FACE PROCESSING IN THE BROAD AUTISM PHENOTYPE: EXPLORING FACE PROCESSING AS AN ENDOGENOTYPE OF AUTISM SPECTRUM DISORDER

By

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# Tables of Contents

List of Tables ................................................................. 4  
List of Figures ................................................................. 6  
Acknowledgements ......................................................... 7  
List of Abbreviations ....................................................... 8  
Abstract ............................................................................. 9  
Introduction ......................................................................... 11  
Methods ............................................................................... 40  
Results ................................................................................ 53  
Discussion ............................................................................. 77  
Tables .................................................................................. 100  
Figures ................................................................................ 132  
Appendix A ........................................................................... 137  
Appendix B ........................................................................... 140  
Appendix C ........................................................................... 145  
References ............................................................................ 147
## List of Tables

<table>
<thead>
<tr>
<th>Table</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Table 1</td>
<td>LFI Identity Skills Battery</td>
<td>100</td>
</tr>
<tr>
<td>Table 2</td>
<td>LFI Emotion Battery</td>
<td>101</td>
</tr>
<tr>
<td>Table 3</td>
<td>LFI Object Battery</td>
<td>102</td>
</tr>
<tr>
<td>Table 4</td>
<td>Group Characteristics I</td>
<td>103</td>
</tr>
<tr>
<td>Table 5</td>
<td>Group Characteristics II</td>
<td>104</td>
</tr>
<tr>
<td>Table 6</td>
<td>Group Characteristics III</td>
<td>105</td>
</tr>
<tr>
<td>Table 7</td>
<td>Correlations of Age and IQ with LFI Measures for Total Sample</td>
<td>106</td>
</tr>
<tr>
<td>Table 8</td>
<td>MANOVA Results for BAPQ Level on LFI Scores</td>
<td>107</td>
</tr>
<tr>
<td>Table 9</td>
<td>Estimated Margins of Means LFI scores for Rigidity Positive vs. Negative, All Participants</td>
<td>108</td>
</tr>
<tr>
<td>Table 10</td>
<td>Correlations Matrix of BAPQ Scores and LFI Scores, All Participants</td>
<td>109</td>
</tr>
<tr>
<td>Table 11</td>
<td>BAPQ Scores Compared by Gender</td>
<td>110</td>
</tr>
<tr>
<td>Table 12</td>
<td>2x2 MANOVA (Gender x BAPQ level)</td>
<td>111</td>
</tr>
<tr>
<td>Table 13</td>
<td>Univariate ANOVA Results for Gender When Analyzed with BAPQ Total Level</td>
<td>112</td>
</tr>
<tr>
<td>Table 14</td>
<td>2x2 MANOVA (Gender x Aloofness Level)</td>
<td>113</td>
</tr>
<tr>
<td>Table 15</td>
<td>Univariate ANOVA Results for Gender when Analyzed with Aloofness Level</td>
<td>114</td>
</tr>
<tr>
<td>Table 16</td>
<td>2x2 MANOVA (Gender x Pragmatic Language Level)</td>
<td>115</td>
</tr>
<tr>
<td>Table 17</td>
<td>Univariate ANOVA Results for Gender when Analyzed with Pragmatic Language Level</td>
<td>116</td>
</tr>
<tr>
<td>Table 18</td>
<td>2x2 MANOVA (Gender x Rigidity Level)</td>
<td>117</td>
</tr>
<tr>
<td>Table 19</td>
<td>Univariate ANOVA Results for Gender when Analyzed with Rigidity Level</td>
<td>118</td>
</tr>
<tr>
<td>Table</td>
<td>Description</td>
<td>Page</td>
</tr>
<tr>
<td>-------</td>
<td>----------------------------------------------------------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>20</td>
<td>Correlations Matrix for Regression Analysis Variables: BAPQ +/- level, Gender, SCQ, and LFI Scores, All Participants</td>
<td>119</td>
</tr>
<tr>
<td>21</td>
<td>BAPQ Total Prediction Model for LFI Discrimination Tests</td>
<td>120</td>
</tr>
<tr>
<td>22</td>
<td>BAPQ Total Prediction Model for LFI Emotion Tests</td>
<td>121</td>
</tr>
<tr>
<td>23</td>
<td>BAPQ Total Prediction Model for LFI Non-Face Tests</td>
<td>122</td>
</tr>
<tr>
<td>24</td>
<td>Aloofness Prediction Model for LFI Discrimination Tests</td>
<td>123</td>
</tr>
<tr>
<td>25</td>
<td>Aloofness Prediction Model for LFI Emotion Tests</td>
<td>124</td>
</tr>
<tr>
<td>26</td>
<td>Aloofness Prediction Model for LFI Non-Face Tests</td>
<td>125</td>
</tr>
<tr>
<td>27</td>
<td>Pragmatic Language Prediction Model for LFI Discrimination Tests</td>
<td>126</td>
</tr>
<tr>
<td>28</td>
<td>Pragmatic Language Prediction Model for LFI Emotion Tests</td>
<td>127</td>
</tr>
<tr>
<td>29</td>
<td>Pragmatic Language Prediction Model for LFI Non-Face Tests</td>
<td>128</td>
</tr>
<tr>
<td>30</td>
<td>Rigidity Prediction Model for LFI Discrimination Tests</td>
<td>129</td>
</tr>
<tr>
<td>31</td>
<td>Rigidity Prediction Model for LFI Emotion Tests</td>
<td>130</td>
</tr>
<tr>
<td>32</td>
<td>Rigidity Prediction Model for LFI Non-Face Tests</td>
<td>131</td>
</tr>
</tbody>
</table>
### List of Figures

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Figure 1</td>
<td>Identity Matching Tests</td>
<td>132</td>
</tr>
<tr>
<td>Figure 2</td>
<td>Face and House Dimensions Tests</td>
<td>133</td>
</tr>
<tr>
<td>Figure 3</td>
<td>Parts/Whole Test of Holistic Processing</td>
<td>134</td>
</tr>
<tr>
<td>Figure 4</td>
<td>Name Game assessment and Matchmaker Expression Test</td>
<td>135</td>
</tr>
<tr>
<td>Figure 5</td>
<td>Parts–Wholes Expression assessment Test</td>
<td>136</td>
</tr>
</tbody>
</table>
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List of Abbreviations

ASD: Autism Spectrum Disorder

BAP: Broad Autism Phenotype

BAPQ: Broad Autism Phenotype Questionnaire

LFI: The Let’s Face It Skills Battery

SCQ: The Social Communication Questionnaire
Face Processing in the Broad Autism Phenotype: Exploring Face Processing as an Endophenotype of Autism Spectrum Disorder

Abstract

By

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The Broader Autistic Phenotype (BAP) consists of milder Autism Spectrum Disorder (ASD) characteristics that occur in some relatives of people with ASD. The core ASD deficits in communication, socialization, and stereotyped/repetitive behavior have been found to manifest themselves separately in the BAP. Due to the strong hereditary nature of ASD, the ASD components expressed in family members of people with ASD meeting criteria for the BAP can serve as endophenotypes in the study of ASD. Many of the social problems experienced by people with ASD stem from deficits in facial processing. Since the BAP consists of mild socialization impairment, face processing has also been studied in relatives of people with ASD, with results showing subclinical similarity to ASD. Lacking in these face processing studies has been: the examination of typical ASD face processing strategies, attention to the siblings of people with ASD who meet criteria for the BAP, and examination of the relationship of the severity level of the proband with ASD to the BAP level and face processing ability of the relatives of people with ASD. This study measured face identity discrimination and emotion recognition in 178 parents and siblings of people with ASD using the Let's Face It Skills Battery. In addition, participants were assessed on the Broad Autism Phenotype Questionnaire, and the Social Communication Questionnaire. While overall face processing scores of family members of people with ASD meeting criteria for the BAP were similar to those
family members not meeting BAP criteria, relatives of people with ASD scoring high on the BAPQ component of Rigidity performed worse on face processing measures than relatives of people with ASD scoring low on Rigidity. BAPQ scores did show some negative correlations with LFI scores, i.e. the higher the BAPQ score the lower the LFI score. In addition, it was found in families of people with ASD that males had higher BAP levels and worse face discrimination processing skills than females. Finally, when BAP level, gender, and severity of the proband with ASD were placed a multiple regression model to predict LFI performance, it was found that overall the model was a better fit than just IQ alone, with BAPQ Rigidity level, BAPQ Pragmatic Language, and Gender as the significant predictors of LFI score. The results indicate that while face processing is an endophenotype of ASD, it may be more related to Rigidity components that social Aloofness. Besides drawing attention to face processing interventions for people with ASD that build on the component of Rigidity rather than correcting social Aloofness, this study may also help clinicians better understand the profiles of the families of people with ASD as well.
Introduction

Autism spectrum disorder (ASD), also referred to as Pervasive Developmental Disorders, is a class of disorders characterized by impairments in social interactions and communication, coupled with stereotyped, repetitive behaviors and restricted interests (APA, 2000; Chawarska, Volkmar, and Klin, 2010; Annaz, Karmiloff-Smith, Johnson, & Thomas, 2009). Until recently, there were five specific diagnoses that make up the spectrum: Autistic Disorder, Asperger’s Disorder, Pervasive Developmental Disorder, NOS; Rett’s Disorder; and, Childhood Disintegrative Disorder (APA, 2000). However, now all the specific diagnoses have been classified as one disorder – ASD (APA, 2013). ASD affects between 1 in 68 and 1 in 240 individuals, for an average of 1 in 110 (CDC, 2014). Prevalence rates increase for males with a rate of 1 in 42 compared to 1 in 189 for female ratio (CDC, 2014). 31% on average of the children who have ASD also have an intellectual disability (IQ <=70) (CDC, 2014). While there is strong hereditary and genetic nature of ASD (Bailey et al., 1995; Folstein & Rutter, 1977) no single genetic cause has been found that accounts for the disorder. In fact, to the contrary, ASD has been shown to have a great genetic variability that includes the interaction of multiple genes that appear to predispose a person for ASD (Szatmari, 1999; Jones & Szatmari, 2002; Sebat et al., 2007; Wassink, Brzustowicz, Bartlett, & Szatmari, 2004). In order to deal with the genetic heterogeneity of ASD, endophenotypes can be examined that isolate the component characteristics of ASD (Gottesman & Gould, 2003; Losh & Piven, 2007). One such endophenotype that has been studied is one that consists of milder ASD characteristics that occur in some relatives of people with ASD, termed the Broad Autism Phenotype (BAP; Bolton et al., 1994, Piven et al., 1997). As opposed to ASD that must
include deficits in communication, socialization, and repetitive behavior, the BAP is thought to be the manifestation of the same ASD genes but the three core ASD behaviors now separate into unique endophenotypes that are narrower in scope than ASD (Losh & Piven, 2007; Pickles et al., 2000; Piven et al., 1997). This division of the full ASD phenotype into endophenotypes occurs since the number of genes required to produce a less complex phenotype is less than needed to bring about the full phenotype (Gottesman & Gould, 2003). The core ASD deficit of socialization has been found to manifest itself in isolation in a unique BAP endophenotype, perhaps even more strongly than other BAP traits (Sung et al., 2005), and has thus been studied (Bolton et al., 1994; Losh, Childress, Lam, & Piven, 2008; Piven et al., 1997).

Successful socialization in both typically developing children and healthy adults involves processing information from faces (Bryant, 1991; Ellis & Fin, 1990), including identity and emotions. While the DSM-IV (APA, 2000) does not list face processing deficits as a core feature, it does list impairments in eye gaze and facial expression as typical features. Therefore, it has been proposed that many of the social problems experienced by people with ASD stem from deficits in facial processing (Hobson, Ouston, & Lee, 1989a; Hobson, Ouston, & Lee, 1989b; Langdell, 1978; Joseph & Tanaka, 2003). Studying face processing in ASD may not only help to explain the etiology and sustaining of social problems in ASD, it may also help to establish diagnostic criterion and may help to identify subgroups amongst the larger heterogeneous population of those with ASD (Sasson, 2006). Since the BAP has also been shown to consist of mild socialization impairment, face processing has also been studied in relatives of people with ASD (Adolphs, Spezio, Parlier, & Piven, 2008; Baron-Cohen,
Wheelwright, & Jolliffe, 1997; Bolte et al. 2003; Dawson et al., 2005a; Losh & Piven, 2007; Losh et al., 2009; Smalley & Asarnow, 1990; Wilson, Freeman, Brock, Burton, & Palermo, 2010; Wallace, Sebastian, Pellicano, Parr, & Bailey, 2010). Mild face processing impairments resembling those of ASD may not only help to further define the BAP but may specifically help to clarify face processing deficits in people with ASD (Adolphs et al., 2008; Losh et al., 2009).

**The Broad Autism Phenotype**

Following up the finding that autism (ASD) and epilepsy frequently occur together (Rutter, 1970), indicating that autism is a brain based disorder, the team of Folstein and Rutter (1977) published genetic testing results showing that the concordance rate of autism was higher in monozygotic (MZ) twins than dizygotic twins (DZ), 36% compared to 0%. This concordance rate difference between MZ and DZ was demonstrated to be even greater when Bailey et al. (1995) found a rate difference of 60% for MZ twins and 0% for DZ twins. Current figures places the twin ASD concordance rates at 60-96% for MZ twins and 0-23% for DZ twins (Gerdts & Bernier, 2011). The DZ twin rate of ASD is approximately that of siblings of individuals with ASD, 2-3%, which is higher than the general population rate (Baron-Cohen & Hammer, 1997). In addition, there is a 20% risk for later born siblings of children with ASD to be born with ASD (Ozonoff et al., 1991).

Besides showing higher rates of autism in MZ twins, Folstein and Rutter (1977) observed a more general phenotype of ASD like features, low levels of language and cognition, which had a higher rate of concordance in the MZ twins than even the high concordance rate of autism. This suggested that ASD features could be inherited in
relatives of people with ASD, whom themselves do not deserve an ASD diagnosis, in the form of milder forms autistic traits (Bailey et al., 1995, Bolton et al., 1994; Losh, Adolphs, & Piven, 2011) that would eventually be termed the Broad Autism Phenotype (BAP; Bolton et al., 1994). While the BAP was originally measured through qualitative family histories (IMGSAC 2000; Landa et al., 1992; Santagelo & Folstein, 1995; Tyrer et al., 1988), it is now documented with quantitative measures (Baron-Cohen, Wheelwright, Skinner, Martin, & Clubley, 2001; Constantino et al., 2005; Dawson et al., 2007; Hurley et al. 2007). The combined empirical proof that ASD has a strong genetic component and that relatives may share milder characteristics of ASD was in fact a delayed confirmation of a notion originally posed by both Leo Kanner (1943) and Hans Asperger (1944) that parents and relatives had a biological connection to ASD. Yet, this idea of ASD having a strong hereditary component had been misinterpreted by the psychodynamic movement that proposed the early influence of parent behavior on a children caused children to develop ASD (Bailey, Palferman, Heavey, & Le Conteur, 1998).

A characteristic of the BAP that has been widely studied is personality (Bolton et al., 1994; Losh et al., 2008; Narayan et al., 1990; Piven et al. 1994: Piven et al., 1997 Szatmari et al., 2000; Wolff, Narayan, & Moyes, 1988). Early BAP studies (Wolff et al., 1988; Narayan et al., 1990) found that parents of people with ASD were more likely than the comparison group to have schizoid personality, i.e., limited emotions and narrowly defined interests. In the first large study of parents and siblings of people with ASD, social personality characteristics deficits of limited affection, friendships, and social play were observed to be more prevalent than the other personality characteristics already
documented (Bolten et al., 1994).

Further studies of the BAP attempted to use more direct and valid measures that quantified BAP characteristics based on sample populations (Piven et al. 1994; Piven et al., 1997). When compared to parents of people with Down syndrome, parents of children with ASD have been shown to exhibit higher rates of the social characteristics deficits such as aloofness, untactful, and undemonstrative. It has been reported that parents of people with ASD from multiplex families (i.e. more than one child with ASD) when compared to typical comparisons, show more social aloofness, have fewer friendships, are more likely to have rigid personalities, and display increased rates of anxiety (Piven et al., 1997). These findings (Piven et al., 1994; Piven et al., 1997) have been replicated in follow-up studies (Losh et al., 2008; Murphy et al., 2000).

Research that compared simplex families of people with ASD (i.e., only one child with ASD), multiplex families of people with ASD (i.e., more than one child with ASD) and adoptive parents of people with ASD found that adoptive parents did not display any BAP characteristics, whereas simplex parents had BAP traits, and multiplex parents displayed the most BAP traits (Szatmari et al., 2000). Another study compared simplex families of children with ASD, multiplex families of children with ASD, and families of children with Down Syndrome (Losh et al., 2008). Social aloofness and rigid personality features occurred most in the multiplex families, less in the simplex families, and the least in the families of children with Down syndrome (Losh et al., 2008). Similarly, multiplex families had the least number of friendships, simplex families had more friendships than the multiplex families, and families of children with Down syndrome had the most friendships (Losh et al., 2008). These BAP studies provided further
evidence of multiplex families of people with ASD having a greater genetic loading than simplex families of children with ASD (Piven & Folstein, 1994; Constantino et al., 2010), and so BAP traits would occur in a greater “dosage” in multiplex families than simplex families. Some research indicates that it is specifically male siblings (Virkud, Todd, Abbacchi, Zhang, & Constantino, 2009) and fathers of children with ASD (De La Marche et al., 2012) who are carrying the most ASD genetic loading of all relatives of people with ASD.

Social characteristics and skills, as well as restricted behaviors have also been examined in the BAP literature (Bolton et al., 1994; Piven et al., 1997; Wolff et al., 1988). Wolff et al., (1988) observed a higher rate of social impairment in parents of people with ASD than parents of other children with other developmental disabilities. Bolton et al., (1994) found a significantly higher proportion of siblings and parents of children with ASD to have social impairments and restricted behavior than controls from families with a child with Down syndrome. Other research (Piven et al., 1997) reported higher levels of social impairment (i.e., aloofness) and restrictive/ repetitive behavior (i.e., difficulty adjusting to change) were in sibling and parents of children with ASD when compared to relatives of children with Down syndrome.

