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IMPAIRED FACE-PROCESSING AS AN ENDOPHENOTYPE FOR AUTISM SPECTRUM DISORDER

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ABSTRACT

Although not a core symptom, impairments in face processing are well-documented in autism. While its genetic basis is unclear, autism is highly heritable and face recognition deficits present frequently in family members of affected individuals. Research has targeted poor recognition behavior as a candidate autism endophenotype – a heritable trait that is related to, but not a phenotypic symptom of, the full disorder. Endophenotypes result from fewer genes and alleles acting with less complexity than phenotypes, and indicate genetic susceptibility, even in non-affected individuals. In Experiment 1, the Autism Spectrum Quotient (AQ) was used to replicate findings which report an inverse relationship between autism-like traits and performance on facial recognition tasks (Cambridge Face and Car Memory Tasks) in typical individuals. Though non-significant, results showed a negative correlation between social subscore on the AQ and facial recognition proficiency in males but not in females. In Experiment 2, we attempted to identify an underlying mechanism for the potential behavioral endophenotype by proposing that differences in recognition abilities between non-affected individuals scoring high and low on measures of autistic traits are related to differences in *holistic processing*, especially in the eye region. In this ongoing experiment, the AQ and Broad Autism Phenotype Questionnaire (BAP-Q) are administered to quantify levels of autistic traits in typically-developed undergraduate students. Results include preliminary data documenting participants' behavioral performance on the Cambridge Face Memory Test and Cambridge Car Memory Test, as well as on two tasks designed to assess holistic processing in faces and novel objects. By targeting autism-like facial recognition behavior in the general population, findings from this

study could facilitate the identification of genes that contribute to a facial impairment endophenotype, and more broadly, to the autism phenotype.

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Chapter 1

Introduction

Autism spectrum disorder describes a continuum of developmental deficits that include social interaction, repetitive behaviors, and deficits in social communication. Autism is heterogeneous in its symptomology and varied in the degree and timeline of its clinical presentation, though some features of the disorder consistently arise. In general, the disorder presents before the age of three years, disrupts typical development, and results in lifelong cognitive and behavioral symptoms. However, while the incidence and symptoms of autism are well-documented, the causal nature of the developmental disorder is largely enigmatic. Autism's specific genetic basis is difficult to identify for several reasons. First, while the relevant literature attempts to associate autism with specific gene loci, it also acknowledges the interaction and impact of environmental risk factors in the ultimate manifestation of the disorder (Liu et al., 2001). Moreover, autism is a polygenic and behaviorally complex disorder, which makes full-genome scans difficult and non-conclusive (Sung et al., 2005). Although the genetic basis for autism has not been clearly defined, previous studies – namely twin studies which document the high concordance rates of autism – indicate genetic susceptibility to the disorder (Folstein & Rutter, 1977). Significant evidence advocates for the heritability of autism, and as a result, those traits that are often associated with autism are observed to varying degrees in family members of autistic individuals and, presumably, in the general population (Baron-Cohen et al., 2001; Geschwind, 2011). This understanding of autism has spawned a search for endophenotypes.

Endophenotypes are heritable traits or symptoms that are related to, but narrower than the entire disorder and are likely to result from a subset of genes and alleles implicated in a psychiatric disorder acting with less complexity. According to current logic, endophenotypes offer genetic targets that occupy the biological space between alleles and phenotypes, such that the biological nature of a disorder might be derived from the genetic correlates of its endophenotype (Flint & Munafo, 2007). An endophenotype for autism describes a subset of symptoms that does not constitute the full disorder, but which – due to its heritability – may present in the general population. Thus, we expect to observe characteristics of autism to varying degrees in subclinical and typically developed individuals.

In order to assess behaviors against variable amounts of autistic traits in the general population, previous studies have employed the Autism Spectrum Quotient (AQ) as an index for characteristics of autism in neurotypical adults (Baron-Cohen et al., 2001). Though not diagnostic of autism spectrum disorders, the AQ is a self-report questionnaire whose items register autism-like thoughts and behaviors in high-functioning and typical adults. The items cover five domains of autistic symptoms, including social skill, attention to detail, attention switching, communication, and imagination. Each item offers four responses, which range from ‘definitely agree’ to ‘definitely disagree’, and scoring produces a quantitative evaluation of autism-like traits. In many studies, the AQ has been used in many studies to explore potential endophenotypes of autism. Not only does the AQ offer evidence for a continuous and quantitative variation of autism-like traits in the typical population, in general, men register higher scores than women do, indicating greater levels of traits associated with autism. Similarly, students studying scientific disciplines score higher than do their counterparts in disciplines related to humanities (Baron-Cohen et al., 2001). AQ has been a predictor of the tendency to avoid looking at the eye region when presented with facial stimuli, poor perception of direct gaze, anti-social behavior, and reduced ability to distinguish between positive and negative disposition based on facial expression, which all constitute some candidate endophenotypes for autism. Higher AQ scores suggest greater levels of autistic characteristics, and with them, greater impairments in social and facial-processing tasks. While the original permutation of the AQ was scored on a binary system that assigned a score of 1 for autism-like traits and a score of 0 for those traits not traditionally associated with autism, more recent studies have adopted a four-point scoring convention to allow for greater variability in AQ scores (Hoekstra eta al., 2008; Rhodes et al., 2013). Additionally, this study uses the Broad Autism Phenotype Questionnaire (BAP-Q) as a secondary form of self-reported autistic traits in our non-clinical undergraduate population (Hurley et al., 2007). Like the AQ, the BAP-Q requires individuals to self-report tendencies toward autism-like thoughts and behaviors.

Although face processing deficits are not a core feature of autism, they represent a well-researched and widely-documented facet of the disorder. As a category of stimuli, faces are uniquely critical to social competence and, in addition to their role in determining the identity of a person, they provide social cues that cannot be gleaned elsewhere (e.g., indication of emotion, direction of attention). In many studies, marked impairments in facial processing have been observed in individuals with autism when compared to typically-developed individuals of the same age (Weigelt et al., 2012). Poor identity recognition and facial processing impairment may be a systemic processing difficulty inherent to the autism phenotype or product of a lack of expertise with faces brought on by a phenotypic lack of social motivation inherent to autism (Halliday et al., 2014). Given that autism is heritable, we expect that these impairments may be observed in members of the general population to varying degrees (Geschwind, 2011). For example, Rhodes et al. suggests that autistic traits in typically-developed individuals may be correlated to coding of facial identity and deficient recognition of facial stimuli, especially in males (2013). Based on the facial deficits observed in autism and the heritability of autism, past work suggests that a potential behavioral facial impairment endophenotype is a viable point from which we might begin to understand the genetics of autism more fully (Rhodes, 2013). Ultimately, appraisal of face skills in the context of autistic traits at varying levels in the typically-developed population may illuminate the basis for impairment of facial processing in individuals on the autism spectrum.

Past studies have probed the relationship between facial recognition and autistic traits in typically developing undergraduate populations (Halliday et al., 2014). While these findings begin to illuminate the social nature of facial processing deficits related to autism, they offer little by way of explaining the disparity between the recognition behavior of autistic individuals and typical individuals. In this study, we seek to determine whether differences in recognition proficiency might be related to differences in coding strategies and to explore a possible mechanism – a difference in holistic processing, particularly in the eye region. Holistic or configural processing is the strategy most widely-attributed to typical individuals, and describes the visuoperceptual strategy by which individuals code faces and their features as a single unit with variable components in a predictable arrangement (Maurer et al., 2002). Holistic processing describes the coding of the relationship between facial features as well as within features, and is demonstrated in Parts and Wholes tasks, which test ability to attach identity to facial features in isolation and in the context of whole faces (Tanaka & Farah, 1993).

