out of the ten speakers differed on one of the thirteen traits between the three conditions, and so these differences are most likely due to Type I Error. If these were meaningfully significant differences, they could support the idea of the existence of the extroverted personality stereotype mentioned previously, because exposure to the friendly and outgoing hypernasal speaker in the video could present a dichotomy where if the speaker being rated does not fit that personality, they must be the *opposite*, and therefore less cooperative.

Conclusion

A likely possibility for the small effect of training condition on the ratings is that the nasal-voiced extroverted personality stereotype has been ingrained in the raters through their exposure to popular culture. The experimenter and the rater taking turns using a nasal voice provides enough information to activate the personality stereotype regardless of whether there is a supplementary video or audio of a hypernasal speaker from popular culture.

Appendix 5

Nasal Discrimination Task

Bolded Number – Nasalized Word

- Volunteer 1
- Volunteer 2
- Volunteer 3
- Volunteer 4

Nasal Training Set 1

1.	Badge	1	2	**3**
2.	Earth	1	**2**	3
3.	Jello	**1**	2	3
4.	Quake	1	2	**3**
5.	Gallop	**1**	2	3
6.	Hot	1	**2**	3
7.	Three	1	2	**3**
8.	Yellow	**1**	2	3
9.	Very	1	**2**	3
10.	Wheel	1	2	**3**

Nasal Training Set 2

11.	Polka	1	2	**3**
12.	Head	1	2	**3**
13.	Large	1	2	**3**
14.	Circle	1	**2**	3
15.	Field	1	**2**	3
16.	Church	1	2	**3**
17.	Four	1	2	**3**
18.	Day	**1**	2	3
19.	Star	1	2	**3**
20.	Cold	1	**2**	3

Nasal Training Set 3

21.	Red	1	**2**	3
22.	Zebra	**1**	2	3
23.	Leap	1	**2**	3
24.	Tag	**1**	2	3
25.	Shell	1	**2**	3
26.	Dot	1	2	**3**
27.	Hotel	1	2	**3**
28.	Grow	1	**2**	3
29.	Walk	1	2	**3**
30.	Turkey	**1**	2	3

Nasal Training Set 4

31.	Jar	1	2	**3**
32.	Zoo	1	2	**3**
33.	Shower	**1**	2	3
34.	Purple	**1**	2	3
35.	Eight	1	**2**	3

36. Rock	**1**	2	3
37. Yes	1	2	**3**
38. Vapour	**1**	2	3
39. Blue	1	**2**	3
40. Thought	1	2	**3**