Another area of BAP research has examined delays in language development in siblings of children with ASD (Gamliel, Yirmiya, & Sigman, 2007; Shaked et al., 2006 Yirmiya et al., 2007) and parents of children with ASD (Bolton et al., 2004; Murphy et al., 2000; Pickles et al., 2007). Pragmatic language deficits are the most common type of language trouble in ASD (Capps, Kehres, & Sigman, 1998; Losh & Caps, 2003; Tager-Flusberg & Sullivan, 1995). Pragmatic language difficulties have also been identified in
relatives of people with ASD (Landa, Folstein, & Isaacs, 1991; Landa et al., 1992). These pragmatic language difficulties manifested themselves in tangential and fragmented discourse, as well production of stories that received lower quality ratings than controls (Landa et al., 1991). In addition, it was observed that parents of children with ASD have a preoccupation with specific topics, are too talkative, and give disjointed verbal accounts (Landa et al., 1992). More recent work has found a similar ASD like use of pragmatic language in simplex and multiplex families of people with ASD (Losh et al., 2008). Multiplex families of people with ASD had the most pragmatic language issues, followed by simplex families of people with ASD, and the least in parents of people with Down Syndrome (Losh et al., 2008). Hence, pragmatic language is an indicator of the genetic propensity for the BAP in families.

BAP research on cognitive profiles has shown mixed results (Folstein & Rutter, 1977; August, Stewart, & Tsai, 1981; Bailey et al., 1995; Baird & August, 1985, Folstein et al., 1999; Fombonne et al., 1997; Minton et al., 1982, Piven et al., 1997). Intellectual delays and disability along with problems in reading and spelling have been documented in relatives of people with ASD (Folstein & Rutter, 1977; August et al., 1981; Baird & August, 1985, Folstein et al., 1999; Minton, Campbell, Green, Jennings, & Samit, 1982; Piven et al., 1997). However, other BAP studies have not found evidence to support higher levels of intellectual delay and disability in relatives of people with ASD, but did find higher prevalence of reading and spelling delays (Fombonne, Bolton, Prior, Jordan, & Rutter, 1997; Piven & Palmer, 1997; Szatmari et al., 1993; Bailey et al., 1995). Baird and August (1985) observed lower IQ in relatives of people with ASD only when the person with ASD had an intellectual deficiency but not when the person with ASD had
normal intelligence. An IQ performance split has been found amongst siblings of people with ASD, with verbal IQ being lower than performance IQ (Leboyer, Plumet, Goldblum, Perez-Diaz, & Marchaland, 1995; Minton et al., 1982), similar to that seen in probands with ASD. Evidence for lower performance IQ in parents of children with ASD than comparison groups has been reported (Folstein et al., 1999; Piven & Palmer, 1997; Schmidt et al., 2008). Fombonne et al., (1997) found siblings and parents of people with ASD to have higher verbal IQ than comparison relatives of people with Down syndrome. In addition, the relatives of people with ASD who scored higher on the BAP had lower IQs than the relatives of people with ASD not meeting criteria for the BAP. Yet, there are also studies than have not found any difference in IQ areas (Bishop et al., 2004; Pilowsky, Yirmiya, Shalev, & Gross-Tsur, 2003; Szatmari et al., 1993; Szatmari et al., 1995). Since the evidence on intelligence differences has not been as overwhelming as personality and language deficits, intelligence has not generally been included in standard BAP measures (Baron-Cohen et al., 2001; Constantino et al., 2005; Dawson et al., 2007; Hurley et al., 2007).

Prevalence of psychiatric illness in relatives of people with ASD has also been well studied (Bolton, Pickles, Murphy, & Rutter, 1998; Daniels et al., 2008; Hollander et al., 2003; Ingersoll & Hambrick, 2011; Losh et al., 2011; Micali et al., 2004; Piven et al., 1991; Piven & Palmer 1999; Smalley et al., 1995; Piven et al., 1991). Higher rates of affective disorder have been found in siblings of people with ASD compared to siblings of people with Down syndrome and the general population rates (Piven et al., 1991). Parents of children with ASD have been reported to exhibit elevated rates of affective disorder and anxiety disorder (Bolton et al., 1998; Daniels et al., 2008; Hollander et al.,
Higher levels of obsessive-compulsive disorder (OCD) have also been documented in Relatives of people with ASD (Bolton et al., 1998; Hollander et al., 2003; Micali et al., 2004). Yet, other studies did not find OCD levels to be higher in Relatives of people with ASD than Down syndrome (Piven et al., 1991; Piven & Palmer, 1999). This particular difference in OCD prevalence is thought to be the result of previous studies not making a distinction between ASD rigidity characteristics (i.e., minimal interest in or difficulty acclimating to change), which were high in parents of children with ASD, and OCD characteristics (i.e., clinical levels of obsessive and compulsive behaviors (Piven & Palmer, 1999). While it might be thought these higher levels of parental mood and anxiety issues would be a direct result of facing the difficulty of raising a child with ASD, evidence shows that episodes of depressive mood and anxiety occurred prior to the birth of the children with ASD (Bolton et al., 1998, Piven & Palmer, 1999), although parent coping strategies and the child’s ASD severity can still be mediating factors (Ingersoll & Hambrick, 2011).

Specifically analyzing the relationship of BAP measures and psychiatric illness in relatives of people with ASD, it was found that severity of affective disorder and anxiety did correlate with BAP level (Bolton et al. 1998; Micali et al., 2004; Piven & Palmer, 1999). In addition, Bolton et al. (1998) reported higher rates of OCD in parents of children with ASD measuring high on BAP social and communication domains. Unexpectedly, a higher rate of affective disorder in parents of children with ASD was also found in those who did not score high on the BAP (Piven & Palmer, 1999). This finding suggested that the higher rates of affective disorder amongst parents of children with ASD that had been reported in the literature (Bolton et al., 1998; Daniels et al.,
might be a result of assertive mating between people high on the BAP with people suffering from affective disorder (Piven & Palmer, 1999; Losh et al., 2011). However, more recent research, using a dimensional BAP measure that adds more power and sensitivity than the categorical BAP measures of previous studies, has shown a positive correlation between symptoms of depression and BAP level based on parent self report (Ingersoll & Hambrick, 2011). In an attempt to determine how severe some of these aforementioned personality issues are in relative of people with ASD, research explored if the personality characteristics found in people scoring high on the BAP were severe enough to justify a clinical diagnosis of a personality disorder (Piven, 2002). Findings indicated the majority of the parents of children with ASD did not have a personality or other disorder related to the BAP features (Piven, 2002). Overall, psychiatric disorders appear to occur more frequently in parents of children with ASD, but there is not overwhelming evidence as to whether or not these disorder are in any way a defining characteristics of the BAP (Piven et al., 2011).

Overall, the literature suggests that the BAP refers to a genetic liability to the ASD phenotype as expressed in: personality traits, language/communication, and social & behavioral characteristics (Gerdt & Bernier, 2011; Piven, 2001; Losh et al., 2011). Just as there is a disproportionate number of males to females with ASD, so too the BAP has generally been found to be at higher levels in men than women (Bolton et al., 1994; Piven et al., 1997; Pickles et al., 2000; Schwichtenberg, Young, Sigman, Hutman, & Ozonoff, 2010; Wheelwright, Auyeung, Allison, & Baron-Cohen, 2010). It is important
to note that not all relatives of people with ASD exhibit BAP characteristics. The majority of studies indicate that at least half of the relatives of people with ASD do not have significant BAP levels (Wolff et al., 1988; Landa et al., 1992; Piven et al., 1997; Whitehouse, Barry, & Bishop, 2007). In addition, when these BAP traits are present, they do not manifest themselves as a typical ASD functional impairment, rather they are mild personality dispositions (Losh et al., 2011) and not in the clinical range (Gerdts & Bernier, 2011).

It should be noted that there have been significant limitations in the BAP studies. Constructions of BAP assessment measures have varied, resulting in different findings. Some BAP assessments use qualitative measures (Bolton et al., 1994), while others use quantitative measures (Hurley et al., 2007); some BAP measures use self-report (Bishop et al., 2003), while others use direct observation (Dawson et al., 2007); some BAP assessments are categorical (Piven et al., 1994), while others are dimensional (Baron-Cohen et al., 2001). This has resulted in different functional definitions of the BAP. The diagnostic criteria for ASD have varied between studies (Ingersoll, Hopwood, Wainer, and Donnellan, 2011). The type of control group used has not been consistent (e.g., relatives of typically developing children and relatives of children with Down syndrome). There may be bias in terms of subject selection, which has frequently been done through existing clinical samples of people with ASD from other studies that result in higher proportions of relatives of people with ASD who are on the BAP (Losh & Piven, 2007). The ages of the relatives of people with ASD have also varied from study to study. Finally, the samples of relatives of people with ASD have varied from study to study, which may include one or a few of the following: parents, siblings, grandparents,
biological relatives, non-biological relatives, simplex families, and multiplex families. All of the aforementioned limitations have created difficulty in terms of the generalizability and the comparison of study results given the relatively limited amount of studies.

*Face processing in Autism Spectrum Disorder*

As early as 1943, Leo Kanner noted that people with ASD have problems making appropriate eye contact and attending to faces (Sterling et al., 2008). Empirical studies of facial processing in ASD began in 1978 with Langdell (1978) who found that when compared to typically developing comparison group, young and older adults with ASD based their facial recognitions on lower parts of the face and did not show the negative effects of recognition caused by inverting viewed faces, which had already been established as an effect occurring in typically developing individuals (Valentine, 1988). Langdell’s work spawned a wealth of studies, many with mixed and often difficult to resolve findings (as reviewed in Harms, Martin, & Wallace, 2010; Weigelt, Koldewyn, & Kanwisher, 2012), that have addressed the issue of abnormalities of facial processing in ASD. Face processing studies of people with ASD have generally focused on facial recognition, facial discrimination, and emotional recognition (Boucher & Lewis, 1992; Deruelle, Rondan, Gepner, & Tardif, 2004; Gauthier, Klaiman, & Schultz, 2009; Hobson et al., 1988; Joseph & Tanaka, 2003; Klin et al. 1999; Tanaka et al., 2012; Wolfe et al., 2008). Studies have included various methodological techniques, including behavioral measures, eye-tracking, electrophysiological measures, and brain imaging (Annaz et al., 2009, Grice et al., 2005; Harms et al., 2010; Tanaka et al., 2012; Weigelt et al., 2012; Wolfe et al., 2008). In turn, these various facial processing studies have resulted in a
number of theories that attempt to account for both how faces are processed by people with ASD and the general causes of the social problems in ASD (Chawarska, Klin, Paul, Macari, & Volkmar, 2009; Golan et al., 2008; Kleinhans et al., 2009; Loth et al., 2010; Sterling et al., 2008). Finally, applied research has proposed methods to improve the impoverished facial processing skills of people with ASD (Bolte et al., 2006; Golan et al., 2010; Tanaka et al., 2010).

It has been hypothesized that atypical face processing in people with ASD is due to insufficient orienting to faces stemming from the lack of attention bias to faces commonly reported in children with ASD (Chawarska et al., 2010; Kikuchi et al., 2009). Behavior observation studies, beginning in infancy, have shown that children with ASD look less at the faces of other people than typically developing children or children with other learning disabilities (Chawarska, Klin, & Volkmer, 2003; Chawarska & Shic, 2009; Joseph & Tanaka, 2003; Osterling & Dawson, 1994). Yet, some studies have found no difference in the face orienting of children with ASD compared to typically developing children (Dawson, Hill, Spencer, Galpert, & Watson, 1990; Joseph & Tager-Flusberg, 1997; Werner, Dawson, Osterling, & Dinno, 2000). A recent review of the literature related to face identity perception in people with ASD reported that, when weighing the evidence for and against, overall people with ASD show most of the normal hallmarks of face processing (face inversion effect, part-whole effect, face composite effect) but nonetheless do not process face identity as well as typically developing individuals (Weigelt et al., 2012). This impairment in face identity perception appears to be driven by specific problems in memory for faces and eye discrimination (Weigelt et al., 2012). It is surprising that Weigelt et al. (2012) do not present reliance on eyes vs. mouth as a
typical marker of face processing or in conjunction with the specific markers of face
processing since when the condition of eyes vs. mouth is considered, cases with ASD
present many irregularities of the typical markers of face processing (Tanaka et al., 2012;
Wolfe et al., 2012). Weigelt et al., (2012) dismisses the proof for abnormal face
processing in the hallmark areas without considering the more complex cases in which it
is manifest (Tanaka et al., 2012; Wolfe et al., 2012). In some eye-tracking studies,
people with ASD displayed less fixation on faces, particularly less on the eyes, and more
on body parts (Kikuchi et al., 2009; Klin, Warren, Shultz, Volkmar, and Cohen, 2003),
but this may be limited to viewing social and dynamic scenes (Kikuchi et al., 2009).
Based on eye-tracking studies, children with ASD showed a preference for identifying
faces by the mouth area (Klin, Jones, Schultz, Volkmar, & Cohen, 2002). Unlike
typically developing children, children with ASD do not detect faces faster than regular
objects, which may reduce cortical development of face expertise (Chawarska et al.,
2010; Kikuchi et al., 2009). Since children with ASD lack an attentional bias for faces
(Chawarska et al., 2010), the lack of attention leads to lack of exposure to faces
(Chawarska et al., 2010; Kikuchi et al., 2009). In addition to lacking an attentional bias
for faces, many of the behavioral and eye-tracking studies suggest that when people with
ASD are processing faces, they show a greater reliance on features (Klin et al., 2002;
Wolfe et al., 2008). A reliance on facial features, less of an inversion effect for faces, and
better object perception than their face abilities, suggests that people with ASD process
faces as objects (Shultz et al. 2000). Processing faces as object is in accordance with the
theory of Weak Central Coherence (Frith, 1989; Schultz et al., 2000), which argues that
the problems experiences by people with ASD are caused by the inability of the brain to
integrate information, especially in terms of having a bias towards local rather than global processing.

Most functional neuroimaging studies indicate that people with ASD show abnormal processing of faces (Gauthier et al., 2009). Some of these fMRI studies have shown weak activation, or hypoactivity, of the fusiform gyrus, which is normally activated in facial perception (Annaz et al., 2009; Corbett et al., 2009; Dalton et al., 2005; Gauthier et al., 2009; Schultz et al., 2000; Kikuchi et al., 2009) and more inferior temporal gyrus activation, which is associated with common object recognition (Schultz et al., 2000). Even when activated for faces, the fusiform activation has been shown to be more lateral and more inferior than the comparison group (Koshini et al., 2009; Schultz et al., 2000), which suggests a facial processing in people with ASD that is similar to the normal processing of non-facial objects, which are processed at the level of features. The fusiform area has also been shown to have a reduced connectivity with the frontal brain areas, implying an abnormal cortical network (Koshino et al., 2009). There is evidence that decreased activity of the fusiform gyrus is related to decrease in time spent fixating on the eyes (Corbett et al., 2009; Dalton et al., 2005). While the fusiform area has activated normally in subjects with ASD for familiar vs. non-familiar faces (Hadjikhani et al., 2004; Sterling et al., 2008), the majority of studies report impairment (Corbett et al., 2009). Due to the relation of the fusiform gyrus to eye-gaze fixation, the fact that the fusiform area has an under activation for faces may be the result of reduced eye-gaze fixation, i.e., how the face is scanned effects how the fusiform area functions (Dalton et al., 2005). There is evidence that when expertise is developed for an initially novel object, the fusiform gyrus becomes activated (Gauthier et al., 1999). Research on a
subject with ASD, who had expertise in a particular cartoon character (Digimon), not only discriminated the Digimon pictures better than familiar faces and common objects but his lateral fusiform gyrus and amygdala activated more in response to Digimon pictures than faces and objects (Grelotti et al., 2005). In addition, brain activity has been measured in high functioning adult ASD participants before and after receiving facial affect recognition training (Bolte et al., 2006). While there was improvement in emotion recognition for the subjects with ASD, there was no accompanying increase in activity of the fusiform gyrus in the participants with ASD. However, there was increase in activity in two compensatory face processing regions: medial occipital gyrus and the superior parietal lobule, which indicates that other brain regions may specialize for faces. In a recent study (Perlman et al., 2011), ASD participants displayed hypoactivation of the fusiform gyrus in normal viewing of faces showed normal level of fusiform gyrus activation when visual scan patterns were forced to the eyes. Thus, the research revealing a hypoactivation of the fusiform gyrus indicates that people with ASD may not share a functional brain based expertise for faces that typically developing people do. Although, the question remains if this brain based expertise is endowed from birth, comes with experience, or has elements of both hardwiring and experience.

Behavioral research suggests that people with ASD use different strategies to process faces from normal controls although there is debate as to what types of strategies people with ASD use to process faces (Gauthier et al., 2009). One theory proposes that they use a part based strategy rather than the normal holistic method as measured (Annaz et al., 2009; Behrmann et al., 2006; Lahaie, et al., 2006; and, Gauthier et al., 2009). Research found that children with ASD only processed faces in a holistic strategy,
including an inversion effect, when recognition was dependent upon the mouth but not when recognition was based on the eyes (Tanaka & Farah, 1993). This lack of an inversion effect and high attention to the mouth area has been confirmed in many studies (Hobson et al., 1988; Langdell, 1978; and Klin et al., 2002). Yet, other studies have failed to find these effects or found them only in the presence of a cued condition (Lopez et al., 2004; Teunisse & de Gelder, 2003). Using more complete holistic measures of facial processing, a composite paradigm (matching misaligned and aligned tops and bottoms of faces) as opposed to a whole-part test (face features viewed in isolation vs. face features in the whole face), finding showed that people with ASD can be driven to process faces holistically by the context of the task but when left to process faces without contextual cues they do not process faces holistically (Gauthier et al., 2009). Unfortunately, most of this research is limited to people on the high functioning end of ASD, so it is uncertain whether or not these results generalize to lower functioning individuals (Annaz et al., 2009).