In Parts and Wholes tasks, one condition requires a participant to recognize a target identity from two test identities, one of which differs from the original target image by a single facial feature (e.g., eyes, nose, mouth). The whole-face condition tests holistic processing, which makes an altered feature more easily recognized within the visual context of a whole face. In the parts condition, participants must select a facial feature in isolation to match a target's. The parts condition depends upon a more featural strategy for encoding identity (Tanaka & Farah, 1993). In many studies, typical participants show an advantage for whole faces over parts of faces, and this advantage is observed only when recognizing upright faces. This follows the logic that, if faces are represented holistically rather than featurally, typically-developed individuals should more readily identify a feature in the context of a whole face rather than in isolation. While typically developing individuals show this advantage only for upright faces, but not for scrambled faces, inverted faces, or objects (Tanaka & Farah, 1993). In one study, individuals on the autism spectrum showed a preserved ability to discriminate faces featurally and holistically, but only in the mouth region, whereas typical individuals attend more exclusively to the eye region (Wolf et al., 2008). Another study corroborated these results and underscored the significance of the mouth region to the facial processing strategies observed in individuals with autism (Joseph & Tanaka, 2002). These differences provide a basis for investigation and make facial processing deficiencies a prime candidate for an autism endophenotype for facial impairments.

The goal of this study was twofold. In an initial experiment, we attempted to replicate findings about AQ score and performance on face recognition tasks produced by Halliday et al. (2014). With the findings related to sex differences in Rhodes et al.'s study of AQ and face recognition tasks, we particularly examined differences in performance between males and females (2013). In a second, ongoing experiment, we are exploring a possible mechanism for the facial impairments documented in autism, and present pilot data for a new Parts-Wholes task. In summary, we predict that a high level of self-reported autistic traits registered by the AQ and BAP-Q will be associated with poor facial recognition ability, and that those who report higher degrees of autistic traits will exhibit the whole face bias to a lesser extent than their lower-scoring counterparts, as evidenced by performance on recognition tasks and a Parts and Wholes task. We will explore the likelihood that those with higher autism traits selectively encode facial stimuli by processing features in isolation with emphasis on the eye region rather than holistically with emphasis on the mouth region, as is suggested by tasks that test recognition of parts of faces (isolated features) in comparison to the whole face (Tanaka & Farah, 1993; Wolff et al., 2008).

Chapter 2

EXPERIMENT 1: The Autism Spectrum Quotient and Face Recognition

Methods

Participants

Participants included 124 healthy adults (age range: 18 – 33; M = 19.6, SD = 1.98; 44 males). Each participant was screened for history of head injury as well as for existing neurological and ongoing psychological conditions in themselves and first-degree relatives.

Measures

<u>Autism Quotient (Appendix A)</u>

The Autism Quotient (AQ) measures autistic traits in typically-developed, high functioning adults (Baron-Cohen et al., 2001). The questionnaire contains 50 items, and tests on 10 items about thoughts and behaviors associated with autism in each of five domains: social skill, attention to detail, attention switching, communication, and imagination. Participants rate the degree to which they agree with each item (‘definitely disagree’, ‘slightly disagree’, ‘slightly agree’, ‘definitely agree’). Though the original source (Baron-Cohen et al., 2001) follows a binary scoring system which assigns a score of 1 or 0 for each item, we applied the four-point scoring system used in more recent studies in order to allow for more variability in scores (Hoekstra et al., 2008). In this updated scoring system, each item receives a score of 1, 2, 3, or 4.

A score of 1 indicates no traits characteristic of autism, while a score of 4 suggests a full endorsement of the autistic trait measured by the item. This scoring procedure makes possible a minimum score of 50 and a maximum score of 200. High scores on the AQ are indicative of levels of autistic traits that resemble those observed in those diagnosed with the full disorder, although the AQ is not used as a diagnostic measure.

Cambridge Face Memory Test (Figure 1)

The Cambridge Face Memory Test (CFMT) is a widely used measure of unfamiliar face recognition. It assesses face recognition ability for six Caucasian male adult faces under varying visual conditions (full face, three-quarter face, added visual noise) (Duchaine and Nakayama, 2006). Consisting of four blocks – a practice, introduction with same images, novel images, and novel images with noise added – the test presents three study images for one of six identities in each set of trials (a left 1/3 profile, a frontal view, and a right 1/3 profile). In the practice and introduction blocks, three test images (the target face and two distractor faces) are presented and participants are instructed to select the test image that is identical to the study item from a set of three (the target and two distractors). This procedure is repeated for the five remaining target identities in each block. The novel image block tests recognition for identities when the images are manipulated in lighting, pose, or both. In the final block, the images include varying levels of Gaussian noise to force reliance upon face-specific processing mechanisms. The long form includes 102 trials and only the upright conditions were used in this study.

Cambridge Car Memory Test (Figure 2)

The Cambridge Car Memory Test (CCMT) is comparable in format to the CFMT, but uses cars instead of faces to assess object recognition ability (Dennett et al., 2011). The CCMT was included as a comparison task for the CFMT and provides a measure of recognition ability for non-facial stimuli. Analysis of performance on the CFMT in the context of performance on the CCMT allows for the isolation of face-specific components of visual memory.

Figure 1: Cambridge Face Memory Test (From Duchaine and Nakayama, 2006)

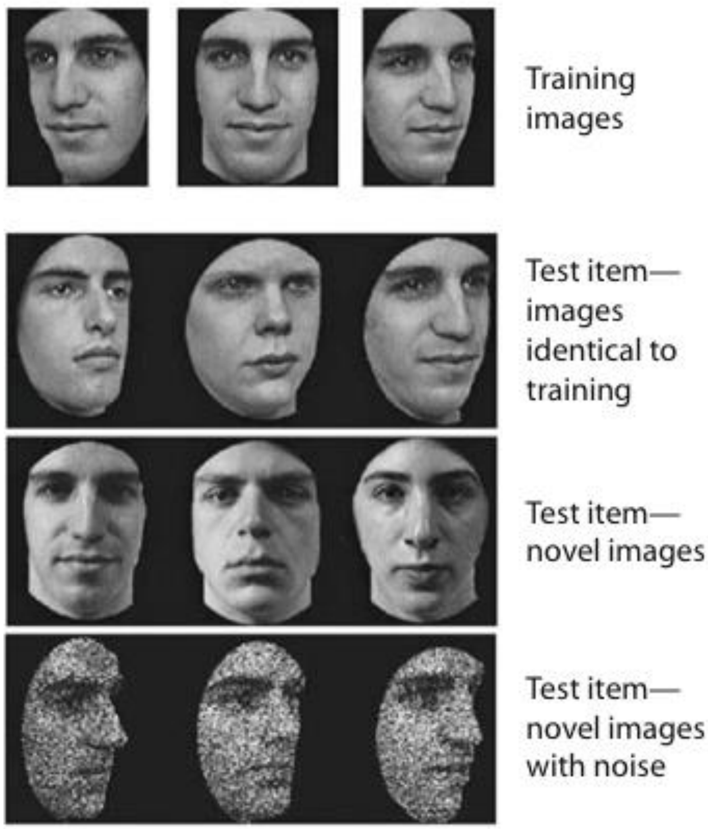


Figure 2: Cambridge Car Memory Test (From Dennett et al., 2011)

Procedure

Participants completed the AQ followed by the Cambridge Face and Car Memory Tests during a single, 60-minute session in a quiet room on a computer. These tasks were included in a larger battery of behavioral testing that took place during this hour-long session. The order of behavioral tasks was counterbalanced across participants.

Data Analysis

Simple t-tests were conducted using SPSS to evaluate the association between participants' total AQ scores and subscores and performance on both the Cambridge Face Memory Test and Cambridge Car Memory Test.

Results

The relationships between accuracy on the Cambridge Memory Tasks (Face and Car) and AQ total score and subscores (Social Skill, Attention Switching, Attention to Detail, Communication, and Imagination) were evaluated using SPSS. Table 1 offers descriptive statistics for performance on the Cambridge Tests and Table 2 offers the descriptive statistics for AQ scores and subscores. Correlations were calculated to test for association between performance on recognition tasks and total AQ score for the full population as well as for the population separated by sex; the results are enumerated in Table 3. T-tests were used to evaluate the differences in values, and $p \leq 0.05$ constituted statistical significance. A similar procedure was conducted for all AQ subscores, and the results are also included in Table 3.

Table 1: Descriptive Statistics for Accuracy on Recognition Tasks

VARIABLE	N	MEAN	SD	MINIMUM	MAXIMUM
CFMT (%)	123	68.69	10.57	45.10	97.06
CCMT (%)	123	70.23	15.16	53.92	99.02

Table 2: Descriptive Statistics for AQ Subscores

VARIABLE	N	MEAN	SD	MINIMUM	MAXIMUM
AQ_Total	123	100.85	10.80	67	132
AQ_SocialSkill	123	17.68	4.00	10	28
AQ_Attention Switching	123	23.41	3/47	16	33
AQ_Attention to Detail	123	23.64	4.17	14	26
AQ_Communication	123	17.01	3.51	10	26
AQ_Imagination	123	19.07	3.34	11	27

The mean AQ Total score falls closer to the minimum possible AQ score (min. = 50) than to the maximum score (max. = 200) which is indicative of more autism-like behavior. The possible range of scores for each subscore ranges from 10 to 40.

Table 3: Correlations between Cambridge Memory Tasks and AQ Scores

		AQ_Total	AQ_Social	AQ_Attn.Sw.	AQ_Attn.Det.	AQ_Comm.	AQ_Imagin.
CFMT (%) – All	Pearson's Correlation	-.074	-.126	0.520	-0.58	-.163	.095
	Significance (2-tailed)	.416	.166	.565	.526	.071	.298
	N	123	123	123	123	123	123
CFMT(%) – Males	Pearson's Correlation	-.104	-.283	-.005	.118	-.235	.126
	Significance (2-tailed)	.509	.065	.976	.451	.129	.421
	N	43	43	43	43	43	43
CFMT (%) – Females	Pearson's Correlation	-.067	-0.47	.075	-.153	-.136	.076
	Significance (2-tailed)	.557	.680	.506	.174	.228	.502
	N	80	80	80	80	80	80
CCMT (%) – All	Pearson's Correlation	.129	.071	-.008	.060	.175	.081
	Significance (2-tailed)	.155	.434	.930	.510	.053	.374
	N	123	123	123	123	123	123
CCMT (%) – Males	Pearson's Correlation	.109	.040	.060	-.052	0.095	.160
	Significance (2-tailed)	.482	.795	.700	.739	.540	.299
	N	44	44	44	44	44	44
CCMT (%) - Females	Pearson's Correlation	.111	.077	-.057	.124	.175	.022
	Significance (2-tailed)	.332	.500	.618	.275	.122	.845
	N	79	79	79	79	79	79

Correlational values are presented for performance on recognition tasks vs. all scores and subscores on the AQ. Furthermore, performance on recognition tasks is separated by type of stimuli (faces or cars). Three populations are evaluated for each Cambridge Test: all participants, male participants, and female participants. Statistical significance is evaluated at $p \leq 0.05$.

Cambridge Face Memory Test vs. AQ scores for all participants

No significant correlation was observed between accuracy on the face memory test and total AQ score or subscores when the full data set was analyzed.

Cambridge Face Memory Test vs. AQ scores for male participants

No significant correlation was observed between performance on the face memory test and total AQ score or subscores when the data was analyzed for males only. However, the correlation ($r = -.283$, $p=.065$) between CFMT accuracy and AQ social score is just below the cutoff for significance ($p \leq .050$). A significant result would suggest, then, that higher levels of social autism-like behaviors is are associated with poorer accuracy on face recognition tasks.

Cambridge Face Memory Test vs. AQ scores for female participants

No significant correlation was observed between accuracy on the face memory test and total AQ score or subscores when the behavioral data was analyzed for females only.

Cambridge Car Memory Test vs. AQ scores for all participants

No significant correlation was observed between accuracy on the car memory test and total AQ score or subscores when the full data set was analyzed. The correlation ($r = .175$, $p = .053$) between accuracy on the CCMT and the AQ communication subscore was just below the cutoff for significance. A significant association would indicate a positive correlation between the two values, suggesting that more autism-like communication behaviors is related to increased car recognition.

Cambridge Car Memory Test vs. AQ scores for male participants

No significant correlation was observed between accuracy on the face memory test and total AQ score or subscores when the behavioral data was analyzed for males only.

Cambridge Car Memory Test vs. AQ scores for female participants

No significant correlation was observed between accuracy on the face memory test and total AQ score or subscores when the behavioral data was analyzed for females only.

Discussion

The goal of this experiment was to replicate findings that typical participants who register lower levels of autism-like thoughts and behaviors on the AQ and its subscores demonstrate augmented performance on tasks that measure facial recognition ability than their higher-scoring counterparts (Halliday et al., 2014). While this study does not offer significant associations between AQ scores or subscores (including Social Skill, Attention Switching, Attention to Detail, Communication, and Imagination) and face- or object-recognition tasks (the Cambridge Face Memory Test and Cambridge Car Memory Test, respectively), it hints at trends and differences that could contribute to our understanding of the documented facial impairments.

Though not statistically significant, the negative correlations between face recognition – but not car recognition – are in accordance with the operating hypotheses for decreased ability with increase AQ scores that indicate increased levels of autism-like traits. Rhodes et al. similarly produced a small, non-significant negative correlation between AQ subscores and CFMT performance (2013). Also, in light of recent work which suggests that differences in male and female performance on recognition tasks might be driven by different classes of symptoms related to autism, the slight, but present differences in performance between males and females should be considered in the context of what we might learn about a sex-dependent manifestation of this and other autism endophenotypes (Rhodes et al., 2013).

In the succeeding study, AQ score is used as an inclusion criteria. Especially following the completion of this study, it seemed important to narrow the field of potential participants to those who qualified as extreme scorers (defined later) in order to concentrate the effect of AQ score, not only with respect to performance on recognition tasks, but also in the interest of locating a mechanism implicated in the face processing deficits related to autism that are alluded to by the results of this experiment and explicit in previous studies. In the following experiment, we develop a task designed to identify differences in the face-processing strategies in high and low scorers on the AQ. The following study seeks to answer the questions that this study poses and to explore the possibility that differences in coding strategy among those exhibiting autism-like traits could serve as a vehicle for discrepancies in recognition abilities.