Abnormal processing of faces in people with ASD has also been shown in ERP (event related potential) studies (Corbett et al., 2009; Gauthier et al., 2009). For example, people with ASD had atypical readings in the face sensitive ERP wave component (N170) with more extended N170 waveform signals for faces than typical controls, no difference in the N170 component for non-face objects, and no typical difference between upright and inverted faces (McPartland, Dawson, Webb, Panagiotides, & Carver, 2004). These results indicate: slower than normal face processing, a lack of normal sensitivity to face configuration, typical recognition of non-face objects, and an inability to take advantage of the way faces are presented in the
normal environment (McPartland et al., 2004). Also using ERP readings, it was found that neural correlates of eye gaze processing have a physiological effect in people with ASD similar to that observed in infants (Grice et al., 2005). Children with ASD had an enhanced negativity over the occipito-parietal electrode sites in response to direct gaze, which was similar to infants, while age-matched controls, like adults, showed no sensitivity to gaze direction (Grice et al., 2005). Therefore, people with ASD show delay in learning and reacting to averted gaze compared to typical controls (Grice et al., 2005). This result may be based on featural processing of the face by people with ASD, since people who use more advanced configural processing do not show the delays in learning and reacting to averted gaze (Grice et al., 2005). Finally, a large proportion of the brain responses to facial expression as measured by ERPs have been linked to genetic factors (Anokhin, Golosheykin, & Heath, 2010). Thus, the ERP component may not only explain face processing deficits in ASD, but may also serve as an endophenotype for genetic studies of disorders with an impaired social behavior due to the fact that they are heritable (Anokhin et al., 2010).

The determination as to whether or not people with ASD have deficits in the recognition of facial emotions is inconclusive, so much so that a recent review of the literature had a primary focus of discussing the different methodologies used by various face emotion studies that have led to the mixture of results (Harms, Martin, & Wallace, 2010). Difficulty in people with ASD recognizing the emotions of anger, disgust, and sadness has been demonstrated (Bolte & Poustka, 2003; Boraston, Blakemore, Chilvers & Skuse, 2007; Celani, Battacchi & Arcidiacono, 1999), as well as trustworthiness and jealousy (Adolphs, Sears, & Piven, 2001; Rump, Giovannelli, Minshew, & Strauss,
Yet, according to other research, emotion recognition for people with ASD is not impaired relative to typical controls (Castelli, 2005; Grossman, Klin, Carter, & Volkmar, 2000; Ozonoff, Pennington, & Rogers, 1990). The discrepancies appear even within individual studies, for example, Tanaka et al. (2012) recently reported intact abilities in emotion labeling but deficits in the ability to generalize emotions across different face identities. These discrepancies have been attributed to different ages of the samples of people with ASD, variation of matching criteria (e.g. verbal vs. non-verbal IQ), and the difficulty of the face emotion recognition tasks (Harms, Martin, & Wallace, 2010). As in face identity recognition, when the emotion recognition of people with ASD is measured, while accounting for the reliance on the eyes and mouth, an impairment in people with ASD has been noticed (Tanaka et al., 2012); people with ASD encode the eyes based on individual features and the mouth holistically, which is the opposite of typical comparisons (Tanaka et al., 2012).

Since the amygdala is the brain region considered to be the seat of emotion regulation, the “amygdala theory of autism” hypothesizes that the early dysfunction of the amygdala could be responsible for the problems in social and emotional functioning in people with ASD (Baron-Cohen et al., 2000; Corbett et al., 2009). The superior temporal sulcus and the amygdala, both regions of the ‘social brain’, have displayed atypical activation in studies of people with ASD (Corbett et al., 2009). This atypical functioning of the amygdala is based on: postmortem studies of brains, MRIs, and fMRIs (Corbett et al., 2009: Schultz et al., 2000). There are also volumetric brain studies of people with ASD showing that the amygdala starts out enlarged in young children and reduces in size into adulthood (Courchesne et al., 2011; Kleinhaus et al., 2009). In
addition, it is reported that the severity of ASD is related to the amygdala growth pattern with the most severe cases showing extra growth in childhood and decrease to the point of atrophy in adulthood (Kleinhaus et al., 2009). Research reveals that children with ASD are accurately able to match facially expressed emotions but have limited activation of the amygdala and relied on other neural networks, including frontal and parietal regions (Ashwin et al., 2007; Baron-Cohen et al., 1999; Critchley et al., 2000; Corbett et al., 2009). Hence, compared to typical controls, people with ASD utilize different neural brain regions to recognize emotions (Ashwin et al., 2007; Baron-Cohen et al., 1999; Critchley et al., 2000; Corbett et al., 2009). The ability to accurately identify emotions but not properly utilize the amygdala may suggest that the appropriate emotional valence and social significance are not being attached to these emotions (Corbett et al., 2009). It has also been established that an anatomical dysfunction exists between the connection of the amygdala and fusiform gyrus with the amygdala determining the fusiform gyrus activity so the emotional processing may be connected to the identity recognition (Herrington et al., 2011; Schultz et al., 2005). In addition, activation of the amygdala is positively related to the time spent fixating on the eyes (Corbett et al., 2009; Dalton et al., 2005), so it is proposed that the diminished eye gaze in people with ASD helps to reduce the hyperactive reaction of the amygdala to social stimuli (Dalton et al., 2005). Additional research (Kleinhaus et al., 2009) reports that the amygdala in people with ASD does not habituate as quickly to face stimuli over time as normal controls and thus remains hyperactive. This runs counter to the research (Dalton et al. 2005) that interpreted the hyperactivation of the amygdala as an increased sensitivity to social related events and stimuli. Instead, the interpretation is that there is an initially normal
hyperactivation of the amygdala in people with ASD that does not diminish with
habituation as it would in typically developing individuals (Kleinhaus et al., 2009). Since
neural habituation demonstrates learning, the research indicates that people with ASD are
not learning face stimuli (Kleinhaus et al., 2009; Lombardo, Chakrabarti, & Baron-
Cohen, 2009). Forcing the direction of visual scan path to the eye region in people with
ASD activated the fusiform gyrus to typical levels in contrast to the amygdala that could
not be forced to normal levels of activation (Perlman et al., 2011). Since the amygdala
appears to direct eye movement to emotional faces in typically developing individuals
and this is disrupted in people with ASD (Perlman et al., 2011), there is a great deal of
support for the amygdala theory of ASD. Given the aforementioned information on
amygdala, if impairment is not found in face emotion processing in people with ASD, it
may very well be due to the result of methodological issues that need to be resolved
(Harms et al., 2010).

Face processing problems have been linked to social impairments in people with
ASD (Annaz et al., 2009; Grice et al., 2005; Klin et al., 1999; Lombardo et al. 2009;
Tanaka et al., 2012; Wolfe et al., 2008). Numerous behavioral, brain-imaging, and eye-
tracking studies have helped to delineate the intricacies and contradictions of the facial
processing found in people with ASD (Annaz et al., 2009; Dalton, Holsen, Abbeduto, &
Davidson, 2008; Harms et al., 2010; Sasson et al., 2006; Weigelt et al., 2012).
Limitations of these studies include small sample sizes lack of low functioning subjects
with ASD that are not true representations of the overall population with ASD, not
matching the subjects on their level of face expertise or experience that does not take into
consideration their skill level, lack of longitudinal studies that would measure the
developmental aspect of face processing, and technical limitations of measurement devices/ instruments that may rely to heavily on verbal components and may not be sensitive enough to the face processing strategies of people with ASD.

In conclusion, the research on facial processing has generated a number of theories attempting to explain the facial perception deficits of people with ASD (Chawarska et al., 2009); these include: limited experience/ lack of expertise with faces; feature based processing as opposed to normal holistic face processing; and, atypical face scanning strategies (Chawarska et al., 2009). The face processing theories of people with ASD have helped to spawn general theories of ASD which include: the Weak Central Coherence (Frith, 1989) arguing that the problems of people with ASD are caused by the inability to integrate information; and, the “amygdala theory of autism”, which finds the early dysfunction of the amygdala as being responsible for the problems in social and emotional functioning in people with ASD (Baron-Cohen, 2002; Corbett et al, 2009).

However, since ASD presents such a wide range of level and variability from person to person, it may be impossible to uniformly and unequivocally define how facial processing occurs in ASD. Rather, a multi-level/ multi-system approach (Corbett, et al., 2009) working at different levels may be a more appropriate explanation of face processing in people with ASD. Therefore, the need is overwhelming to look for endophenotypes of the ASD face processing deficits that may limit and isolate the impairments enough to elucidate them better.

*Face Processing in Relatives of people with ASD*

Smalley and Asarnow (1990) were the first to examine the possibility of ASD like face processing deficits in relatives of people with ASD without intellectual deficiency.
Results from this pilot study (Smalley & Asarnow, 1990), indicated that siblings of people with ASD, while not displaying deficits, exhibited more difficulty on face emotion recognition than identity recognition, similar to people with ASD. While the trend was not a significant difference between emotion and identity recognition, typical comparisons did not show a similar pattern (Smalley & Asarnow, 1990). In addition, no indication of deficits commonly found in people with ASD was observed in parents of children with ASD (Smalley & Asarnow, 1990). The initial research of Smalley and Asarnow (1990) triggered a line of research comparing the face processing abilities of both siblings of people with ASD and parents of children with ASD with ASD probands and controls (Adolph et al., 2008; Baron-Cohen et al., 1997; Bolte et al. 2003; Dalton, Nacewicz, Alexander, & Davidson, 2007; Dorris, Espie, Knott, & Salt, 2004; Dawson et al., 2005; Losh et al., 2007; Losh et al., 2009; Smalley et al., 1990; Wilson et al., 2010; Wallace et al., 2010). This research has examined both face discrimination/ recognition (Dalton et al., 2007; Dawson et al., 2005; Losh et al., 2007; Wilson et al., 2010; Wallace et al., 2010) and face emotion recognition (Baron-Cohen et al., 1997; Bolte et al. 2003; Dorris et al., 2007; Losh et al., 2007; Losh et al., 2009; Wallace et al., 2010). Results of these studies can most easily be distinguished in terms of those based on parents of children with ASD (Adolphs et al., 2008; Baron-Cohen et al., 1997; Bolte et al. 2003; Dawson et al., 2005; Losh et al., 2007; Losh et al., 2009; Smalley et al., 1990; Wilson et al., 2010; Wallace et al., 2010) and those based on Siblings of people with ASD (Bolte et al., 2003; Dalton et al., 2007; Dorris et al., 2007; Smalley et al., 1990; Wallace et al., 2010).
The research on face processing in parents of children with ASD has taken a number of different approaches and have yielded a mix of results (Adolphs et al., 2008; Baron-Cohen et al., 1997; Bolte et al. 2003; Dawson et al., 2005; Losh et al., 2007; Losh et al., 2009; Smalley et al., 1990; Wilson et al., 2010; Wallace et al., 2010). When focusing on the studies that examined all parents of children with ASD, with no further subdivisions, on neurocognitive face identity tasks, most studies have not found impairments in face processing (Dawson et al., 2005; Losh et al., 2007). A significant difference between parents of children with ASD and parents of typical children was found, but scores were still in the normal range (Dawson et al., 2005). However, even though the parents of children with ASD were in the normal range of face identity recognition, their face identity recognition skills were significantly worse than their visual spatial and verbal abilities (Dawson et al., 2005). Only one study found parents of children with ASD performing in the impaired range of face identity recognition on neurocognitive measures, on the Cambridge Face Memory Task (Duchaine & Nakayama, 2006), but not when measured on a simple non-validated lab created face-matching task (Wilson et al., 2010). This discrepancy appears to be attributable to the varying degree of difficulty between the two face recognition tests (Wilson et al., 2010).

Face identity recognition in parents of children with ASD has been explored further by taking parents’ BAP level into account, but no correlation has been shown between BAP level and face processing (Wilson et al., 2010). The authors speculate that a correlation between BAP and face processing abilities may not have been found since processing face identity is different than processing face emotions, and only emotion processing may be correlated to the BAP (Wilson et al., 2010). Looking at the effects of
gender on parents of children with ASD face identity performance, a significant positive association was found between the mother’s face processing abilities and the face processing of the probands with ASD (Wilson et al., 2010). Since it is the fathers who usually have stronger BAP characteristics (Piven et al., 1997), this finding is unusual. The authors conjectured that the connection to the mothers face processing might either be indicative a gene marked for maternal expression or that mothers spend more time shaping the face processing of their children (Wilson et al., 2010). Finally, studies examining parents of children with ASD in multiplex families have observed that parents of children with ASD scored significantly lower than typical comparisons, but better than probands with ASD (Dawson et al., 2005; Wilson et al., 2010). As is typically found in people with ASD, these discrimination differences found in parents from multiplex families were true only for face stimuli but not object stimuli (Wallace et al., 2010). Further, these same parents from multiplex families, like the probands with ASD, did not show an advantage for direct verses averted gaze, but did show a whole to part advantage for judging eye direction that was not found in the probands with ASD (Wallace et al., 2010). In addition, ERP readings of face identity processing in parents of children with ASD from multiplex families, found that parents from multiplex families exhibited brain readings similar to those found in people with ASD, i.e. atypical readings for faces but normal readings for non-face stimuli (Dawson et al., 2005). The parents of children with ASD did not show the typical shorter latency of the N170 ERP face component and did not exhibit the normal right brain lateralization pattern (Dawson et al., 2005). Therefore, while parents of children with ASD do not appear to be significantly different than
typical controls in general, when factors such as BAP, gender, and multiplex/simplex are taken into consideration face processing more resembles the patterns found in ASD.

Regarding research on emotion based faced processing in parents of children with ASD, one study found parents of children with ASD to be worse than typical comparisons (Baron-Cohen et al., 1997), while another study did not (Bolte et al., 2003). Fathers of children with ASD have been shown to be significantly worse than mothers of children with ASD on face processing tasks involving emotions (Baron-Cohen et al., 1997). Comparing multiplex and simplex families on an emotion recognition task, parents of children with ASD from simplex families were shown to have a significant advantage in performance compared to parents of children with ASD from simplex families (Bolte et al., 2003). In addition, parents from multiplex families scored worse than typical comparisons on emotion recognition of fear and disgust (Wallace et al., 2010). Taking BAP level into account, research has shown that parents of children with ASD scoring high on the BAP show impairment on face emotion recognition tasks compared to both typical comparisons and parents of children with ASD not rated high on the BAP (Adolphs et al., 2008; Losh et al., 2007; Losh et al., 2009). More narrowly defined, parents of children with ASD scoring poorly on socially aloof aspect of the BAP were worse on detecting emotion from the eye region than both normal comparisons and parents of children with ASD who displayed either no BAP characteristics or only displayed a high level of the BAP component of rigidity (Losh et al., 2007). Much like face identity recognition studies, parents of children with ASD more resembled face processing of people with ASD when more subdivisions were considered, i.e., ASD type deficits in face emotion recognition in parents of children with ASD surface on face tasks.
when additional factors of gender, multiplex/simplex, and BAP are taken into consideration.

In addition to studying face processing in parents of children with ASD, face processing has also been explored in siblings of people with ASD (Dalton et al., 2007; Wallace et al., 2010). Using fMRI and eye tracking, one study reported that siblings of people with ASD had reduced eye gaze, reduced activation of fusiform gyrus, and reduced amygdala volume compared to controls (Dalton et al., 2007). In other research, found similarly to people with ASD, siblings of people with ASD had problems distinguishing between face stimuli but not objects (Wallace et al., 2010). In addition, like probands with ASD, siblings of people with ASD failed to show an advantage for direct verses indirect gaze, but did have advantage of whole to part of face for detecting eye gaze, unlike ASD (Wallace et al., 2010). Additional factors that have proven to be important in the study of face identity processing in parents of children with ASD, such as BAP, gender, and multiplex/simplex family structure, have not yet been examined in siblings of people with ASD.

Studies have also examined face emotion recognition in siblings of people with ASD (Bolte et al., 2003; Dorris et al., 2004). Dealing with siblings of people with ASD in general, one study concluded that siblings of people with ASD did not differ from controls in performance on the face emotion recognition task (Bolte et al., 2003) while another study found sibling of people with ASD performed significantly worse than typical comparisons on an emotion based face recognition (Dorris et al., 2004). This difference may be the result of difficulty level and design complexity of the face processing measures used. However, research has also found that siblings of people with
ASD from simplex families performed significantly higher than siblings of people with ASD from multiplex families (Bolte et al., 2003) and that siblings of people with ASD from multiplex families were worse than typical controls at recognizing the specific emotions of fear and disgust (Wallace et al., 2010). When gender was considered, male siblings of people with ASD performed worse on emotion recognition task than typical comparisons (Dorris et al., 2004). BAP level has yet to be explored as a factor indicating the emotion face processing abilities in siblings of people with ASD.

Overall, there appears to be compelling evidence that parents and siblings of children with ASD perform more similar to probands with ASD than typical comparisons both in face identity recognition and face emotion recognition (Adolphs et al., 2008; Baron-Cohen et al., 1997; Bolte et al. 2003; Dawson et al., 2005; Dorris et al., 2004; Losh et al, 2007; Losh et al., 2009; Smalley et al., 1990; Wilson et al., 2010; Wallace et al., 2010). Relatives of people with ASD who have stronger BAP traits tend to have more face processing difficulties (Losh et al., 2007; Losh et al., 2009). Relatives of people with ASD from multiplex families are more likely to have face-processing abilities similar to probands with ASD than relatives from simplex families (Bolte et al., 2003; Wallace et al., 2010). Finally, male relatives of people with ASD are more likely to process faces in a similar manner to probands with ASD than females (Baron-Cohen, 1997; Dorris et al., 2007). Therefore, it seems that face processing anomalies resembling those found in people with ASD extend to family member of people with ASD as part of the BAP.
Purpose and Hypotheses

Based on the face processing research pertaining to relatives of people with ASD (Baron-Cohen et al., 1997; Bolte et al. 2003; Dalton et al., 2007; Dawson et al., 2005; Dorris et al., 2007; Losh et al., 2007; Losh et al., 2009; Wilson et al., 2010; Wallace et al., 2010) a number of issues remain to be clarified. It is still unclear as whether or not relatives of people with ASD use some of the same face processing strategies typically employed by people with ASD, such as featural vs. configural processing and analytic vs. holistic encoding (Tanaka et al., 2012; Wolfe et al., 2008). Next, the BAP has yet to be examined in siblings of people with ASD as it relates to face processing, including gender differences. Finally, the relationship of the severity of the proband with ASD to the face processing of the relative of the person with ASD needs to be explored.