Chapter 3

EXPERIMENT 2: The Autism Spectrum Quotient and Parts and Wholes

Methods

Participants

The Autism Quotient (see above) was electronically administered to undergraduates in the Penn State Psychology Subject Pool. For the subset of 800 students who consented to be contacted for participation in psychological studies, AQ total scores were calculated. The distributions for these total scores were examined separately for males and females (Males: M = 112.7, SD = 11.30; Females: M = 110.5, SD = 12.5). Initially, participants who scored ±1 SD than the mean of their group mean were contacted via email to participate in the full study (Male inclusion criteria: total AQ score ≤ 101.4 or total AQ score ≥ 124; Female inclusion criteria: total AQ score ≤ 98 or total AQ score ≥ 123). The original inclusion criteria were later broadened in order to open the study to a greater number of potential participants (Male inclusion criteria: total AQ score ≤ 105 or total AQ score ≥ 120; Female inclusion criteria: total AQ score ≤ 102 or total AQ score ≥ 119). The preliminary data set and discussion below includes 28 participants (age range: 18 – 22, M = 19.0, SD = 1.00; 7 males) composed of the following groups: 1 low male (total AQ score ≤ 105), 6 high males (total AQ score ≥ 120), 10 low females (total AQ score ≤ 102), and 11 high females (AQ score ≥ 119).

Stimuli

Face stimuli for the Parts-Wholes task included grey-scaled images of male and female faces from the NimStim Face Stimulus Set, which were manipulated by Jim Tanaka and his colleagues at the University of Victoria. The Parts-Wholes greeble task used colored greeble images from the TarrLab Stimulus Repository within the Center for the Neural Basis of Cognition Stimulus Repository. Greebles are digitally-rendered objects that were originally designed to be comparison stimuli to human faces (Gauthier and Tarr, 1997).

Measures

Autism Quotient (Appendix A)

As in Experiment 1, each subject completed the AQ and a four-point scoring system was applied.

Broad Autism Phenotype Questionnaire (Appendix B)

The Broad Autism Phenotype Questionnaire (BAP-Q) was also administered to participants in order to offer a second set of subscores which reflect autism-like dimensions of personality and which are different from those measured by the AQ. Similarly to the AQ, the BAP-Q operates on the basis of evidence for the heritability of autism (Folstein and Rutter, 1977). The BAP-Q quantifies the expression of autistic-like dimensions of personality and language in the general population, especially in relatives of autistic individuals, in order to characterize the Broad Autism Phenotype (Hurley et al., 2007). The questionnaire's 36 items correspond to three primary components of the Broad Autism Phenotype: aloof personality, rigid personality, and pragmatic language. These three components are theoretically relevant to some of the major behavioral domains of autistic symptoms (social, repetitive behavior, communication deficits), often appear to varying degrees in parents of those with autism, and are reliable measures (Hurley et al., 2007). Participants rate their agreement with each statement on a scale from 1 to 6 (1 = 'very rarely' and 6 = 'very often'), and higher summed scores indicate a greater exhibition of the Broad Autism Phenotype. Summary scores are calculated for each of the three subscores (aloof personality, rigid personality, pragmatic language).

Cambridge Face Memory Test (Figure 1)

As in Experiment 1, the long-form, upright Cambridge Face Memory Test was administered to each participant.

Cambridge Car Memory Test (Figure 2)

As in Experiment 1, each participant completed the upright Cambridge Car Memory Test.

Parts-Wholes Task (Figure 3)

Behavioral studies of parts and wholes in faces tests the hypothesis that facial features are more recognizable when embedded in the context of the whole face and subject to second-order spatial relationships with adjacent features than when presented in isolation. Subjects in previous studies of parts and wholes were asked to recognize target features (e.g., eyes, nose, mouth) when presented in isolation and when presented in the context of a whole face. These studies register a part-whole effect and suggest that typical individuals code holistic – rather than featural – representations of faces and their identifying features (Tanaka & Farah, 1993). In the current task, participants studied a target image (either a whole face or whole greeble), and were then tested on their ability to select from two images that which contained the feature identical to that depicted in the target image. Face trials presented two potential choices (both either whole faces or isolated features) and required participants to identify the whole face or isolated feature that belonged to the target image, and differed either in the eye region or mouth region. The nose region was excluded based on prior work, which suggests that autistic individuals attend most to the eye and mouth regions when discriminating between faces (Tanaka and Schultz, 2008). Similarly, in greeble trials, participants were required to discriminated between greeble features in the context of the whole stimulus and when in isolation.

Faces

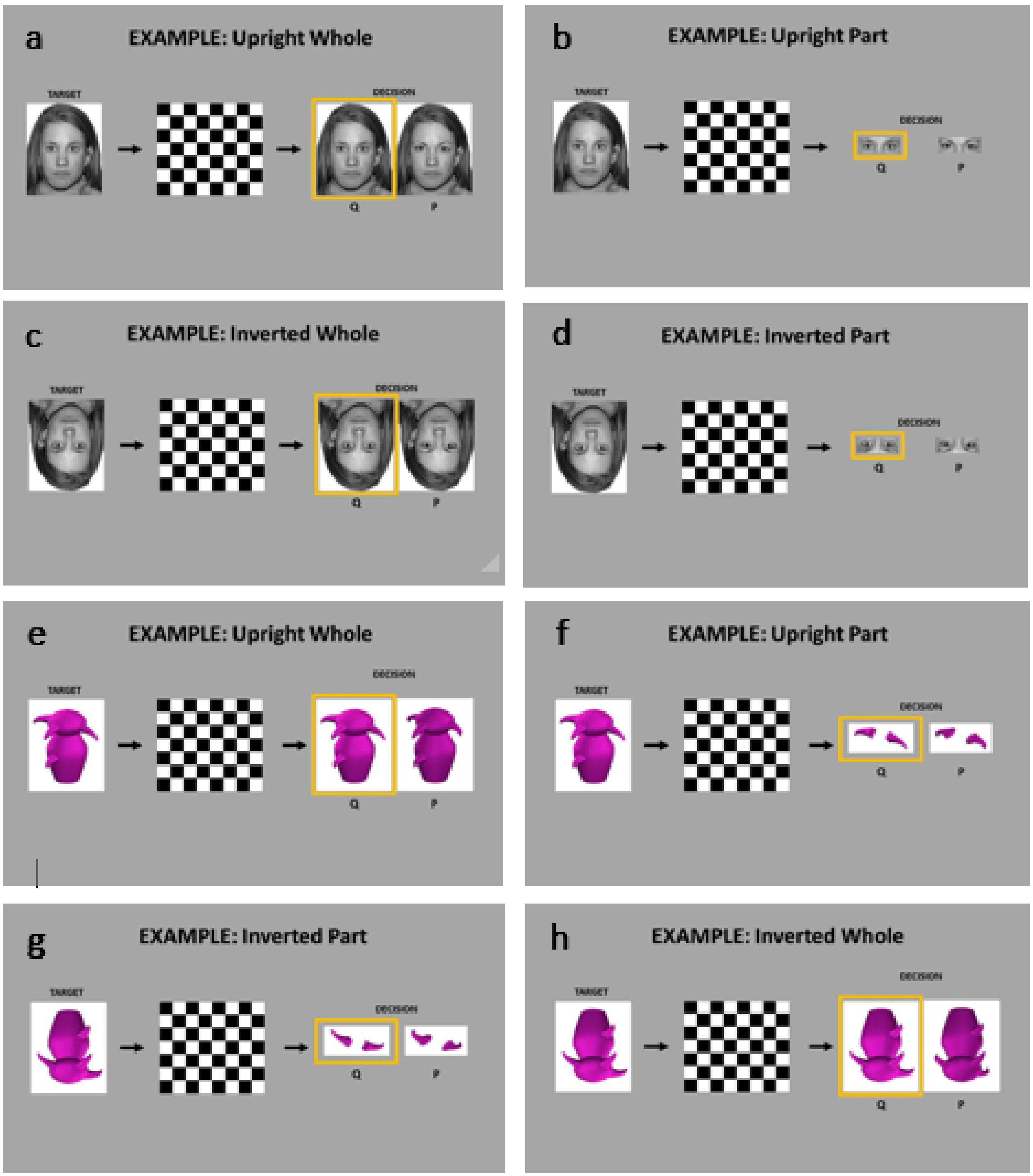
Stimuli consisted of 6 male identities and 6 female faces. For each trial, one of these faces served as the target identity and was displayed for 750 milliseconds. The target face was followed by a checker board mask for 500 milliseconds. Finally, two images were presented side-by-side and the participant was required to select the image that corresponded to the target face. In the *whole condition*, both images were of whole faces, the target face and the target face with either the eyes or mouth replaced with new eyes or mouth (see Figure 3a). In the *parts condition,* the whole face target was followed by images of isolated eyes *or* mouth, one of which belonging to the target face and the other belonging to a new face (see Figure 3b). Trials were separated by a 500 millisecond fixation. Each of the 12 faces was used as a target face twice in the whole condition (eyes/mouth distractors) and twice in the parts condition (eyes/mouth parts). Trials were randomized across condition and face region, resulting in 48 upright face trials. The same procedure was repeated with the same images inverted to produce 48 inverted face trials, for a total of 96 trials. The upright orientation always preceded the inverted orientation. The inverted orientation was included for comparison; holistic processing effects are not expected in the inverted condition. Effects of inversion in previous work include poorer accuracy and increased reaction time (Maurer et al., 2002).

Greebles

Greebles were chosen as comparison stimuli in this study because of their novelty, but also because their perceptual homogeneity requires holistic and configural processing to extract identity representations. Designed as control stimuli for faces in previous studies, greebles are digitally-rendered, three-dimensional objects which exhibit canonical structure that includes three types of appendages. The uppermost features are two boges which are positioned laterally and opposite one another, and which are analogous to the eyes of a human face. Positioned perpendicularly to the boges are a quiff and dunth, which are analogous to a nose and mouth. Differences among these features yield various “identities” among greebles. Furthermore, male greebles are distinguished by upward-reaching appendages, while female greebles are indicated using downward-reaching appendages. Because they exhibit a homogeneity in general structure similar and subtle differences at the individual level in a manner similar to faces, greebles were included in this study to offer a control, without which observed effects could not be attributed uniquely to face-specific effects (Gauthier & Tarr, 1997). As with faces, 6 individual “male” and 6 individual “female” greebles were selected as target identities. The same conditions that were tested in the Parts-Wholes face task (gender, orientation, feature) were also tested in the greeble task to produce 96 corresponding trials.

Notably, rather than testing on differences in eye and mouth regions as with facial stimuli, the greeble task tested on differences in boges and quiff regions.

Figure 3: Parts-Wholes Task Blocks



Procedure

The aforementioned battery of behavioral tasks was administered during a single, 60-minute session on a computer in a quiet room. Each participant was screened for existing neurological and ongoing psychological conditions, and completed the BAP-Q electronically prior to beginning the behavioral battery. The order of the recognition and parts/wholes tasks was counterbalanced across participants. Within the recognition tasks, the order of the faces and cars task was counterbalanced across participants. Within the parts-wholes tasks, the order of face and greeble tasks was randomized for each participant, but the upright condition was always run before the inverted condition.

Data Analysis

Because, for each participant, this procedure requires collection of data across multiple conditions which are not necessarily independent, a repeated measures ANOVA will be run on the full data set in order to examine the relationship between AQ score and performance on the CFMT, CCMT, and Parts-Wholes tasks. With accuracy as a dependent measure and mean reaction time for correct trials within each task as a second dependent measure, the data will be evaluated for normality, including skew and kurtosis. High vs. low group serves as the between-subjects factor, while test condition serves as the within-subjects factor. A 2 x 2 x 2 x 2 repeated measures design will accommodate the four test factors: orientation (upright vs. inverted), stimuli type (face vs. greeble), feature (eyes vs. mouth/boges vs. quiff), and condition (part vs. whole).

Results

Cambridge Face and Car Memory Tests and AQ scores

Data was collected for 28 participants (7 males) scoring high or low on the AQ. Table 4 offers descriptive statistics for the Cambridge Tests and AQ scores and Table 5 outlines the correlations between the measures as calculated in SPSS and are included for comparison with the data collected in Experiment 1.

Table 4: Descriptive Statistics for CMT's and AQ's

	Mean	SD	N
CFMT_Accuracy	65.0700	10.71267	28
CCMT_Accuracy	65.5754	15.93175	28
AQ_Total	114.0000	19.44413	28
AQ_Social	20.3571	5.27899	28
AQ_AttentionSwitching	24.4643	3.47991	28
AQ_AttentionToDetail	25.8929	4.74802	28
AQ_Communication	21.1071	5.44562	28
AQ_Imagination	21.4643	4.85708	28

Means and SD's were calculated for the 28 data sets collected in this experiment and processed in SPSS.

Table 5: Correlations for CFMT and CCMT vs. AQ Scores

		AQ_Total	AQ_Social	AQ_Attn.Sw.	AQ_Attn.Det.	AQ_Comm.	AQ_Imagin.
CFMT (%)	Pearson's Correlation	-.308	-.437*	-.133	.219	-.418*	-.103
	Significance (2-tailed)	.111	.020	.499	.514	.027	.600
	N	28	28	28	28	28	28
CCMT(%)	Pearson's Correlation	.100	.068	.291	.037	.076	.038
	Significance (2-tailed)	.6224	.729	.133	.851	.702	.847
	N	28	28	28	28	28	28

Correlational values are presented for performance on recognition tasks vs. all scores and subscores on the AQ. Furthermore, performance on recognition tasks is separated by type of stimuli (faces or cars). Three populations are evaluated for each Cambridge Test: all participants, male participants, and female participants. Statistical significance is evaluated at $p \leq 0.05$ and denoted by an "*".

In this population, unlike in Experiment 1, the correlation between Social AQ subscore and accuracy on the CFMT is significant and negative (r = -.437, p = .020), suggesting that higher scores (indicating more autism-like behavior) on the social dimension are related to poorer accuracy on the CFMT. Likewise, the correlation between Communication AQ subscore and CFMT accuracy is significant and negative (r = -.418, p = .027). Otherwise, no interactions of AQ score or subscore with CFMT or CCMT accuracy are significant.