It is first hypothesized that ASD family members meeting criteria for the BAP will have poorer face processing skills than family members of people with ASD not on the BAP. In particular, those relatives of people with ASD who score poorly on the BAP characteristic of aloof personality will have the most trouble with face processing. In addition, BAP scores will correlate negatively with face processing scores, i.e. the higher the BAP score the lower the face processing score. Second, it is hypothesized that male relatives of people with ASD will have higher BAPs and worse face processing skills than female relatives of people with ASD. Finally, it is hypothesized that BAP level, gender, and severity level of the relative with ASD will predict scores on face processing measures in the family members of people with ASD.
METHODS

Participants

There were a total of 247 biological relatives of people with ASD who participated in the study, of which 178 participants completed the entire study, ranging from 15 to 50 years of age. 69 Participants did not finish the entire study. Since all of these 69 participants stopped participation either right before or during the face processing assessment, it seems likely that they did not continue due to the length of time required to complete the face processing measures. Of the total participants who completed the entire study, 62 were males and 116 were females (Table 4). There were 150 parents, 52 father and 98 mothers, and 28 siblings, 18 sisters and 10 brothers (Table 5).

Parents and siblings of people with ASD were recruited from the Interactive Autism Network (IAN) research database. IAN is an online service that informs, matches, and connects individuals with ASD and their families to current research projects. IAN was created in January 2006 at Kennedy Krieger Institute, Maryland. IAN has over 25,000 families in its database, nearly 40,000 individuals have participated in IAN research, and over 300 research studies have used IAN resources. In order to register, participants must have an ASD diagnosis from a professional. Research indicates that the status of ASD reported on IAN is valid (Rosenberg et al., 2009)

As an incentive to all participants, $20 of monetary compensation was offered and participants were entered into a lottery drawing for a larger prize.

In order for a participant to be included in the study as a sibling or parent of a person with ASD, the participant had to be a registered member of the IAN. In the case
of participating sibling of people with ASD who were minors, their parents/ guardians were required to complete a parental consent form and to assist the minor participant in completing the *The Social Communication Questionnaire* (SCQ) (Rutter, Bailey, & Lord, 2003) on the ASD proband.

Parents and siblings of children with ASD were excluded from the study if the proband with ASD did not meet ASD criteria on the *SCQ* of a score of 12 as established by IAN (Lee et al., 2010; Van Steijn et al., 2012). Parents and siblings of children with ASD were excluded if they themselves had a documented diagnosis of ASD. Exclusion also occurred if the participants reported: a psychiatric diagnosis, a brain injury, had a significant visual, auditory, or motor impairment, and, if the participants do not read English. Finally, parents and siblings of children with ASD were excluded if they did not have a computer with internet and email access. These exclusion criteria resulted in 31 individuals being excluded from study participation.

**Procedure**

Participants were sent an email notification of the study from IAN and contacted the investigators by phone or email. Interested participants were sent an email with welcome message, a unique web link to the study, and a unique code to be used for access to the face processing measures. All assessments were conducted online. Upon accessing the study website, all participants received an online introduction to the research and were asked to sign an electronic informed consent form or have a parental permission form electronically signed. All participants were then asked basic demographic information (see Appendix B). Participants were prompted to take *The Social Communication Questionnaire* (SCQ) (Rutter et al., 2003) (See Appendix B) and
the Broad Autism Phenotype Questionnaire (BAPQ) (Hurley et al., 2006) (See Appendix C). Next, all participants followed a web link to take the Wonderlic Cognitive Ability Pre-Test (Wonderlic, Inc., 1983, Wonderlic, Inc., 2007). Finally, all participants followed a link to the Let’s Face It Skills Assessment Battery (LFI) (Tanaka et al., 2012; Wolfe et al., 2008) which asked for the participant’s unique code.

Measures

Broad Autism Phenotype Questionnaire (BAPQ) (Hurley et al., 2006)

The BAPQ (see Appendix C) was constructed as an assessment device to measure factors of personality and language that have been suggested as defining characteristics of the Broader Autistic Phenotype in parents of individuals with ASD who themselves did not have or deserve a diagnosis of ASD. Hurley et al., (2006) define the BAP to be a milder expression of the underlying genetic liability for ASD found in relatives of people with ASD. The 36 item BAPQ was designed to be: brief, administered remotely, easily scored, inexpensive, and requiring no clinical expertise. The authors based the BAPQ on the Modified Personality Assessment Schedule (MPASR) (Piven et al., 1994) and the Pragmatic Rating Scale (PRS) (Landa et al., 1992) that they had used to assess personality and pragmatic language in parents of people with ASD in previous studies. Specifically, the BAPQ assesses three areas: aloof personality, rigid personality, and pragmatic language deficits (Hurley et al., 2006). These three subscales on the BAPQ are intended to be quantitative measures that parallel the criteria for ASD established by the DSM-IV (American Psychiatric Association, 1994). Hurley et al., (2006) defines the BAPQ subscales as follows: aloof personality is having no interest in or enjoyment of social interaction; rigid personality is lacking interest in change or having trouble
adjusting to change; and *pragmatic language* is problems in social language that cause trouble communicating effectively or in holding a typical conversation. Participants are asked to respond to statements in terms of how frequently it occurs to them based on a 6-point scale ranging from (1) rarely applies to (6) applies very often. Certain test items are reverse scored to reduce the response set bias. BAPQ was based on sample population of 86 autism parents and 64 control parents. Total score is calculated by averaging across the 36 items and subscales are determined by averaging across each subscale’s 12 items. The total score and the subscale scores have a score range of 1 to 6. Parents of people with ASD with a clinically defined BAP (i.e., aloof and/or rigid personality on the Modified Personality Assessment Scale Revised (M-PAS-R; Piven et al., 1997) and/or pragmatic language deficits on the Pragmatic Rating Scale (PRS; Landa et al., 1992) scored significantly higher (X=3.58) on the Total BAPQ than both parents of people with ASD without a direct clinically defined BAP (X=2.67) and from comparisons parents with no family history of ASD (X=2.74). There was also significant difference found on the *aloof personality* measure with the parents of children with ASD with a defined BAP scoring higher (X=3.77) that both the parents of children with ASD without a significantly defined BAP (X=2.55) and the typical comparison parents (X=2.75). The inter-item reliability for each of the BAPQ subscales, given in Cronbach’s alpha coefficient was: .94 for the aloofness, .91 for the rigidity, .85 for the pragmatic language, and .95 across all 36 items. The total correlations for each item in relation to the remaining items in that subscale (with that item removed) were ≥ .39. The three BAPQ subscales were significantly correlated with each other for both groups. For the group with a diagnosis of ASD the subscale correlations were: aloofness and rigidity $r = .72$,
aloofness and pragmatic language $r = .61$, and rigid and pragmatic language $r = .61$. For the control group the correlations were: aloofness and rigidity $r = .54$, aloofness and pragmatic language $r = .53$, and for rigidity and pragmatic language $r = .51$. These correlations were comparable for male and female subjects. The approximate sensitivity and specificity for the total BAPQ scores were 80%. Sensitivity and specificity figures were used by the Hurley et al. (2006) to create cutoff values for BAP determination. The following cutoff values were determined: aloofness=3.25, rigidity=3.50, pragmatic language=2.75, and total score=3.15 (Hurley et al., 2006). For the three subscales all reached the sensitivity and specificity of at least 70%. These cutoff values were re-determined with greater specificity using a general population (Sasson, Lam, Parlier, Daniels, & Piven, 2013b). These new cutoff values, specifically for the BAPQ self report scores are: BAPQ Total = 3.63, Aloofness = 4.19, Pragmatic = 3.29, Rigidity = 4.20 (Sasson et al., 2013a)

Seidman and colleagues (2012) found that, on the BAPQ, fathers scored higher than mothers on aloofness, whereas mother scored higher on rigidity. In addition, no significant correlations between parent BAPQ score and characteristics of their child with autism were reported, including: child’s severity of symptoms as measured by ADOS score, social communication as measured by SCQ score, adaptive behavior as determined by Vineland-II score, and cognitive ability. Wilson et al., (2010) also found that father’s scores were significantly higher on all parts of the BAPQ than mothers. Also, Davidson et al., 2012, found, in a sample of 3,178 parents from simplex families of ASD, that only 11.5% of parents scored at or above the cutoff for BAPQ, 14.5% for females and 8.5% males, males scored higher on all BAPQ measures. In a comparison study of frequently
used measures of the BAP, Ingersoll et al., (2011) recommended the BAPQ over both the Social Responsiveness Scale- Adult (SRS-A; Constantino and Todd, 2005) and Autism Spectrum Quotient (Baron-Cohen et al., 2001) since the BAPQ has the best internal consistency, showed expected distribution of scores and gender differences, had a replicable factor structure, had better criterion and incremental validity, is shorter, and is a direct measure of the BAP (i.e. aloofness, rigidity, and pragmatic language) as opposed to assessing for ASD.

The Let’s Face It Skills Battery (LFI) (Tanaka & Schultz, 2008)

The Let’s Face It Skills Battery was (Tanaka & Schultz, 2008) created as an interactive computer based assessment to measure one’s ability to perceive face identity and emotion over a variety of face processing tasks. The three main test sections of the LFI are: the face identity battery (includes 5 subtests, see Table 1), emotion recognition battery (includes 3 subtests, see Table 2), and non-face object discrimination battery (includes 2 subtests, see Table 3).

LFI Face Identity (see Figures 1, 2, and 3)

Featural and configural face dimensions (Same Difference Face Dimensions) subtest assesses the perception of parts of the face (i.e. mouth, nose, eyes) that are features and the spatial distances between the features, referred to as configural knowledge. Feature and configural dimensions are tested in both the upper and lower sections of the face. The task consists of two faces that are presented next to each other. The participant must decide if the faces are identical or different in terms of changes in either featural or configural dimension dimensions. Faces appear until a response is made. This subtest consists of 76 items, 31 identical and 45 different. Face pictures were
eight original pictures of children (four males and four females) taken by the LFI authors (Wolfe et al., 2008).

*Parts/whole identity* subtest determines to what extent the participant uses a holistic (the entire face) or featural (parts of the face) strategy for face recognition. In this test, a face is presented for 4 seconds and then either two whole faces are presented, one that is identical to the test face and one that differs by only one face part (e.g. nose), or two parts of a face are presented, one that is from the test face and one that is different than that of the test face (e.g. two noses). In both cases, the participant is asked to select the one that matches the test face. This subtest contains 51 trials that include: 21 part determinations (11 eye parts, 10 mouth parts) and 29 whole faces (18 with different eyes and 11 with different mouths). The face stimuli are from a set of images used by the LFI creators in past research (Joseph and Tanaka, 2003; Tanaka et al., 1998). The face stimuli present gray-scale images.

*Matching identity across masked features (Matchmaker ID)* tests the ability to match face identity when the eye or mouth are covered. The target face is shown alone for 500 msec. Then, three faces are presented, in a 45 degree rotation in one of the three conditions: no obstructions, mouth covered, or eyes covered. The participant must match one of the three test faces to the target face based on identity. There are 55 questions. Face pictures are in color and taken from the Karolinska Face Set (Lundqvist, Flykt, & Ohman, 1998).

*Matching identity across expressions* measures the ability to recognize face identities while expressions are changing. A target face is presented alone for 500 msec and then remains while three test faces are presented above the target face with different
expressions (i.e., happy, angry, sad, disgusted, and frightened). The participant is asked to select the face of the same identity. There are a total of 29. Face pictures are in color and taken from the Karolinska Face Set (Lundqvist et al., 1998)

**Immediate memory for faces** tests short-term memory for faces. A test face is shown for 1,000 msec. The test face is then replaced with three faces angled at ¼ orientation. The participant is asked to select the one face of the three that is the same face as the test face. This test has 14 trials. The face stimuli gray-scale images from the Karolinska Face Set (Lundqvist et al., 1998).

**LFI Emotion Recognition** (see Figures 4 and 5)

In **Parts-Whole Expression**, participants are asked to identify happy and angry expression using both featural and holistic face processing strategies. Participants are also tested to check if they are relying more on the mouth area than the eyes area, which has been found to be the case in face identity recognition in people with autistic spectrum disorder (Joseph & Tanaka, 2003; Tanaka et al., 2012; Wolf et al., 2008). The participant is presented with a test face for 2 seconds depicting either a consistent expression (top and bottom half of face express the same emotion) or an inconsistent (top and bottom of face express different emotions from the combination of two pictures of the same person expressing different emotions). The test is then replaced with either a part of the face (eyes of mouth) or a whole face and the participant is asked which new stimuli is from the test face. The face stimuli consist of four faces that were normed for expression from the NimStim set of facial expressions (Tottenham et al., 2009) and is comprised of 41 trials.

In the **Matchmaker Expression** test, the participant is presented with a test face, in
a front view, for 1 second expressing one of five emotions (sad, angry, frightened, disgust, happy) and is then asked which of the three new faces presented above the test face is expressing the same emotion as the test face. All faces remain on the screen until there is a response. In so doing, the participant is exhibiting the ability to generalize expression of emotion across face identities. This subtest has 29 trials. The face stimuli are all in color and are taken from the NimStim face database (Tottenham et al., 2009).

*Name Game* tests the ability to label the emotions of: happy, sad, angry, disgust, surprise and fear. In this task, a face expressing an emotion is presented with the names of six emotions listed to the right of the test face. The participant is asked to select the emotion name that is shown in the face. In order to deal with the reading demands, the computer software pronounces the emotion name as the computer mouse scrolls over the label. After a decision is made there is a 1 sec delay before then next trial. The face stimuli are color images from the NimStim set of facial expressions (Tottenham et al., 2009). This *Name Game* has a total of 66 trials that are comprised of 11 items for each of the six emotions (happy, sad, angry, disgust, frighten, and surprise).

**Non-face object discrimination** (see Figure 2)

In the *Featural and Configural House Dimensions (Same Difference Houses)* test two houses are presented next to one another. The participant is asked to decide if the pictures are the same or different. The house pictures remain until a decision is made. The house pictures are not aligned either horizontally or vertically in so that the participant can not use alignment based recognition strategies. Identical house pictures are to be correctly answered the “same”. For different trials the houses vary according to either featural characteristics (size of the two small windows or one large window) or
configural qualities (space separating the two small windows or elevation level of the one large window). This test consists of 29 trials made up of 9 “same” and 20 “different” trials organized randomly. The stimuli consist of pictures of eight houses that each have eight digital variations.

*Immediate Memory Cars* tests for the short-term memory of cars. A test picture of a car is presented for 1,000 msec at a frontal view. The test car picture is replaced with three car pictures that are at a \( \frac{3}{4} \) angle orientation. The participant is asked to find which of the three cars matches the test car. The test consists of 14 trials.

The LFI Face Identity and Emotion Batteries were developed on a sample of 85 ASD participants, 71 males and 14 females, with a mean age of 11.58 (a range of: 5.81–20.72 years) and a mean full scale IQ of 99.74 (a range of: 58–147 points). The ASD group consisted of 36 individuals with Autistic Disorder, 21 with Asperger’s Disorder, and 28 with PDD-NOS. There were 130 typically developing participants, 87 males and 53 females, with a mean age of 11.96 years (a range of: 5.10–18.10 years) and a mean full scale IQ of 113.28 (a range of: 81–119 points).

Wolfe et al., (2008) found both deficits and strengths on the LFI Skills Battery amongst the ASD participants. The ASD group showed impairment in recognizing facial identity across different face images, due to changes in orientation, expression, or feature information. In addition, ASD participants displayed a deficit in their ability to discriminate information in the eye region of the face but a spared ability to discriminate information in the area of the mouth. Individuals with autism, like the typical control participants, showed normal holistic recognition of faces, i.e. better recognition of a face part in the whole face than when isolated (Wolfe et al., 2008). Lastly, the impairments in
the ASD group found in face processing were not found for non-face object processing. The ASD group performed as well on the automobiles as the typical group and was superior to the typical group on the houses test. Magnitude of the effect sizes ranges from moderate to large (Wolfe et al., 2008).

Tanaka et al. (2012) found the ASD group to show a slight deficit on the Name Game Task but did perform significantly worse in recognizing angry expression. ASD participants did display a deficit in recognizing emotions across different identities as measured in the Matchmaker Expression test (Tanaka et al., 2012). Differences were observed in terms of how parts of the face were recognized. Typical controls recognized eyes holistically and mouth featurally, whereas the ASD group recognized eyes featurally and mouth holistically (Tanaka et al. 2012). Significant correlations were found between severity of impairment of emotion labeling and recognition to measures of social adaptation; those with worse emotion identification had poorer social skills. The effect sizes for the major findings ranged from moderate to large.

Finally, the most recent research using the LFI (Halliday, MacDonald, Sherf, & Tanaka, 2014) found that in a sample of typically developed adults, gender, academic major, immediate memory for a non-face task (birds), and Autism Quotient score (Baron-Cohen, Wheelwright, Skinner, Martin, Clubley, 2014) - a self-assessment of autism traits predicted LFI score on Immediate Memory for Face recognition. Conversely, it was also found that the Immediate Memory for Faces significantly predicted Autism Quotient score.

The WPT-R was designed as a brief measure of general cognitive ability and has been promoted as an accurate measure of employment success. It can be administered in a paper-pencil form, as well as an online administration. Research indicates equivalent scores from both methods of administration. The WPT-R is designed to be given to people age 15 and up. Testing time is 12 minutes. The WPT-R contains 50 questions. An individual’s score is the number of correct answers with no correction for guessing. The test taker attempts as many of the 50 questions as possible within the given 12 minutes of test administration, so speed of answering is an important factor. The items are arranged according to their level of difficulty with easier items coming first. The WPT-R was last normed in 2003 and has a mean of 21.6 and a standard deviation of 7 (Wonderlic, Inc., 2007). The WPT-R was developed through five rounds of field testing and 36,543 test takers. The test provides a broad range of questions that include: analogies, geometric figures, arithmetic, disarranged sentences, proverbs, similarities, logic, definitions, judgment, direction following using clerical, and spatial relations. The WPT-R has strong correlation with the older Wonderlic Classic Cognitive Ability Personnel, with correlations ranging from \( r = .86 \) to \( r = .91 \) (Geisinger, 2001; Schraw, 2001). The WPT-R correlations with instruments such as the WAIS Full Scale IQ and the General Aptitude Test Battery's 'Aptitude G' (for general mental ability or intelligence) are in the range of \( r = .70 \) to \( r = .92 \). In terms of internal consistency, across the five WPT-R forms, Cronbach’s alphas range from .89 to .91. The manual reports test-retest coefficients of .82-.94.
The Social Communication Questionnaire (SCQ) (Rutter et al., 2003)

The SCQ is a screening measure designed to assess symptoms of autism spectrum disorder in individuals above 4 years of age, provided that their mental age exceeds 2 years. It was derived from the much longer Autism Diagnostic Interview-Revised (ADI-R) (Rutter, Le Couteur, Lord, 2003). The assessment is based on the responses of parents and primary caregiver who can complete the assessment without direct supervision. The 40 items on the SCQ are structured in a yes or no format. Administration time for the SCQ is estimated at 10 minutes and scoring takes 5 minutes by an administrator (Rutter et al., 2003). The two forms of the SCQ are the SCQ AutoScore Form: Lifetime and SCQ AutoScore Form: Current (Rutter et al., 2003). The first form, based on the individual’s entire life history, is intended for making an ASD diagnosis and the latter form, based on the behavior of the individual over the last 3 months, is designed for evaluating current experiences, school plans, and treatment plans (Rutter et al., 2003). The SCQ produces a total scores that is interpreted in relation to a cutoff score derived from research on a clinical population of autistic spectrum disorder. There are also two SCQ subscores that include: Qualitative Abnormalities in Communication and Restricted, Repetitive, and Stereotyped Patterns of Behavior. The cutoff score on the SCQ is 15 and is normed on a sample of 200 individuals (Rutter et al., 2003). However, the authors (Rutter et al., 2003) state that a lower SCQ cutoff may be used if there are other risk factors. Research indicates that a slightly lower SCQ cutoff of 12 recommended by IAN has proven to be valid and reliable (Lee et al., 2010) and has been implemented in other studies (Constantino et al., 2010; Van Steijn et al., 2012)
**Results**

*Power Analysis*

A statistical a priori power analysis was performed, completed on *G*\(^{-}\text{Power 3.1}\) software (Faul, Erdfelder, Lang, & Buchner, 2007), to determine the number of participants needed in this proposed study. The following data was entered in the power analysis: a medium effect size \(f = .25\), an alpha error probability = .01, a power (1-beta probability) = .8, a numerator degrees of freedom = 1, number of groups = 2, and number of covariates = 2. The following output parameters were determined: noncentrality parameter \(\lambda = 11.93\), critical \(F = 6.77\), denominator degrees of freedom = 187, total sample size = 191, and actual power = .801. The total number of participants, 178, was under the recommended power estimates.

*Reliability Analysis*

Due to the strong reliance on the BAPQ, the internal consistency for the BAPQ and its subscales were examined to see if it met the established criteria established by the producers and researchers of the measure (Hurley et al., 2006; Sasson et al., 2013a). Cronbach’s alpha was used to measure how strongly a specific question was correlated with the other items from the questionnaire from which it was drawn. The Cronbach alpha value across the entire 36 item questionnaire = .94. The Cronbach alpha values for the three subscales were: Aloofness = 0.92, Pragmatic Language = .83, and Rigidity = 0.89. These alpha values are similar to those established by the BAPQ research (Hurley et al., 2006; Sasson et al., 2013a) and are at or above the acceptable range for research purposes (Nunnally, 1967). With the right statistical caveats, alpha values of 0.80 are held to be moderately high to high (Field, 2009) and .70 or above are considered strong for self-report measures (Morling, 2012).
Data Analysis

Statistical analysis of the descriptive and behavioral data was completed using SPSS 21.0 (IBM, 2012) software package. Outliers were identified and removed before hypothesis statistical hypothesis testing.

Hypothesis 1: Family members of people with ASD meeting criteria for the BAP will have poorer face processing skills than family members of people with ASD not on the BAP. In particular, those relatives of people with ASD who score poorly on the BAP characteristic of aloof personality will have the most trouble with face processing. In addition, BAPQ scores will correlate negatively with LFI scores, i.e. the higher the BAPQ score the lower the LFI score.

Covariates: While high and low BAP groups did not differ in IQ, they did show differences in age (Table 6). This was driven by the fact that the siblings fell almost entirely in the low BAP group. In relation to groupings done by BAP level, IQ showed strong correlations with many of the LFI dependent variable face processing measures. However, age was only strongly correlated with one of the LFI measures, the Name Game, which implies that while there was some difference between groups on age, it was not an influential factor (Table 7). Hence, in order to minimize error variance, IQ was used as a covariate in MANCOVA tests for all group comparisons on face processing, and age was added as a covariate for comparisons on the Name Game measures.

High vs. Low Total BAPQ groups:

All Participants: As shown in Table 8, using Pillai’s trace there was no significant effect of BAPQ level on LFI face discrimination scores, $V=.011$, $F(5, 139)=.298$, $p=.913$. There was no significant effect of BAPQ level on LFI emotion recognition tests, $V=.016$,
High vs. Low Aloof groups:

All Participants: Using Pillai’s trace, there was no significant effect of Aloofness level on LFI face discrimination main scores, $V=.009$, $F(5, 139)=.253$, $p=.938$ (Table 8). There was no effect of BAPQ Aloofness level on LFI main emotion recognition tests, Pillai’s trace $V=.007$, $F(3,143)=.352$, $p=.788$ (Table 8). There was no effect of BAPQ Aloofness level on LFI non-face tests, $V=.006$, $F(2, 150)=.429$, $p=.652$ (Table 8).

High vs. Low Pragmatic Language

All Participants: As shown in Table 8, using Pillai’s trace there was no significant effect of Pragmatic level on LFI face discrimination scores, $V=.044$, $F(5, 139)=1.29$, $p=.270$. Using Pillai’s trace there was no significant effect of Pragmatic level on LFI face emotion scores, $V=.021$, $F(3, 143)=1.04$, $p=.378$ (Table 8). There was no effect of BAPQ Pragmatic level on LFI non-face tests, $V=.005$, $F(2, 150)=.365$, $p=.695$ (Table 8).

High vs. Low Rigidity

All Participants: Pillai’s trace revealed a significant effect of Rigidity level on Main LFI face discrimination scores, $V=.080$, $F(5, 139)= 2.41$, $p=.040$ (Table 8). See Table 6 for univariate ANOVA’s of face discrimination scores. Pillai’s trace did not reveal a significant effect of Rigidity level on Main LFI face emotion recognition scores, $V=.028$, $F(3, 143)= 1.39$, $p=.247$ (Table 8). There was an effect of BAPQ Rigidity level on LFI non-face tests, $V=.072$, $F(2, 150)= 5.86$, $p=.004$ (Table 8). See Table 9 for univariate ANOVA’s of non-face discrimination scores. To ensure that the unequal group sizes of BAPQ Rigidity levels did not violated the MANCOVA assumption of
homogeneity of covariance (Field, 2009) and thus skew the significant main effects for Rigidity level on LFI face and non-face discrimination Box’s test was examined (Field, 2009). Box’s tests for both of these MANCOVA analyses were non-significant at the accepted test level of p<.001 (Field, 2009). Therefore, there is strong reason to believe that the assumption of homogeneity of covariance was not violated and the significant main effects are accurate. Since some effect values such as eta squared and partial eta squared could be influenced by the unequal sample sizes in this study, Cohen’s d effect values were calculated (Cohen, 1988; Cohen, 1992). Cohen’s d values for the significant findings were as follows: Matchmaker Identity= -.58 (medium effect size), Part Whole Identity = -.43 (small to medium effect size), and Same Different House = -.56 (medium effect size).

Correlations of BAPQ scores with LFI scores

Table 10 lists the correlations for BAPQ scores and LFI scores. The BAPQ Total score showed significant negative correlations with 2 of the 10 LFI scores. The BAPQ Total score was negatively correlated with Match Maker Identity and Part Whole Identity (Table 10). Aloofness was negatively correlated with 2 of the 10 LFI measures, and this correlation was significant, p<.05, for Match Maker Identity and Part Whole Identity (Table 10). Aloofness correlated positively, p<.05, with Part Whole Expression. Pragmatic Language was negatively correlated with 2 of the 10 LFI measures, and this correlation was significant, p<.01, for Match Maker Identity and Part Whole Identity, as well as, p<.05, Match Maker Expression (Table 10). Rigidity was negatively correlated with 2 of the 10 LFI measures, and this correlation was significant, p<.01, for Match
Maker Identity and Part Whole Identity (Table 10). Rigidity was positively correlated, p<.05, with Immediate Memory for Cars (Table 10).

**Results summary of Hypothesis 1:**

While face processing ability between BAP+ and BAP- relatives was generally similar (Table 8), a key difference was found, not on the BAPQ Aloofness criteria as predicted, but when BAPQ Rigidity level was considered (Tables 8 & 9). Relatives scoring positive for Rigidity performed significantly worse than relatives who were negative for Rigidity on face and non-face discrimination tasks, but not on emotion recognition (Table 8). Effect sizes for these differences on Rigidity ranged from small to medium. The specific differences on the LFI were on the tests of: Match Maker Identity, Part Whole Identity, and Same Different House (Table 9).

**Hypothesis 2:** Male family members of people with ASD will have higher BAP levels and worse face processing skills than female family members of people with ASD.

**Covariates:** Total male and female groups approached significance on differing on IQ (see Table 6), but they did not show significant differences in age (Table 7). In relation to groupings done by gender, IQ showed modest correlations with many of the LFI dependent variable face processing measures. However, age was only correlated with one of the LFI measures, the Name Game. IQ was not significantly correlated with BAPQ measures in either males or females but Age was significantly correlated with Aloofness. In order to minimize error variance, IQ was used as a covariate in MANCOVA tests for all group comparisons on face processing, and age was added as a covariate for comparisons on the Name Game measures. Due to group differences and
correlations, IQ was used as a covariate for all BAPQ comparisons and age was added as a covariate only for the Aloofness score comparisons.

**BAPQ score comparison by gender**

As shown in Table 11, the total BAPQ scores (note: actual score not the dichotomous factor of BAPQ positive and negative) between all males and females were significantly different, $F(1, 163)=10.05, p=.010$, with males scoring higher than females. Males scored significantly higher, $F(1, 162)=7.02, p=.009$, on the BAPQ measure of Aloofness than females (Table 11). On the BAPQ Pragmatic Language, there was a significant difference, $F(1, 163)=11.14, .001$, with males scoring higher than females (Table 11). The difference on Rigidity scores on the BAPQ between males and females was significant, $F(1, 163)=4.44, p=.037$, with higher male scores (Table 11).

**LFI scores compared by gender and BAPQ**

Next, LFI scores were examined by comparing scores by gender; first, all males compared to all females. 2x2 MANCOVAs were performed with gender and BAPQ positive and negative criteria (for Total BAPQ, then Aloof, then Pragmatic, and then Rigid) as the independent variables and main LFI Total scores as the dependent variables, in order to examine the effect of each independent variable and their interaction. IQ was used as a covariate and Age was added as a covariate for the LFI Name Games.

**Gender with Total BAPQ criteria:** In Table 12, Comparing all male and female participants on main LFI face discrimination tests, Pillai’s trace revealed a significant effect of gender on main LFI face discrimination scores, $V=.094, F (5, 136)= 2.81, p=.019$. Due to unequal groups sizes, Box’s test revealed no violation of homogeneity of covariance at $p<.001$. See Table 13 for univariate ANOVA’s for gender on LFI face
scores. There was no significant effect of BAPQ level on main LFI face discrimination tests, $V=.015$, $F (5, 136)=.403$, $p=.846$ (Table 12). There was no overall interaction effect of gender and BAPQ level, $V=.034$, $F (5, 136) .558$, $p=.845$ (Table 12).

Comparing all male and female participants on main LFI face emotion recognition tests, Pillai’s trace revealed no significant effect of gender on main LFI scores, $V=.032$, $F (3, 140)= 1.54$, $p=.205$ (Table 12). There was no significant effect of BAPQ Total level on main LFI emotion recognition tests, $V=.013$, $F (3, 140)=.403$, $p=.616$ (Table 12). There was no overall interaction effect of gender and BAPQ level, $V=.004$, $F (3, 140) .558$, $p=.616$ (Table 12).

There was no overall effect of gender on LFI non-face tests, Pillai’s trace $V=.005$, $F(2, 147)=.367$, $p=.693$ (Table 12). BAPQ level did not have a significant effect on LFI non-face tests, Pillai’s trace $V=.029$, $F(2, 147)=2.19$, $p=.115$ (Table 12). There was no significant interaction of gender and BAPQ level, Pillai’s trace $V=.020$, $F(2, 147)=1.46$, $p=.234$ (Table 12).

**Gender with Aloofness criteria:** In Table 14, Pillai’s trace revealed an effect of gender on main LFI face discrimination tests that approached significance, $V=.074$, $F (5, 136)= 2.18$, $p=.059$. Due to unequal groups sizes, Box’s test revealed no violation of homogeneity of covariance at $p<.001$. See Table 15 for univariate ANOVA’s of gender on LFI discrimination scores. There was no significant effect of Aloofness level on main LFI scores, $V=.020$, $F (5, 136)=.515$, $p=.421$ (Table 14). There was no overall interaction effect of gender and BAPQ level, $V=.035$, $F (5, 136) .999$, $p=.421$ (Table 14).

Examining male and female participants on LFI emotion recognition Pillai’s trace revealed no significant effect of gender on Name Game scores, $V=.029$, $F(3, 140)= 1.39$,
p=.248 (Table 14). Aloofness did not have a significant effect on LFI emotion recognition tests, Pillai’s trace, V=.009, F(3, 140)=.431, p=.731 (Table 14). There was no significant interaction effect of gender by Aloofness level, Pillai’s trace V=.005, F(3, 140)=.243, p=.866 (Table 14).

There was no overall effect of gender on LFI non-face tests, Pillai’s trace V=.002, F(2, 147)=.151, p=.860 (Table 14). Aloofness level did not have a significant effect on LFI non-face tests, Pillai’s trace V=.006, F(2, 147)=.473, p=.624 (Table 14). There was no significant interaction of gender and BAPQ level, Pillai’s trace V=.007, F(2, 147)=1.46, p=.541 (Table 14).

**Gender with Pragmatic Language criteria:** In Table 16, comparing all male and female participants on main LFI face discrimination tests, Pillai’s trace revealed a significant effect of gender on main LFI discrimination scores, V=.091, F (5, 136)= 2.73, p=.022. Due to unequal groups sizes, Box’s test revealed no violation of homogeneity of covariance at p<.001. See Table 17 for univariate ANOVA’s for gender on LFI face scores. There was no significant effect of Pragmatic level on main LFI scores, V=.035, F (5, 136)=.973, p=.437 (Table 16). There was no overall interaction effect of gender and Pragmatic level, V=.044, F (5, 136) 1.26, p=.282 (Table 16).

There was no overall effect of gender on LFI emotion recognition tests, Pillai’s trace V=.012, F(3, 140)=.554, p=.646 (Table 16). Pragmatic level did not have an overall effect on LFI emotion recognition tests, Pillai’s trace V=.018, F(3, 140)=.879, p=.454 (Table 16). Gender and Pragmatic level did not have a significant overall interaction, Pillai’s V=.008, F(3,140)=.378, p=.769 (Table 16).
There was no overall effect of gender on LFI non-face tests, Pillai’s trace \( V=.015,\) \( F(2, 147)=1.12, p=.330 \) (Table 16). Pragmatic level did not have a significant effect on LFI non-face tests, Pillai’s trace \( V=.003, F(2, 147)=.244, p=.783 \) (Table 16). The interaction of gender and Pragmatic level was not significant, Pillai’s trace \( V=.033, F(2, 147)=2.49, p=.086 \) (Table 16).

**Gender with Rigidity criteria:** In Table 18, comparing all male and female participants on main LFI discrimination scores, Pillai’s trace revealed a significant effect of gender on main LFI face discrimination scores, \( V=.092, F(5, 136)=2.77, p=.021 \). Due to unequal groups sizes, Box’s test revealed no violation of homogeneity of covariance at \( p<.001 \). See Table 19 for univariate ANOVA’s for gender on LFI face scores. There was a significant effect of Rigidity level on main LFI face discrimination scores, \( V=.101, F(5, 136)=3.06, p=.012 \) (Table 18). Univariate ANOVAs showed significant differences, females higher than males, on main LFI scores of: Match Maker ID, \( F(1, 140)=11.96, p=.001 \), and Part Whole ID, \( F(1, 140)=5.42, p=.021 \) (Table 19). There was no overall interaction effect of gender and Rigidity level, \( V=.035, F(5, 140) = .994, p=.424 \) (Table 18).