Parts-Wholes Task Pilot Results

Though the full set of participants completed the Parts-Wholes task in addition to the CFMT and CCMT, an error in the coding of task outputs prevented accurate analysis of the data at this time. These participants completed a computerized version of this task programmed in Java, and a problem involving the program's internal timer caused the participants' responses to be aligned incorrectly with the task's recording of trials within each block. This error resulted in a miscalculation of accuracy for all blocks included in the task, and the error in coding has since been corrected. All future presentations of this data will include the realigned responses and corrected accuracies for the Parts-Wholes task. Though this experiment is ongoing and will continue to recruit participants who qualify as high- and low-scorers on the AQ, preliminary Parts-Wholes data is present below for two participants in Tables 6 and 7. The data presented in Tables 6 and 7 was collected via a version of the task programmed in E-Prime, which does not feature the error detected in the Java version. Participant 1, whose data is shown below in Table 6, is an 18-year old female who scored 100 on the AQ (Social Skill = 17, Attention Switching =

24, Attention to Detail = 23, Communication = 17, Imagination = 19), and is a low-scorer (fewer reported autism-like thoughts and behaviors) according to the loosened criteria. This participant also scored 87 out of a possible 216 points on the BAP-Q (Aloof Personality = 32, Pragmatic Language = 22, Rigid Personality = 33).

Table 6: Performance on Parts-Wholes Task (Participant 1)

TEST BLOCK	Accuracy (% out of 12 trials)	Mean Correct RT (ms)
Upright / Face / Eyes / Whole	75.00	1647.6
Upright / Face / Eyes / Part	83.33	1257.0
Upright / Face / Mouth / Whole	91.67	1230.5
Upright / Face / Mouth / Part	58.33	950.1
Upright / Greeble / Boges / Whole	66.67	1360.1
Upright / Greeble / Boges / Part	75.00	1230.3
Upright / Greeble / Quiff / Whole	75.00	851.6
Upright / Greeble / Quiff / Part	66.67	1010.5
Inverted / Face / Eyes / Whole	83.33	1436.0
Inverted / Face / Eyes / Part	83.33	1094.0
Inverted / Face / Mouth / Whole	25.00	1107.7
Inverted / Face / Mouth / Part	66.67	1126.4
Inverted / Greeble / Boges / Whole	75.00	1346.6
Inverted / Greeble / Boges / Part	83.33	1221.1
Inverted / Greeble / Quiff / Whole	66.67	1136.8
Inverted / Greeble / Quiff / Part	66.67	1047.8

Accuracy (%) out of 12 trials are recorded for each block, whose factors are divided as follows: orientation (upright vs. inverted), stimuli type (face vs. greeble), feature (eyes/boges vs. mouth/quiff), and condition (whole vs. part). Mean reaction time for correct responses within each block are also recorded

In the upright blocks, Participant 1 demonstrated a bias for the whole condition based on accuracy in the mouth blocks and quiff blocks, but not for the eyes blocks or boges blocks. In the inverted blocks, Participant 1 did not demonstrate a bias for the whole face or greeble in any sets of blocks. Accuracies were equal for the eyes and quiff blocks, and greater for parts in the mouth and boges blocks.

In terms of Mean Reaction Time, only the Upright / Greeble / Quiff and Inverted / Face / Mouth blocks showed an advantage for the whole condition. In all other blocks, Participant 1 demonstrated smaller (faster) RT. Generally, RT was also slightly faster for inverted trials (M = 1189.6 ms) than for upright trials (M = 1192.2 ms), faster for greebles (M = 1150.6 ms) than faces (M = 1231.2 ms), faster for mouth (M = 1103.7 ms) than eyes (M = 1358.7 ms), and faster for quiff (M = 1011.7 ms) than for boges (M = 1289.5 ms).

The data suggests a possible speed-accuracy tradeoff in both the upright and inverted mouth blocks. In the upright block, accuracy decreased from whole to part, but the participant's RT was lower for the part condition. In the inverted mouth blocks, the participant increased in accuracy from whole to parts, but the respective RT's increased slightly.

Participant 2, whose data is shown below in Table 7, is a 19-year old female who scored 97 on the AQ (Social Skill = 18, Attention Switching = 25, Attention to Detail = 24, Communication = 15, Imagination = 15). As was true for Participant 1, this score places Participant 2 in the low-scoring category (indicating fewer self-reported autism-like behaviors). Participant 2 scored 84 out of a possible 216 points on the BAP-Q (Aloof Personality = 22, Pragmatic Language = 28, Rigid Personality = 34).

Table 7: Performance on Parts-Wholes Task (Participant 2)

TEST BLOCK	Accuracy (% out of 12 trials)	Mean Correct RT (ms)
Upright / Face / Eyes / Whole	66.67	564.6
Upright / Face / Eyes / Part	100.00	752.0
Upright / Face / Mouth / Whole	50.00	525.0
Upright / Face / Mouth / Part	75.00	652.7
Upright / Greeble / Boges / Whole	75.00	545.4
Upright / Greeble / Boges / Part	66.67	467.5
Upright / Greeble / Quiff / Whole	41.67	562.4
Upright / Greeble / Quiff / Part	41.67	408.4
Inverted / Face / Eyes / Whole	58.33	460.0
Inverted / Face / Eyes / Part	50.00	587.0
Inverted / Face / Mouth / Whole	16.67	493.0
Inverted / Face / Mouth / Part	41.67	569.0
Inverted / Greeble / Boges / Whole	66.67	300.4
Inverted / Greeble / Boges / Part	41.67	274.0
Inverted / Greeble / Quiff / Whole	33.33	445.3
Inverted / Greeble / Quiff / Part	50.00	241.5

Accuracy (%) out of 12 trials are recorded for each block, whose factors are divided as follows: orientation (upright vs. inverted), stimuli type (face vs. greeble), feature (eyes/boges vs. mouth/quiff), and condition (whole vs. part). Mean reaction time for correct responses within each block are also recorded.

In the upright blocks, Participant 2 demonstrated a bias for the whole condition based on accuracy in the boges blocks, but not in the quiff, mouth, or eyes. In the inverted blocks, Participant 2 demonstrated a bias for the whole rather than part in the eyes blocks and boges blocks. Accuracies were greater for the part condition in both mouth and quiff.

In terms of Mean Reaction Time, all face trials exhibited a whole face bias; the participant reacted more quickly for whole face trials than face part trials. In greeble trials, on the other hand, the participant always responded more rapidly (evidenced by smaller RT) in the part condition than the whole condition Generally, RT was also slightly faster for inverted trials (M = 421.3 ms) than for upright trials (M = 559.33 ms), faster for greebles (M = 405.6 ms) than faces (M = 575.4 ms), faster for eyes (M = 590.9 ms) than mouth (M = 559.9 ms), and faster for boges (M = 396.8 ms) than for quiff (M = 414.4 ms).

Overall, Participant 2 demonstrated faster reaction times than Participant 1, but poorer accuracy. The data highlights a possible speed-accuracy tradeoff, but only in the inverted mouth block.

Discussion

Cambridge Memory Tests

The Cambridge tasks were included in this experiment to attempt to replicate the negative correlation between AQ score and face recognition ability observed in earlier studies (especially Halliday et al., 2014). Whereas the data in the larger sample of Experiment 1 did not include any significant correlations between AQ scores and performance on the Cambridge Tests of face and object recognition, the sample of participants in Experiment 2 elicited significant negative correlations between social AQ score and CFMT in the full sample (N = 28) as well as between communication AQ score and CFMT in the full sample. Thus, Experiment 2 suggests that as social and communicative characteristics approach levels observed in autistic individuals, face recognition ability declines. Importantly, the same is not true for performance on the CCMT, suggesting that this trend is face-specific.

The AQ has now been used in several studies which have failed to detect statistically significant correlations between AQ scores and their dependent measures, we might consider possible reasons for the varied results (Hedley at al., 2011; Rhodes et al., 2013). In this study, as in Rhodes et al., men are underrepresented in the sample, suggesting the potential for a change in significance with the future inclusion of more male participants. If, as Rhodes et al. poses, females are not accurately characterized by the proposed endophenotype for facial impairments in autism, then a sample predominately comprised of women could encourage faulty conclusions. In future evaluations of this data set, the BAP-Q will be included to counteract this possibility.

Parts-Wholes Task

While the data available for evaluation participant performance on the Parts-Wholes Task is limited, the collected data offers an opportunity to assess the difficulty of the task and to look at patterns in performance on an individual basis. In some ways, the participants conformed to our expectations. We would expect that, since both participants are low-scorers on the AQ, they would exhibit the whole face bias that is consistent with an intact holistic face-processing strategy. We also expected that low scorers would show a selective advantage for upright trials over inverted trials and for the eye region of faces over the mouth region. Participant 1 did not behave as such, and in fact performed with greater accuracy on the part condition across all blocks. While the participant showed a slight bias for upright over inverted trials and eye region over mouth region, she performed with greater accuracy on greeble trials than face trials. While Participant 2 performed with greater accuracy in upright trials, face trials, and eyes trials over mouth trials, she did not unanimously demonstrate the whole-face bias either. These unexpected results might suggest a structural issue with the task design. The accumulation of more data sets will allow for a more accurate evaluation of the task's difficulty.

Chapter 4

Future Directions and Implications

Data collection will continue for Experiment 2 to accumulate sufficient data about high- and low- scorers and males and females to make conclusions about possible mechanisms for a behavioral facial impairment endophenotype for autism with special attention to the way that this endophenotype may manifest differently in men and women. Additionally, this data could implicate the genetic underpinnings of autism and offer geneticists the means for understanding the genotypic basis for the disorder.

As it relates to differing facial processing strategies, the investigation of a targeted endophenotype of autism is intriguing, and poses therapeutic promise for the development of interventions. This research most directly aims to determine whether, in typically-developed individuals, higher scores on measures of autistic traits correspond to greater deficits or atypicalities in facial recognition. The ultimate goal of this continuing research is the identification of impaired face processing as an endophenotype for autism, especially as it may inform or be informed by specific features of the disorder. Study of this endophenotype will enhance our understating for the nature and genetic basis for autism, and this project underscores the possibility that impaired facial recognition and its underlying neural vulnerability constitute a valid endophenotype. The findings from this research will be useful to both our understanding of the heterogeneous disorder and to future therapies and interventions designed to help autistic individuals compensate for inherent deficits.

Appendix A

Autism Quotient (Baron-Cohen, 2001)

1. I prefer to do things with others rather than on my own.	definitely agree	slightly agree	slightly disagree	definitely disagree
2. I prefer to do things the same way over and over again.	definitely agree	slightly agree	slightly disagree	definitely disagree
3. If I try to imagine something, I find it very easy to create a picture in my mind.	definitely agree	slightly agree	slightly disagree	definitely disagree
4. I frequently get so strongly absorbed in one thing that I lose sight of other things.	definitely agree	slightly agree	slightly disagree	definitely disagree
5. I often notice small sounds when others do not.	definitely agree	slightly agree	slightly disagree	definitely disagree
6. I usually notice car number plates or similar strings of information.	definitely agree	slightly agree	slightly disagree	definitely disagree
7. Other people frequently tell me that what I've said is impolite, even though I think it is polite.	definitely agree	slightly agree	slightly disagree	definitely disagree
8. When I'm reading a story, I can easily imagine what the characters might look like.	definitely agree	slightly agree	slightly disagree	definitely disagree
9. I am fascinated by dates.	definitely agree	slightly agree	slightly disagree	definitely disagree
10. In a social group, I can easily keep track of several different people's conversations.	definitely agree	slightly agree	slightly disagree	definitely disagree
11. I find social situations easy.	definitely agree	slightly agree	slightly disagree	definitely disagree
12. I tend to notice details that others do not.	definitely agree	slightly agree	slightly disagree	definitely disagree
13. I would rather go to a library than a party.	definitely agree	slightly agree	slightly disagree	definitely disagree
14. I find making up stories easy.	definitely agree	slightly agree	slightly disagree	definitely disagree
15. I find myself drawn more strongly to people than to things.	definitely agree	slightly agree	slightly disagree	definitely disagree
16. I tend to have very strong interests, which I get upset about if I can't pursue.	definitely agree	slightly agree	slightly disagree	definitely disagree
17. I enjoy social chit-chat.	definitely agree	slightly agree	slightly disagree	definitely disagree
18. When I talk, it isn't always easy for others to get a word in edgeways.	definitely agree	slightly agree	slightly disagree	definitely disagree
19. I am fascinated by numbers.	definitely agree	slightly agree	slightly disagree	definitely disagree
20. When I'm reading a story, I find it difficult to work out the characters' intentions.	definitely agree	slightly agree	slightly disagree	definitely disagree
21. I don't particularly enjoy reading fiction.	definitely agree	slightly agree	slightly disagree	definitely disagree
22. I find it hard to make new friends.	definitely agree	slightly agree	slightly disagree	definitely disagree
23. I notice patterns in things all the time.	definitely agree	slightly agree	slightly disagree	definitely disagree
24. I would rather go to the theatre than a museum.	definitely agree	slightly agree	slightly disagree	definitely disagree
25. It does not upset me if my daily routine is distubed.	definitely agree	slightly agree	slightly disagree	definitely disagree
26. I frequently find that I don't know how to keep a conversation going.	definitely agree	slightly agree	slightly disagree	definitely disagree
27. I find it easy to "read between the lines" when someone is talking to me.	definitely agree	slightly agree	slightly disagree	definitely disagree
28. I usually concentrate more on the whole picture, rather than the small details.	definitely agree	slightly agree	slightly disagree	definitely disagree
29. I am not very good at remembering phone numbers.	definitely agree	slightly agree	slightly disagree	definitely disagree
30. I don't usually notice small changes in a situation, or a person's appearance.	definitely agree	slightly agree	slightly disagree	definitely disagree
31. I know how to tell if someone listening to me is getting bored.	definitely agree	slightly agree	slightly disagree	definitely disagree
32. I find it easy to do more than one thing at once.	definitely agree	slightly agree	slightly disagree	definitely disagree
33. When I talk on the phone, I'm not sure when it's my turn to speak.	definitely agree	slightly agree	slightly disagree	definitely disagree
34. I enjoy doing things spontaneously.	definitely agree	slightly agree	slightly disagree	definitely disagree
35. I am often the last to understand the point of a joke.	definitely agree	slightly agree	slightly disagree	definitely disagree
36. I find it easy to work out what someone is thinking or feeling just by looking at their face.	definitely agree	slightly agree	slightly disagree	definitely disagree