The effect of gender on LFI emotion recognition subtests was not significant, Pillai’s Trace \( V=.035, F(3, 140)=1.69, p=.170 \) (Table 18). Rigidity level did not have a significant effect on LFI emotion recognition tests, Pillai’s Trace \( V=.026, F(3, 140)=1.24, p=.298 \) (Table 18). There was no significant interaction of gender and Rigidity level, \( V=.001, F(3, 140)=.032, p=.992 \) (Table 18).

There was no overall effect of gender on LFI non-face tests, Pillai’s trace \( V=.001, F(2, 147)=.055, p=.947 \) (Table 18). Rigidity level did have a significant effect on LFI
non-face tests, Pillai’s trace $V=.070$, $F(2, 147)=5.50$, $p=.005$ (Table 18). Univariate ANOVAs showed a significant differences on the LFI non-face test of Same Different Houses, $F(1, 148)=10.37$, $p=.002$, with higher negative scores. The interaction of gender and Rigidity level was not significant, Pillai’s trace $V=.001$, $F(2, 147)=.088$, $p=.916$ (Table 18).

Results summary of Hypothesis 2:

First, male relatives consistently showed higher BAPQ scores than female relatives across all BAPQ components (Table 11). Second, while males did not do worse that females on all LFI face processing, males did perform significantly worse on LFI face discrimination measures with no evidence of any interaction effect between gender and BAPQ level (Tables 12, 14, 16, & 18). More precisely, when comparing LFI discrimination performance in a 2x2 factorial design (gender x BAP component level), Immediate Memory for Faces and Part-Whole Identity were two LFI discrimination tests that measured females scoring significantly higher than males (Tables 13, 15, 17, & 19). The Match Maker Identity LFI Discrimination test also showed females scoring significantly higher than males, but this was only for the gender x BAPQ Rigidity level (Table 19). Overall, there were more differences on LFI tests between males and females than between BAP+ and BAP- groups.

Hypothesis 3: BAP level, gender, and severity of the family member with ASD will predict face processing scores of family members of people with ASD.

Hierarchical multiple regression analysis was performed with the following variables, in order: BAP level (BAPQ component), gender, and ASD relative’s severity level (SCQ) to analyze how much of the variance they explain in LFI scores. Due to
relatively strong covariance, IQ was also entered into each regression analysis and Age was also entered for each regression analysis related to LFI Name Games. For each independent variable (LFI test) the following measures are provided: R (Multiple R is the correlation between the value observed on the Y-axis (independent variable) and the values of Y-axis predicted by the multiple regression; R² is the amount of variation in the independent variable predicted by the regression model; the F-ratio and p-value tell the significance of the model; the standardized Beta value (β) tells the number of standard deviations the outcome of the independent variable will change when an individual predictor value changes one standard deviation; and, the Beta value accompanying t-test (t) that measures whether or not this change is significant (Field, 2009). In addition, two values are supplied for each independent variable to determine if the regression model has met the statistical assumptions of multiple regression: the Variance Inflation Factor (VIF) which tests how strong a linear relation the predictor has with the other predictors (value of 10 and higher are a concern), and the Durbin-Watson value, which tests for independent errors, an assumption of multiple regression, values less than 1 or greater than 3 may be a concern (Field, 2009). Correlations for variables used in regression analysis are listed in Table 20.

**BAPQ Total Regression Model**

**LFI Face Discrimination**

*Immediate Memory for Faces*: Tests for multicollinearity indicated that a very low level of multicollinearity was present (VIF = 1.03 for IQ, 1.01 for BAPQ, 1.04 for gender, and 1.02 for SCQ). IQ, BAPQ Total, gender, and SCQ did not predict a significant amount of the variance for Immediate Memory for Faces, R = .128, R² = .016,
F(4,149) = .624, p = .646, Durbin Watson = 1.96 (Table 21). None of the Beta coefficients were significant (Table 21).

**Matchmaker ID:** Tests for multicollinearity indicated that a very low level of multicollinearity was present (VIF = 1.04 for IQ, 1.01 for BAPQ, 1.04 for gender, and 1.02 for SCQ). IQ, BAPQ Total, gender, and SCQ did not predict a significant amount of the variance for Matchmaker ID, R = .209, R² = .044, F(4,153) = 1.75, p = .142, Durbin Watson = 2.13 (Table 21). Beta coefficients were not significant, but the Beta for Gender approached significance, β = .140, t = 1.73, p = .086 (Table 21).

**Matchmaker ID Across Expression:** Tests for multicollinearity indicated that a very low level of multicollinearity was present (VIF= 1.03 for IQ, 1.02 for BAPQ, 1.04 for gender, and 1.02 for SCQ). IQ, BAPQ Total, gender, and SCQ did not predict a significant amount of the variance for Matchmaker ID Across Expression, R = .194, R² = .038, F(4,151) = 1.48, p = .211, Durbin Watson = 2.41 (Table 21). Beta coefficient for Gender was significant, β = .179, t = 2.20, p = .029 (Table 21).

**Part Whole ID:** Tests for multicollinearity indicated that a very low level of multicollinearity was present (VIF = 1.03 for IQ, 1.01 for BAPQ, 1.04 for gender, and 1.01 for SCQ). IQ, BAPQ Total, gender, and SCQ predicted a significant amount of the variance for Part Whole ID, R = .390, R² = .152, F(4,158) = 7.08, p = .001, Durbin Watson = 1.90 (Table 17=8). Beta coefficients were significant for IQ, β = .242, t = 3.25, p = .001, and gender, β = .342, t = 4.58, p = .001(Table 21).

**Same Face Difference:** Tests for multicollinearity indicated that a very low level of multicollinearity was present (VIF = 1.05 for IQ, 1.01 for BAPQ, 1.06 for gender, and 1.01 for SCQ). IQ, BAPQ Total, gender, and SCQ did not predict a significant amount of
the variance for Same Face Difference for Faces, R = .116, R$^2$ = .014, F(4,152) = .654, p = .625, Durbin Watson = 1.95 (Table 21). None of the Beta coefficients were significant (Table 21).

**LFI Emotion recognition**

*Name Game*: Tests for multicollinearity indicated that a very low level of multicollinearity was present (VIF = 1.05 for IQ, 1.06 for age, 1.06 for BAPQ, 1.04 for gender, and 1.03 for SCQ). IQ, age, BAPQ Total, gender, and SCQ approached significance for predicting a significant amount of the variance for Name Game, R = .253, R$^2$ = .064, F(5,149) = 2.04, p = .076, Durbin-Watson = 1.99 (Table 19). Beta coefficients were significant for Age, $\beta = -.167$, $t=2.04$, $p = .043$, and approached significance for Gender, $\beta = .139$, $t=1.71$, $p = .088$ (Table 22).

*Part Whole Expression*: Tests for multicollinearity indicated that a very low level of multicollinearity was present (VIF = 1.03 for IQ, 1.01 for BAPQ, 1.05 for gender, and 1.03 for SCQ). IQ, BAPQ Total, gender, and SCQ were significant for predicting a significant amount of the variance for Part Whole Expression, R = .255, R$^2$ = .065, F(4,144) = 2.49, p = .045, Durbin-Watson = 2.12 (Table 22). Beta coefficients were significant for IQ, $\beta = .207$, $t = 2.53$, $p = .013$ (Table 22).

*Match Expression*: Tests for multicollinearity indicated that a very low level of multicollinearity was present (VIF = 1.04 for IQ, 1.02 for BAPQ, 1.05 for gender, and 1.02 for SCQ). IQ, BAPQ Total, gender, and SCQ did not predict a significant amount of the variance for Match Maker Expression, R = .203, R$^2$ = .041, F(4,151) = 1.62, p = .173, Durbin-Watson = 2.08 (Table 22). Beta coefficients were significant for gender $\beta = .200$, $t = 2.46$, $p = .015$ (Table 22).
**LFI Non-Face**

*Immediate Memory for Cars:* Tests for multicollinearity indicated that a very low level of multicollinearity was present (VIF = 1.04 for IQ, 1.02 for BAPQ, 1.05 for gender, and 1.03 for SCQ). IQ, BAPQ Total, gender, and SCQ predicted a significant amount of the variance for Immediate Memory for Cars, $R = .279$, $R^2 = .078$, $F(4,149) = 3.15$, $p = .016$, Durbin Watson = 2.14 (Table 23). The Beta coefficient was significant for IQ, $\beta = .222$, $t = 2.77$, $p = .006$ (Table 23).

*Same Different Houses:* Tests for multicollinearity indicated that a very low level of multicollinearity was present (VIF = 1.03 for IQ, 1.02 for BAPQ, 1.04 for gender, and 1.03 for SCQ). IQ, BAPQ Total, gender, and SCQ predicted a significant amount of the variance for Same Different Houses test, $R = .290$, $R^2 = .084$, $F(4,151) = 3.46$, $p = .010$, Durbin Watson = 1.91 (Table 23). Beta coefficients were significant for IQ, $\beta = .285$, $t = 3.60$, $p = .001$ (Table 23).

**Aloofness Regression Model**

**LFI Face Discrimination**

*Immediate Memory for Faces:* Tests for multicollinearity indicated that a very low level of multicollinearity was present (VIF = 1.03 for IQ, 1.02 for Aloofness, 1.02 for gender, and 1.04 for SCQ). IQ, Aloofness, gender, and SCQ did not predict a significant amount of the variance for Immediate Memory for Faces, $R = .123$, $R^2 = .015$, $F(4,149) = .576$, $p = .681$, Durbin Watson = 1.97 (Table 24). None of the Beta coefficients were significant (Table 24).

*Matchmaker ID:* Tests for multicollinearity indicated that a very low level of multicollinearity was present (VIF = 1.04 for IQ, 1.02 for Aloofness, 1.02 for gender, and
IQ, Aloofness, gender, and SCQ did not predict a significant amount of the variance for Matchmaker ID, \( R = .176, \ R^2 = .031, \ F(4,153) = 1.22, \ p = .303 \), Durbin Watson = 2.13 (Table 24). Beta coefficients were not significant, but the Beta for gender approached significance, \( \beta = .146, t = 1.79, \ p = .075 \) (Table 24).

**Matchmaker ID Across Expression:** Tests for multicollinearity indicated that a very low level of multicollinearity was present (VIF= 1.04 for IQ, 1.02 for Aloofness, 1.02 for gender, and 1.05 for SCQ). IQ, Aloofness, gender, and SCQ did not predict a significant amount of the variance for Matchmaker ID Across Expression, \( R = .189, \ R^2 = .036, \ F(4,151) = 1.39, \ p = .238 \), Durbin Watson = 2.40 (Table 24). Beta coefficients showed significance for gender, \( \beta = .181, t = 2.22, \ p = .028 \) (Table 24).

**Part Whole ID:** Tests for multicollinearity indicated that a very low level of multicollinearity was present (VIF = 1.03 for IQ, 1.02 for Aloofness, 1.01 for gender, and 1.05 for SCQ). IQ, Aloofness, gender, and SCQ predicted a significant amount of the variance for Part Whole ID, \( R = .382, \ R^2 = .146, \ F(4,158) = 6.75, \ p = .001 \), Durbin Watson = 1.91 (Table 24). Beta coefficients were significant for IQ, \( \beta = .240, t = 3.20, \ p = .002 \), and gender, \( \beta = .344, t = 4.57, \ p = .001 \) (Table 24).

**Same Face Difference:** Tests for multicollinearity indicated that a very low level of multicollinearity was present (VIF = 1.05 for IQ, 1.02 for Aloofness, 1.01 for gender, and 1.06 for SCQ). IQ, Aloofness, gender, and SCQ did not predict a significant amount of the variance for Same Face Difference for Faces, \( R = .079, \ R^2 = .006, \ F(4,152) = .241, \ p = .915 \), Durbin Watson = 1.90 (Table 24). None of the Beta coefficients were significant (Table 24).
LFI Emotion recognition

*Name Game*: Tests for multicollinearity indicated that a very low level of multicollinearity was present (VIF = 1.05 for IQ, 1.06 for age, 1.06 for Aloofness, 1.03 for gender, and 1.05 for SCQ). IQ, age, Aloofness, gender, and SCQ approached significance for predicting a significant amount of the variance for Name Game, $R = .253$, $R^2 = .064$, $F(5,149) = 2.04$, $p = .076$, Durbin-Watson = 1.99 (Table 25). Beta coefficients were significance for Age, $\beta = -.167$, $t = -2.04$, $p = .043$, and the Beta coefficient approached significance for gender, $\beta = .139$, $t = 1.72$, $p = .088$ (Table 25).

*Part Whole Expression*: Tests for multicollinearity indicated that a very low level of multicollinearity was present (VIF = 1.03 for IQ, 1.02 for Aloofness, 1.03 for gender, and 1.05 for SCQ). IQ, Aloofness, gender, and SCQ approached significance for predicting a significant amount of the variance for Part Whole Expression, $R = .233$, $R^2 = .054$, $F(4,144) = 2.07$, $p = .088$, Durbin-Watson = 2.09 (Table 25). Beta coefficients were significant for IQ, $\beta = .210$, $t = 2.55$, $p = .012$ (Table 25).

*Match Maker Expression*: Tests for multicollinearity indicated that a very low level of multicollinearity was present (VIF = 1.04 for IQ, 1.02 for Aloofness, 1.02 for gender, and 1.05 for SCQ). IQ, Aloofness, gender, and SCQ did not predict a significant amount of the variance for Match Maker Expression, $R = .201$, $R^2 = .040$, $F(4,151) = 1.58$, $p = .181$, Durbin-Watson = 2.08 (Table 25). Beta coefficients were significant for gender, $\beta = .202$, $t = 2.47$, $p = .015$ (Table 25).

LFI Non-Face

*Immediate Memory for Cars*: Tests for multicollinearity indicated that a very low level of multicollinearity was present (VIF = 1.04 for IQ, 1.02 for Aloofness, 1.03 for
gender, and 1.06 for SCQ). IQ, Aloofness, gender, and SCQ predicted a significant amount of the variance for Immediate Memory for Cars, $R = .252$, $R^2 = .063$, $F(4,149) = 2.52$, $p = .044$, Durbin Watson = 2.18 (Table 26). The Beta coefficient was significant for IQ, $\beta = .229$, $t = 2.83$, $p = .005$ (Table 26).

Same Different Houses: Tests for multicollinearity indicated that a very low level of multicollinearity was present (VIF = 1.03 for IQ, 1.02 for Aloofness, 1.03 for gender, and 1.05 for SCQ). IQ, Aloofness, gender, and SCQ predicted a significant amount of the variance for Same Different Houses test, $R = .292$, $R^2 = .085$, $F(4,151) = 3.53$, $p = .009$, Durbin Watson = 1.89 (Table 26). The Beta coefficient for IQ was significant, $\beta = .286$, $t = 3.62$, $p = .001$ (Table 26).

Pragmatic Language Regression Model

LFI Face Discrimination

Immediate Memory for Faces: Tests for multicollinearity indicated that a very low level of multicollinearity was present (VIF = 1.03 for IQ, 1.03 for Pragmatic language, 1.06 for gender, and 1.02 for SCQ). IQ, Pragmatic language, gender, and SCQ did not predict a significant amount of the variance for Immediate Memory for Faces, $R = .112$, $R^2 = .013$, $F(4,149) = .474$, $p = .755$, Durbin Watson = 1.95 (Table 27). None of the Beta coefficients were significant (Table 27).

Matchmaker ID: Tests for multicollinearity indicated that a very low level of multicollinearity was present (VIF = 1.03 for IQ, 1.03 for Pragmatic language, 1.07 for gender, and 1.01 for SCQ). IQ, Pragmatic language, gender, and SCQ approached significance for predicting the amount of the variance for Matchmaker ID, $R = .238$, $R^2 =$
.057, F(4,153) = 2.31, p = .061, Durbin Watson = 2.13 (Table 27). Beta coefficients showed significance for Pragmatic language, $\beta = .172$, $t = 2.16$, $p = .033$ (Table 27).

**Matchmaker ID Across Expression:** Tests for multicollinearity indicated that a very low level of multicollinearity was present (VIF = 1.03 for IQ, 1.04 for Pragmatic, 1.07 for gender, and 1.02 for SCQ). IQ, Pragmatic language, gender, and SCQ did not predict a significant amount of the variance for Matchmaker ID Across Expression, $R = .189$, $R^2 = .036$, $F(4,151) = 1.41$, $p = .235$, Durbin Watson = 2.40 (Table 27). Beta coefficients were significant for gender, $\beta = .178$, $t = 2.15$, $p = .033$ (Table 27).

**Part Whole ID:** Tests for multicollinearity indicated that a very low level of multicollinearity was present (VIF = 1.03 for IQ, 1.02 for Pragmatic language, 1.06 for gender, and 1.01 for SCQ). IQ, Pragmatic language, gender, and SCQ predicted a significant amount of the variance for Part Whole ID, $R = .418$, $R^2 = .175$, $F(4,158) = 8.36$, $p = .001$, Durbin Watson = 1.88 (Table 27). Beta coefficients were significant for IQ, $\beta = .241$, $t = 3.28$, $p = .001$, Pragmatic language, $\beta = .176$, $t = 2.41$, $p = .017$, and gender, $\beta = .315$, $t = 4.23$, $p = .001$ (Table 27).

**Same Face Difference:** Tests for multicollinearity indicated that a very low level of multicollinearity was present (VIF = 1.05 for IQ, 1.02 for Pragmatic language, 1.07 for gender, and 1.01 for SCQ). IQ, Pragmatic language, gender, and SCQ did not predict a significant amount of the variance for Same Face Difference for Faces, $R = .080$, $R^2 = .006$, $F(4,152) = .242$, $p = .914$, Durbin Watson = 1.97 (Table 27). None of the Beta coefficients were significant (Table 27).
LFI Emotion recognition

*Name Game:* Tests for multicollinearity indicated that a very low level of multicollinearity was present (VIF = 1.05 for IQ, 1.03 for age, 1.04 for Pragmatic language, 1.07 for gender, and 1.02 for SCQ). IQ, age, Pragmatic language, gender, and SCQ approached significance for predicting a significant amount of the variance for Name Game, R = .253, R^2 = .064, F(5,149) = 2.05, p = .075, Durbin-Watson = 1.99 (Table 28). Beta coefficients were significance for Age, β = -.166, t=-2.07, p = .040, and the Beta coefficient approached significance for gender, β = .143, t = 1.74, p = .084 (Table 28).