37. If there is an interruption, I can switch back to what I was doing very quickly.	definitely agree	slightly agree	slightly disagree	definitely disagree
38. I am good at social chit-chat.	definitely agree	slightly agree	slightly disagree	definitely disagree
39. People often tell me that I keep going on and on about the same thing.	definitely agree	slightly agree	slightly disagree	definitely disagree
40. When I was young, I used to enjoy playing games involving pretending with other children.	definitely agree	slightly agree	slightly disagree	definitely disagree
41. I like to collect information about categories of things (e.g. types of car, types of bird, types of train, types of plant, etc.).	definitely agree	slightly agree	slightly disagree	definitely disagree
42. I find it difficult to imagine what it would be like to be someone else.	definitely agree	slightly agree	slightly disagree	definitely disagree
43. I like to plan any activities I participate in carefully.	definitely agree	slightly agree	slightly disagree	definitely disagree
44. I enjoy social occasions.	definitely agree	slightly agree	slightly disagree	definitely disagree
45. I find it difficult to work out people's intentions.	definitely agree	slightly agree	slightly disagree	definitely disagree
46. New situations make me anxious.	definitely agree	slightly agree	slightly disagree	definitely disagree
47. I enjoy meeting new people.	definitely agree	slightly agree	slightly disagree	definitely disagree
48. I am a good diplomat.	definitely agree	slightly agree	slightly disagree	definitely disagree
49. I am not very good at remembering people's date of birth.	definitely agree	slightly agree	slightly disagree	definitely disagree
50. I find it very easy to play games with children that involve pretending.	definitely agree	slightly agree	slightly disagree	definitely disagree

Appendix B: Broad Autism Phenotype Questionnaire (Hurley et al., 2006)

1—Very rarely	2—Rarely	3—Occasionally
4—Somewhat often	5—Often	6—Very often

Questions:

1. I like being around other people	1 2 3 4 5 6
2. I find it hard to get my words out smoothly	1 2 3 4 5 6
3. I am comfortable with unexpected changes in plans	1 2 3 4 5 6
4. It's hard for me to avoid getting sidetracked in conversation	1 2 3 4 5 6
5. I would rather talk to people to get information than to socialize	1 2 3 4 5 6
6. People have to talk me into trying something new	1 2 3 4 5 6
7. I am "in-tune" with the other person during conversation***	1 2 3 4 5 6
8. I have to warm myself up to the idea of visiting an unfamiliar place	1 2 3 4 5 6
9. I enjoy being in social situations	1 2 3 4 5 6
10. My voice has a flat or monotone sound to it	1 2 3 4 5 6
11. I feel disconnected or "out of sync" in conversations with others***	1 2 3 4 5 6
12. People find it easy to approach me***	1 2 3 4 5 6
13. I feel a strong need for sameness from day to day	1 2 3 4 5 6
14. People ask me to repeat things I've said because they don't understand	1 2 3 4 5 6
15. I am flexible about how things should be done	1 2 3 4 5 6
16. I look forward to situations where I can meet new people	1 2 3 4 5 6
17. I have been told that I talk too much about certain topics	1 2 3 4 5 6
18. When I make conversation it is just to be polite***	1 2 3 4 5 6
19. I look forward to trying new things	1 2 3 4 5 6
20. I speak too loudly or softly	1 2 3 4 5 6
21. I can tell when someone is not interested in what I am saying***	1 2 3 4 5 6
22. I have a hard time dealing with changes in my routine	1 2 3 4 5 6
23. I am good at making small talk***	1 2 3 4 5 6
24. I act very set in my ways	1 2 3 4 5 6
25. I feel like I am really connecting with other people	1 2 3 4 5 6
26. People get frustrated by my unwillingness to bend	1 2 3 4 5 6
27. Conversation bores me***	1 2 3 4 5 6
28. I am warm and friendly in my interactions with others***	1 2 3 4 5 6
29. I leave long pauses in conversation	1 2 3 4 5 6
30. I alter my daily routine by trying something different	1 2 3 4 5 6
31. I prefer to be alone rather than with others	1 2 3 4 5 6
32. I lose track of my original point when talking to people	1 2 3 4 5 6
33. I like to closely follow a routine while working	1 2 3 4 5 6
34. I can tell when it is time to change topics in conversation ***	1 2 3 4 5 6
35. I keep doing things the way I know, even if another way might be better	1 2 3 4 5 6
36. I enjoy chatting with people ***	1 2 3 4 5 6

***Casual interaction with acquaintances, rather than special relationships such as with close friends and family members.

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EDUCATION

The Pennsylvania State University — **University Park, PA**
Bachelor of Science in Biology (Neuroscience), Eberly College of Science — *2011 – Present*
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HONORS & AWARDS

- Dean's List, The Pennsylvania State University*, 2011 – Present*
- President's Freshman Award, *2012*
- Schreyer Honors College Academic Excellence Scholarship, *2011 – Present*
- Summer Undergraduate Discovery Grant, *2014*

RESEARCH EXPERIENCE

Scherf Lab of Developmental Neuroscience — **Pennsylvania State University**
Undergraduate Research Assistant — *2012 – Present*

- Provided technical and stimuli-related support for ongoing research projects related to the neural correlates of facial recognition, especially in developing adolescents
- Trained in safety precautions and practices of functional magnetic resonance imaging
- Assisted in the development of a discovery program designed to teach children about neuroanatomy and cerebral processing
- Pursuing a thesis on endophenotypes in subclinical populations for facial processing deficiencies in autism

CLINICAL EXPERIENCE

Mount Nittany Medical Center — **State College, PA**
Shadow — *April 2014*

- Observed eight hours of otolaryngological surgeries under Dr. James E. Freije, MD

Summer Clinical Preceptorship Program — **Hershey, PA**
Student — *June 2014*

- One of ten participants selected for Penn State University College of Medicine's shadowing program
- Completed rotations in family and community medicine, internal medicine, orthopedics and rehabilitation, pediatrics, and general surgery

EMPLOYMENT EXPERIENCE

Ice Land Skating Center — **Hamilton, NJ**
Receptionist — *Summer 2012*

- Served customers (enrollment, payment, information, first aid)
- Scheduled programming and events (including employee shifts, camps, league games)
- Designed promotional materials for the following season's programming

LEADERSHIP & ACTIVITIES

The Penn State IFC/Panhellenic Dance Marathon — **University Park, PA**
Rules and Regulations Committee Member — *Fall 2011 – Spring2013*

- Participated in THON (world's largest student-run philanthropy for patients of pediatric cancer and their families) as a member of the Rules and Regulations committee

Penn State's Peace Love Lyrical Dance Company **University Park, PA**
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- Attended weekly rehearsals in preparation for on-campus performances and fundraisers (including THON, Homecoming, Penn State's Best Dance Crew, and semesterly recitals)

Penn State Ballroom Dance Team **University Park, PA**
Team Member *Fall 2012 – Fall 2013*

- Attended several practices each week (in addition to those required by the Advanced Ballroom course)
- Competed in several regional and inter-collegiate competitions

Phi Sigma Pi National Honor Fraternity – Alpha Pi Chapter **University Park, PA**
Brother, Brother at Large, Rush/Public Relations Chair, Webmaster, Initiate Adviser *Spring 2012 – Present*

- Organized and led events designed to recruit prospective brothers with an interest in developing values of leadership, fellowship, and scholarship
- Participated and aided in planning of fundraisers to benefit Phi Sigma Pi's national philanthropy, Teach for America
- D
  eveloped a website for the promotion of the organization and distribution of information to the student body
- Led a twelve-week initiation program (4 hours/week) for an incoming class of twenty-three brothers to teach the history, duties, and ideals of Phi Sigma Pi
- Actively participated in fraternity fundraising for Penn State's Dance Marathon (THON) between 2012 and 2015
- Represented Phi Sigma Pi as a dancer in THON 2015, an annual 46-hour, no-sitting, no-sleeping dance marathon held in celebration of our yearlong fundraising efforts for families and children battling pediatric cancer

Penn State Ice Crew **University Park, PA**
Ice Girl *Fall 2013 – Present*

- Served as a member of the promotional team for Penn State's Division I men's ice hockey team
- Cleared ice during media breaks at home games to ensure continuous play