*Part Whole Expression:* Tests for multicollinearity indicated that a very low level of multicollinearity was present (VIF = 1.03 for IQ, 1.02 for Pragmatic language, 1.06 for gender, and 1.02 for SCQ). IQ, Pragmatic language, gender, and SCQ approached significance for predicting a significant amount of the variance for Part Whole Expression, R = .249, R^2 = .062, F(4,144) = 2.38, p = .055, Durbin-Watson = 2.12 (Table 28). Beta coefficients were significant for IQ, β = .210, t = 2.57, p = .011 (Table 28).

*Match Maker Expression:* Tests for multicollinearity indicated that a very low level of multicollinearity was present (VIF = 1.03 for IQ, 1.04 for Pragmatic language, 1.08 for gender, and 1.01 for SCQ). IQ, Pragmatic language, gender, and SCQ did not predict a significant amount of the variance for Match Maker Expression, R = .209, R^2 = .044, F(4,151) = 1.72, p = .148, Durbin-Watson = 2.09 (Table 28). Beta coefficients were significant for gender, β = .191, t = 2.31, p = .022 (Table 28).
**LFI Non-Face**

_Immediate Memory for Cars:_ Tests for multicollinearity indicated that a very low level of multicollinearity was present (VIF = 1.04 for IQ, 1.04 for Pragmatic language, 1.05 for gender, and 1.02 for SCQ). IQ, Pragmatic language, gender, and SCQ predicted a significant amount of the variance for Immediate Memory for Cars, \( R = .258, R^2 = .066, F(4,149) = 2.65, p = .036, \) Durbin Watson = 2.19 (Table 29). The Beta coefficient was significant for IQ, \( \beta = .227, t = 2.82, p = .005 \) (Table 29).

_Same Different Houses:_ Tests for multicollinearity indicated that a very low level of multicollinearity was present (VIF = 1.03 for IQ, 1.04 for Pragmatic language, 1.08 for gender, and 1.02 for SCQ). IQ, Pragmatic language, gender, and SCQ predicted a significant amount of the variance for Same Different Houses test, \( R = .287, R^2 = .083, F(4,151) = 3.40, p = .011, \) Durbin Watson = 1.92 (Table 29). The Beta coefficient was significant for IQ, \( \beta = .283, t = 3.58, p = .001 \) (Table 29).

**Rigidity Regression Model**

**LFI Face Discrimination**

_Immediate Memory for Faces:_ Tests for multicollinearity indicated that a very low level of multicollinearity was present (VIF = 1.03 for IQ, 1.03 for Rigidity, 1.04 for gender, and 1.04 for SCQ). IQ, Rigidity, gender, and SCQ did not predict a significant amount of the variance for Immediate Memory for Faces, \( R = .130, R^2 = .017, F(4,149) = .641, p = .634, \) Durbin Watson = 1.97 (Table 30). None of the Beta coefficients were significant (Table 30).

_Matchmaker ID:_ Tests for multicollinearity indicated that a very low level of multicollinearity was present (VIF = 1.04 for IQ, 1.03 for Rigidity, 1.04 for gender, and
IQ, Rigidity, gender, and SCQ predicted a significant amount of the variance for Matchmaker ID, $R = .313$, $R^2 = .098$, $F(4,153) = 4.15$, $p = .003$, Durbin Watson $= 2.15$ (Table 30). Beta coefficients were significant for Rigidity, $\beta = .267$, $t = 3.44$, $p = .001$. Beta coefficients for gender approached significance, $\beta = .136$, $t = 1.73$, $p = .085$, and the Beta approached significance for IQ, $\beta = .137$, $t = 1.75$, $p = .082$ (Table 30).

**Matchmaker ID Across Expression:** Tests for multicollinearity indicated that a very low level of multicollinearity was present (VIF= 1.04 for IQ, 1.03 for Rigidity, 1.04 for gender, and 1.04 for SCQ). IQ, Rigidity, gender, and SCQ did not predict a significant amount of the variance for Matchmaker ID Across Expression, $R = .207$, $R^2 = .043$, $F(4,151) = 1.69$, $p = .155$, Durbin Watson $= 2.41$ (Table 30). Beta coefficients showed significance for gender, $\beta = .178$, $t = 2.19$, $p = .030$ (Table 30).

**Part Whole ID:** Tests for multicollinearity indicated that a very low level of multicollinearity was present (VIF = 1.04 for IQ, 1.01 for Rigidity, 1.04 for gender, and 1.02 for SCQ). IQ, Rigidity, gender, and SCQ predicted a significant amount of the variance for Part Whole ID, $R = .429$, $R^2 = .184$, $F(4,158) = 8.92$, $p = .001$, Durbin Watson $= 1.89$ (Table 30). Beta coefficients were significant for IQ, $\beta = .342$, $t = 4.67$, $p = .001$, gender, $\beta = .201$, $t = 4.23$, $p = .001$, and Rigidity, $\beta = .201$, $t = 2.78$, $p = .006$ (Table 30).

**Same Face Difference:** Tests for multicollinearity indicated that a very low level of multicollinearity was present (VIF = 1.05 for IQ, 1.01 for Rigidity, 1.05 for gender, and 1.01 for SCQ). IQ, Rigidity, gender, and SCQ did not predict a significant amount of the variance for Same Face Difference for Faces, $R= .102$, $R^2 = .010$, $F(4,152) = .398$, $p = .
.810, Durbin Watson = 1.96 (Table 30). None of the Beta coefficients were significant (Table 30)

**LFI Emotion recognition**

*Name Game:* Tests for multicollinearity indicated that a very low level of multicollinearity was present (VIF = 1.05 for IQ, 1.03 for age, 1.03 for Rigidity, 1.04 for gender, and 1.04 for SCQ). IQ, age, Rigidity, gender, and SCQ were significant for predicting the variance for Name Game, $R = .291$, $R^2 = .085$, $F(5,149) = 2.76$, $p = .021$, Durbin-Watson = 1.97 (Table 31). Beta coefficients were significant for Age, $\beta = -.173$, $t = -2.18$, $p = .031$, approached significance for Rigidity, $\beta = .146$, $t = 1.83$, $p = .069$, and approached significance for gender, $\beta = .135$, $t = 1.68$, $p = .094$ (Table 31).

*Part Whole Expression:* Tests for multicollinearity indicated that a very low level of multicollinearity was present (VIF = 1.03 for IQ, 1.03 for Rigidity, 1.05 for gender, and 1.05 for SCQ). IQ, Rigidity, gender did not predict a significant amount of the variance for Part Whole Expression, $R = .221$, $R^2 = .049$, $F(4,144) = 1.84$, $p = .124$, Durbin-Watson = 2.12 (Table 31). Beta coefficients were significant for IQ, $\beta = .210$, $t = 2.57$, $p = .011$ (Table 31).

*Match Maker Expression:* Tests for multicollinearity indicated that a very low level of multicollinearity was present (VIF = 1.04 for IQ, 1.03 for Rigidity, 1.05 for gender, and 1.04 for SCQ). IQ, Rigidity, gender, and SCQ did not predict a significant amount of the variance for Match Maker Across Expression, $R = .205$, $R^2 = .042$, $F(4,151) = 1.66$, $p = .162$, Durbin-Watson = 2.09 (Table 31). Beta coefficients were significant for gender, $\beta = .203$, $t = 2.49$, $p = .014$ (Table 31).
LFI Non-Face

*Immediate Memory for Cars:* Tests for multicollinearity indicated that a very low level of multicollinearity was present (VIF = 1.04 for IQ, 1.04 for Rigidity, 1.06 for gender, and 1.05 for SCQ). IQ, Rigidity, gender, and SCQ predicted a significant amount of the variance for Immediate Memory for Cars, $R = .253$, $R^2 = .064$, $F(4,149) = 2.54$, $p = .042$, Durbin Watson = 2.18 (Table 32). The Beta coefficient was significant for IQ, $\beta = .228$, $t = 2.83$, $p = .005$ (Table 32).

*Same Different Houses:* Tests for multicollinearity indicated that a very low level of multicollinearity was present (VIF = 1.04 for IQ, 1.03 for Rigidity, 1.05 for gender, and 1.04 for SCQ). IQ, Rigidity, gender, and SCQ predicted a significant amount of the variance for Same Different Houses test, $R = .372$, $R^2 = .138$, $F(4,152) = 6.05$, $p = .001$, Durbin Watson = 1.82 (Table 32). The Beta coefficients were significant for IQ, $\beta = .301$, $t = 3.91$, $p = .001$, and for Rigidity, $\beta = .241$, $t = 3.14$, $p = .002$ (Table 32).

**Summary of results of Hypothesis 3:**

The LFI face discrimination test of Part Whole Identity was predicted by each regression model of IQ, BAPQ component, gender, and SCQ (Tables 21, 24, 27, & 30). Of the BAPQ components, only Pragmatic Language and Rigidity made significant contributions (Tables 27, 30, & 32). The LFI face discrimination test of Match Maker Identification was predicted only by the model of IQ, Rigidity, gender, and SCQ (Table 30). In this model, Rigidity alone was a significant predictor of Match Maker Identification (Table 30). The only model to predict an LFI emotion recognition test was that of IQ, Rigidity, gender, and SCQ, which predicted the Name Game test (Table 31); only age was a significant predictor, but Rigidity and gender approached significance as
predictors (Table 31). Finally, in terms of predicting the LFI non-face tests, only the model of IQ, Rigidity, gender, and SCQ predicted the LFI Same Different Houses test (Table 32); IQ and Rigidity contributed significantly to the model (Table 32).
Discussion

The present study sought to further the research on face-processing abilities in parents and siblings of people with ASD (Adolphs et al., 2008; Losh et al., 2009), specifically focusing on those relatives who meet criteria for the BAP (Losh et al., 2007; Losh et al., 2009). The factors of BAP level, gender, and severity level of ASD proband were all evaluated regarding how they relate to face processing in terms of group difference, correlation, and model of prediction. In addition, this study aimed at examining the endophenotypes of ASD (Gottesman & Gould, 2003; Losh & Piven, 2007; Pickles et al., 2000; Piven et al., 1997) that manifest themselves separately in the BAP, each establishing a separate relationship to face processing. By examining these endophenotypes separately as opposed to all of them lumped together in ASD, it was hoped that light would be shed on the face processing problems encountered by people with ASD and the sources of these problems.

Hypothesis 1

First, the current finding that face processing ability between BAP+ and BAP- relatives was generally similar (Table 8) contradicts previous findings of a connection between BAP level and face discrimination (Wilson et al., 2010). Compared to the present study, the previous research (Wilson et al., 2010), a sample of 33 participants, was much smaller, contained only parents of people with ASD, did not examine group differences, and used the old BAPQ cut off values (Hurley et al., 2006; Sasson et al., 2013a). Large sample size is essential to capture enough individuals meeting criteria for the BAP since only a small percentage, 14–23% (Sasson et al., 2013b), have been found to meet BAP criteria. Second, the current study results contradict previous results that
BAP+ parents show impairment on face emotion recognition tasks compared to both typical comparisons and parents negative on the BAP (Adolphs et al., 2008; Losh et al., 2009) with more pronounced differences when Aloofness was taken into consideration (Losh et al., 2007; Losh et al., 2009). The use of the BAPQ in the current study takes advantage of BAP assessment advances developed since the previous research (Sasson et al., 2013a; Seidman et al., 2012), adding in the Pragmatic Language component of the BAP (Adolphs et al., 2008; Losh et al., 2007; Losh et al., 2009). In addition, the past research (Adolphs et al., 2008; Losh et al., 2007; Losh et al., 2009) had much smaller and restricted sample populations than the current study. Therefore, there is strong reason to accept the current results of face discrimination and emotion.

Research conducted on developing the LFI Test (Tanaka et al., 2012; Wolfe et al., 2008) found that people with ASD performed worse than typically developed comparisons on all the LFI face discrimination tests (Wolfe et al., 2008), on the LFI emotion tests of Matchmaker Expression and Parts Wholes Expression, but not on the emotion Name Games (Tanaka et al., 2012). The differences between groups found in the current study were not nearly as strong as the LFI research on comparing people with ASD to typical comparisons (Tanaka et al., 2012; Wolfe et al., 2008). However, the BAP face processing literature has found that relatives of people with ASD tend to perform better than people with ASD but not as well as typical comparisons (Adolphs et al., 2008; Bolte et al., 2003; Dawson et al., 2005; Dorris et al., 2004; Losh et al., 2007; Losh et al., 2009; Wilson et al., 2010; Wallace et al., 2010). Therefore, it makes sense that the current contrast on the LFI between BAP+ and BAP- relatives of people with ASD is
more modest compared to the LFI studies comparing people with ASD to typical comparisons (Tanaka et al., 2012; Wolfe et al., 2008).

In contrast to the face-processing measures, the previous LFI research on non-face measures showed that people with ASD score as well as typical comparisons on the Immediate Memory for Cars test and exhibit superior performance on the Same Different Houses Test (Wolfe et al., 2008). The skills tested on the LFI non-face tests are the same general cognitive/visual skills tested on the LFI face processing tests but presented in a context free of faces. Since the LFI face and non-face scores were much different, the authors (Wolfe et al., 2008) argued that people with ASD specifically were having problems processing faces and not with the general cognitive/visual skills. Like the LFI research (Wolfe et al., 2008), the present study also found similar performance on the Immediate Memory for Cars and a significant difference on the LFI Same Different Houses test. Yet, this present significant difference on the LFI Same Different Houses test revealed the BAP- group to be higher than the BAP- group, i.e. the group with less ASD features did better. Hence, when compared to the BAP- group, it did not matter whether the BAP+ group was being tested for memory for faces or cars, groups score similarly and faces did not cause a greater challenge than non-face objects. However, compared to the BAP- group, it did matter whether the BAP+ group was making same different judgments about faces or houses; houses posed a greater challenge. So the current findings of non-face objects do not support the idea that faces pose a specific problem for relatives of people with ASD. The Immediate Memory for Cars and Same Different Cars tests may be more cognitively demanding for the relatives of people with
ASD since these LFI tests are significantly correlated with IQ, while IQ is not correlated with the Immediate Memory for Faces or Same Different Faces (Table 7)

An explanation must be offered as to why the BAPQ Rigidity component and not the Aloofness component was the strongest criteria establishing differences between groups. First, while there was a significant difference between groups on the Rigidity component, it must again be stated that the effect sizes for these differences ranges from small to moderate: Matchmaker Identity = -.58 (medium effect size), Part Whole Identity = -.43 (small to medium effect size), and Same Different House = -.56 (medium effect size). These are smaller than the effect sizes reported in the LFI research comparing people with ASD to typically developing individuals (Wolfe et al., 2008). However, as already stated, small to moderate differences should most likely be expected, since the BAP research indicates that while there may be differences in relatives of people with ASD, the relatives as a whole are still performing in the normal range (Adolphs et al., 2008; Bolte et al. 2003; Dawson et al., 2005; Dorris et al., 2004; Losh et al., 2007; Losh et al., 2009; Wilson et al., 2010; Wallace et al., 2010). Second, it was anecdotally reported by female participants in the present study that their male relatives not diagnosed with ASD are more affected than they would report. In a recent study (Sasson, Faso, Parlier, Daniels, & Piven, 2014), a bias in BAPQ score self-report was found showing that males meeting criteria for BAP+ rate themselves lower than the informant reports. However, the one BAPQ component that was not affected by this self-report bias was Rigidity (Sasson et al., 2014). It is hypothesized that overall BAP+ males are not as accurate at self-reporting as females, but the component of Rigidity is viewed as something negative by spouses (informants) and positive by the person for both males
and females (Sasson et al., 2014). Also, while there may be a BAPQ self-report bias, this is accounted for in the different cut-off scores for self-report and informant report, as well as separate male and female cutoff scores for self-report and informant report (Hurley et al., 2007; Sasson et al., 2013a). So, it seems improbable that the difference observed in the present study revolving around the BAPQ component of Rigidity is due to a self-report bias. A more probable explanation may be that the LFI test is formatted in such a way that it is more difficult for relatives of people with ASD scoring high on the BAPQ Rigidity component. The LFI is a relatively long face test, 51 questions, with multiple subtests, presented in many variations (Tanaka et al., 2012; Wolfe et al., 2008). Perhaps this constantly changing aspect of the LFI test creates more problems for the participants with a high BAPQ Rigidity component. However, a more expansive explanation comes from large amounts of research indicating that people with ASD, even if they are accurate in face processing, use different methods and techniques than typical controls (Corbett et al., 2009; Dalton et al., 2005; Gauthier et al., 2009; Klin et al., 2002; Tanaka et al., 2012; Weigelt et al., 2012; Schultz et. al., 2000). In fact, research has argued that people with ASD view faces as if they were objects (Chawarska et al., 2010; Gauthier et al., 2009; Kikuchi et al., 2009). Furthermore, based on the atypical way in which people with ASD processing faces, it has been argued that ASD social deficits are due to emotion processing and not face processing measures that do not involve reading affect, i.e., identity, matching, recognition, and configuration (Dobel et al., 2007; Hefter, Manoach, & Barton, 2005; Krebs et al., 2010). This research (Dobel et al., 2007; Hefter et al., 2005; Krebs et al., 2010) indicates that for people with ASD face discrimination processing is a non-social activity. ASD face processing is generally a much more rule
governed and rigid way of processing faces, which is attested to by the fact that most documented ASD face processing studies gain their findings by tapping into extremely precise and atypical face processing strategies (Sasson, 2006; Harms et al., 2010; Weigelt et al., 2012). The highly rigid aspect of ASD face processing may also help to account for the success of behavioral learning theory based programs that teach people with ASD how to process faces more successfully (Tanaka et al., 2010; Golan et al., 2010).

Examining the BAP is a way to allow the components of ASD to dissociate and appear in isolation (Losh & Piven, 2007; Pickles et al., 2000; Piven et al., 1997). If, as the research indicates (Dobel et al., 2007; Hefter et al., 2005; Krebs et al., 2010), much of face processing in people with ASD is a rule based and rigid process, this would appear in line with the Rigidity component of the BAP. Therefore, while Aloofness had originally been considered (Adolphs et al., 2008; Sung et al., 2005) to be of particular importance in the BAP in terms of face processing, it may be that Rigidity plays a more primary role.

In addition to BAP group difference, it was hypothesized that BAPQ scores would correlate negatively with LFI scores, i.e. the higher the BAPQ score the lower the LFI score. This was based on the idea that as ASD traits get higher face processing would get worse. Some significant negative correlations were found and those with an alpha level of .01 were highlighted to reduce Type I error (Table 10). Yet, the strength of these correlations (Table 10) was still only small to medium (Cohen, 1988; Cohen, 1992). LFI tests of Match Maker Identity and Part Whole Identity were negatively correlated with all BAPQ criteria. Yet, the negative correlation between LFI and Aloofness was the weakest of the correlations between LFI and BAPQ components (Table 10). Only the BAPQ Pragmatic Language was negatively correlated with the LFI test of Match Maker
Expression (Table 10). Other significant correlations, albeit modest ones, showed
Aloofness correlated positively with Part Whole Expression and Rigidity was positively
correlated with Immediate Memory for Cars (Table 10). The aforementioned negative
correlation results are in disagreement with previous research that found no correlation
between BAP and face discrimination measures (Wilson et al., 2010). However, the
previous research did predict that BAP would be correlated with emotion recognition face
processing measures (Adolphs et al., 2008, Wilson et al., 2010). One explanation as to
why there were not more negative correlations is that the BAPQ was designed as a
classification tool, BAP+ vs. BAP-, and not as a measure of an ASD continuum (Hurley
et al., 2006; Sasson et al., 2013a). Therefore, scores ranges on the BAPQ are not as
meaningful as cutoff scores classifying one as either on the BAP or not. As far as the
negative correlations that were observed, it is again interesting to note, in light of the
aforementioned discussion of the importance of the Rigidity component, that the negative
correlations were found with non-emotion based face tests (Dobel et al., 2007; Hefter,
Manoach, & Barton, 2005; Krebs et al., 2010) and that Aloofness had only a minor
correlation. Therefore, these correlation findings strengthen the argument of face
discrimination deficits having a connection to Rigidity.

Hypothesis 2

Male relatives consistently showed higher BAPQ scores than female relatives
across all BAPQ components (Table 11). This is consistent with previous research
showing that BAP levels are higher in men than women (Bolton et al., 1994; Piven et al.,
1997; Pickles et al., 2000; Schwichtenberg et al., 2010; Wheelwright et al., 2010) and that
male relatives possess higher levels of ASD genetic loading (De La Marche et al., 2012;
Virkud et al., 2009). In fact, the official cutoff values established on the BAPQ are higher for males than females (Hurley et al., 2007; Sasson et al., 2013a). Second, overall, there were more differences on LFI tests between males and females than between BAP+ and BAP- groups. This appears to be due to the fact that the males consistently had higher scores on BAP than females (Table 11), despite the unexpected fact that females had a higher percentage of BAP+ members than males (Table 4).

Regarding why males did not perform worse than females on all discrimination tests, it may be because none of the relatives of people with ASD are in the clinically severe range of ASD traits; non-affected relative of people with ASD scores would not be drastically different from one another since they are mainly in the normal range (Gerdts & Bernier, 2011; Losh Wallace et al., 2010).

These new findings are in contrast to research arguing that fathers of people with ASD are significantly worse than mothers on face processing tasks involving emotions (Baron-Cohen et al., 1997) and that male siblings of people with ASD performed worse on emotion recognition task than controls (Dorris et al., 2004). It may also be the case that there were not enough males in the present study, especially compared to females, in order to capture enough males meeting criteria for the BAP. The lack of males may account for the results that females had slightly higher percentages of BAP+ than males for all BAPQ components except for Pragmatic Language (Table 5). Lastly, the fact that there were no overall interaction effects between gender and BAP helps to build an argument that gender and BAP are two distinct entities that function independently.
Hypothesis 3

Since SCQ has been shown to be significantly related to BAPQ (Sasson et al., 2013b) and BAPQ has been shown to be related to face processing (Losh et al., 2007; Losh et al., 2009), it was surprising that SCQ score was the least significant of the proposed variables for predicting face processing performance. SCQ was only a significant predictor when combined with Aloofness and IQ in terms of predicting the LFI Part Whole Identity test (Table 23). One explanation for the low predictive power of SCQ may be that the range of SCQ scores was restricted. The SCQ scores ranged from 10 to 32 but the mean was 23.37, the median was 20, and the mode was 23, so the participants scored their family members diagnosed with ASD predominantly high. Participants were initially recruited from the IAN Network database and only those with a child or sibling with an on record SCQ score of 15 were eligible. This was to ensure that participants definitely had a child or sibling with ASD. However, this recruiting criterion eliminated participants with higher functioning children or siblings, i.e. less severe so lower scores. A wider range of SCQ score may be needed to observe a correlation of SCQ and LFI tests. Also, it may be that beyond a certain SCQ score, there really is not much significant difference in manifest behavior.

Gender made the most consistent contribution, above IQ, to predicting face processing ability. This fact adds to the argument that gender and BAP are distinct entities. Face processing studies have examined gender differences in relatives of people with ASD (Baron-Cohen et al., 1997; Dorris et al., 2007; Wilson et al., 2010). This study helps to show that gender contributes to a different aspect of face processing than BAP. Specifically, gender explained a significant part of the LFI Part Whole Identity and
approached significance for the Name Game. It was predicted that gender would significantly contribute to the regression model on all LFI tests, since it has been maintained in the research that male relatives of people with ASD are closer to the ASD phenotype than females (Bolton et al., 1994; Piven et al., 1997; Pickles et al., 2000; Schwichtenberg et al., 2010; Wheelwright et al., 2010). However, a more modest contribution to a few LFI tests is quite reasonable since the ASD characteristics in relatives of people with ASD are themselves subclinical and more modest (Adolphs et al., 2008; Bolte et al. 2003; Dawson et al., 2005; Dorris et al., 2004; Losh et al., 2007; Losh et al., 2009; Wilson et al., 2010; Wallace et al., 2010). Also, it stands to reason that the LFI Part-Whole Identity test is predicted by gender since this is a specific test on which people with ASD have been found to employ atypical face strategies (Wolfe et al., 2008), so it would be expected that male relatives of people with ASD would exhibit these atypical strategies more than females. It was surprising that gender made a significant contribution to the LFI Name Games since this LFI test did not differentiate people with an ASD diagnosis (Tanaka et al., 2012). Perhaps this is just an example of a difference between relatives of people with ASD and the probands with ASD (Bolton et al., 1994; Piven et al., 1997; Pickles et al., 2000; Schwichtenberg et al., 2010; Wheelwright et al., 2010).

It was predicted that BAPQ Total, as well as all of the BAPQ component scores, would significantly predict LFI scores. Results of this study showed that the BAPQ total and Aloofness did not significantly contribute to the regression model (Tables 20-25), while Pragmatic language and Rigidity did contribute (Tables 26-32). Although, since the $R^2$ and $\beta$ values (Tables 26-31) were relatively small, this contribution of Pragmatic
Language and Rigidity was only modest. As was the case with the small to moderate effect size for group differences on the Rigidity component, small to moderate size prediction of variance in LFI score could also be expected, since the BAP research indicates that while there may be differences in relatives of people with ASD, the relatives as a whole are still performing in the normal range (Adolphs et al., 2008; Bolte et al. 2003; Dawson et al., 2005; Dorris et al., 2004; Losh et al., 2007; Losh et al., 2009; Wilson et al., 2010; Wallace et al., 2010). Specifically, Pragmatic language only predicted the Part Whole Identity, while Rigidity predicted Part Whole Identity, Match Maker Identity, and Same Different Houses. Since Aloofness (social characteristics) and Total BAPQ score, which has Aloofness as a sub-component, did not predict LFI scores, whereas Pragmatic language and Rigidity predicted LFI scores, this may be further evidence, as argued earlier, that people on the BAP or with ASD do not treat faces as social entities and instead look at faces like any other object (Chawarska et al., 2010; Gauthier et al, 2009; Kikuchi et al., 2009). Hence, rather than using social abilities to process faces, people with ASD or who are on the BAP use more rigid rules (Dobel et al., 2007; Hefter et al., 2005; Krebs et al., 2010), and even elements of Pragmatic language rules to process faces. Therefore, relatives of people with ASD who meet criteria on the BAPQ Rigidity component, as well as the Pragmatic language, tend to do more poorly on face processing than those relatives who do not meet criteria on these BAPQ components.

Two remaining questions are: why all BAPQ components consistently predicted the LFI Part Whole Identity test as opposed to other LFI tests, and why the BAPQ Rigidity component additionally predicted Match Maker ID and Same Difference Houses. This is in contrast to recent research showing that BAPQ score helps to predict
Immediate Memory for Faces score, in a sample of typically developed individuals (Halliday et al., 2014). The Part-Whole Identity test measures whether or not a person can better discriminate eyes and mouth when presented in a whole face as opposed to in isolation (Joseph & Tanaka, 2003; Wolfe et al., 2008). Comparisons from families without someone with ASD have an easier time distinguishing eyes and mouth from a whole face as opposed to in isolation (Tanaka & Farah, 1993). People with ASD have been shown to have a deficit in the advantage for the whole face when discriminating eyes but not mouth (Wolfe et al., 2008). Hence, this documented ASD problem of not displaying a complete advantage for the whole face (Wolfe et al., 2008) may be manifesting itself in relatives of people with ASD meeting BAP criteria, but only in relatives meeting criteria for the BAP components of Pragmatic language and Rigidity. Lacking the typical advantage for interpreting whole faces may indeed result in social problems for people with ASD, but this problem does not appear to have its roots in the person’s social characteristics, i.e. Aloofness. Instead, an ASD delay for whole faces is related the person’s Pragmatic language and Rigidity characteristics. Another related issue with the LFI Part Whole Identity test is that there is a time factor (Wolfe et al., 2008). In a review of the face processing literature for people with ASD (Weigelt et al., 2012) it is argued that the problems people with ASD have with face processing are most often observed when a demand is placed on memory for faces. Since the LFI Part Whole Identity test has a time delay between the target face and test faces, this may add to the reasons why Part Whole Identity is noticed as an LFI test that the BAP components predicts.
As already stated, the BAPQ Rigidity component also predicted the LFI Match Maker Identity test score. The Match Maker Identity test measures the ability to match face identity when the eye or mouth are covered (Wolfe et al., 2008). This task is a variation of the Part Whole Identity test; instead of presenting the whole face vs. parts of face in isolation, the whole face is presented with the specific face part covered up or masked (Wolfe et al., 2008). People with ASD were found to do worse than typical controls on this task (Wolfe et al., 2008). However, unlike the Part Whole Identity results, no preference for masked mouths or eyes was observed (Wolfe et al., 2008). The Match Maker Identity test is also time based (Wolfe et al., 2008), which, as previously stated, makes the possibility of noticing a face processing problem related to ASD more probable (Weigelt et al., 2012). Therefore, the present BAP results indicate that the problem people with ASD have with typical holistic face processing may be related to the person’s Rigidity characteristics and not the person’s social characteristics.

Finally, the current study revealed that the BAPQ Rigidity component significantly predicted score on the LFI Same Different House test. The LFI includes both the Same Different House and the Immediate Memory for Cars tests as two non-face tests that use the same matching strategies, respectively, as the LFI Same Different Faces and Immediate Memory for Faces (Wolfe et al., 2008). The purpose of these tests in the LFI assessment is to show that face processing problems of people with ASD are unique to viewing faces (Wolfe et al., 2008). This is demonstrated if a deficit is shown in the LFI face test, but not in the corresponding non-face test (Wolfe et al., 2008). Research on the LFI showed that participants with ASD did worse than typical comparisons on the LFI Same Different Faces and Immediate Memory for Faces (Wolfe et al., 2008).
However, on the corresponding non-face tests, these same participants with ASD scored as well as typical comparisons on the Immediate Memory for Cars test and superior to typical comparisons on the Same Different Houses test (Wolfe et al., 2008). In the present study, none of the BAP+ groups showed a disadvantage to the BAP- groups on either the Immediate Memory for Cars test or on the Same Different Houses test (Tables 8 & 9). On the corresponding LFI non-face tests, a difference between BAP + and – groups was only found for the Rigidity component (Tables 8 & 9). The Rigidity+ group did as well as the Rigidity- group on the Immediate Memory for Cars test, but worse than the Rigidity- group on the Same Different Houses test (Tables 8 & 9). Since this data shows no difference on the Immediate Memory for Faces test or on the Same Different Faces test between BAP+ and BAP- groups (Tables 8 & 9), there is no evidence for a specific deficit for faces. The fact that there was a difference between Rigidity + and – groups on the Same Different Houses test, and the finding that the BAPQ Rigidity component significantly predicts the Same Different Houses tests may be most reflective of the fact that this same test is also strongly correlated with IQ (Table 7). The lack of a correlate finding of a deficit on faces, but a strength on non-faces (Wolfe et al., 2008), may simply be a point of divergence between relatives of people with ASD on the BAP and people with ASD.

Conclusion

In summary, relatives of people with ASD meeting criteria for the BAP and those not meeting criteria were more similar in their face processing abilities than different. One area that discriminated between the BAP+ and BAP- relatives was the BAPQ component of Rigidity. Those relatives of people with ASD who scored positive on
Rigidity performed worse on the LFI face discrimination measures and non-face measures than relatives of people with ASD not meeting BAPQ Rigidity criteria. No differences were observed on LFI emotion based face tests. The BAP provides an advantage over diagnosed cases of ASD since it disentangles the multiple components of ASD into separate entities (Gottesman & Gould, 2003; Losh & Piven, 2007; Pickles et al., 2000; Piven et al., 1997). It appears based on these findings that face discrimination measures may tap more into the Rigidity component of ASD and not the Aloofness, i.e. social component, as hypothesized. In support of the BAP group difference findings, there were also found to be some negative correlations between BAPQ level and LFI scores, i.e. more severe BAPQ scores (Table 10). While the BAPQ was designed as a diagnostic tool with cutoff criteria (Hurley et al.; Sasson et al., 2013a) the fact that significant negative correlations were found demonstrates that the BAPQ has meaningful scores on a continuum. However, since there were not many significant negative correlations between the BAPQ and the LFI, it may be the case that above a certain point of BAPQ severity there is little difference.

Gender provided another interesting point of comparison. As expected, males had significantly higher scores on all component areas of the BAPQ. In addition, males performed worse on LFI face discrimination measures than females, but performed similar to females on LFI emotion recognition and non-face measures. No overall interaction effect was found between gender and BAPQ, which means that gender and BAP are separate entities.

Finally, hierarchical multiple regression analysis showed that BAPQ, gender, and SCQ may help to predict LFI face processing scores above IQ and age alone. SCQ
provided almost no significance as a predictor, but this may have been due to a restricted range. These results again seem to indicate that the face processing deficits typically found in people with ASD may have their source not in the lack of ASD social characteristics, but in the Rigidity and Pragmatic language. This could only be determined by examining the endophenotypes of the BAP.

There are a number of broader implications that are suggested by the specific findings of the present study. First, the findings add a change in understanding ASD itself. If, as it has been theorized that the BAP allows researchers to tease apart ASD into its components and look at those components in isolation (Losh & Piven, 2007; Pickles et al., 2000; Piven et al., 1997), the current findings suggest that Rigidity may be a stronger ASD endophenotype than even the much touted Aloofness component (Sung et al., 2005; Bolton et al., 1994; Losh et al., 2008; Piven et al., 1997). While social Aloofness had been considered to be the governing hallmark trait in ASD (Sung et al., 2005; Bolton et al., 1994; Losh et al., 2008; Piven et al., 1997), it may very well be that the Rigidity components takes precedence even to Aloofness. Second, the current study gives a new perspective to previous research that face processing, specifically face discrimination, is not a social activity for people with ASD (Dobel et al., 2007; Hefter et al., 2005; Krebs et al., 2010). Not only does the current study also suggest that face discrimination is not a socially based skill in ASD, but that face discrimination may be inherited in families of people with ASD as a non-social trait, showing up in family members who are BAP+ or whom are diagnosed with ASD. Next, the current research adds to the previous BAP research (Losh & Piven, 2007; Pickles et al., 2000; Piven et al., 1997; Schwichtenberg et al., 2010; Wheelwright et al., 2010) suggesting people with ASD are not only have many
obstacles before them in terms of their own diagnosis, but also may have additional
hurdles thrown in front of them in terms of being born into a family environment that
may already be manifesting troubles. Any areas of applied intervention with people with
ASD should take knowledge of the whole BAP family unit into account, especially those
related to the Rigidity component, in terms of creating effective programing. Finally, in
terms of improving early detection and diagnosis of ASD, this study would suggest that
the Rigidity component could play key role in identifying those children at high risk for
ASD. Rigid behaviors and personality characteristics may be one of the most strongly
related factors to the full diagnosis of ASD.

Limitations

There are a number of limitations in this study. First, there were some problems
regarding the participant sample. There were unequal numbers of males and females.
This was due to difficulty recruiting fathers, as well as siblings, as participants. Most
recent estimates of the percentage of relatives of people with ASD who exhibit the BAP
range from 14–23% of (Sasson et al., 2013b). While these percentages were met in the
groups of fathers and mothers, except for Pragmatic + mothers, there were actually
relatively few BAP+ in each group to capture the BAP behavior. Also, the number of
sibling participants was also low and nearly all of them were BAP-. This made it
impossible to perform valid comparisons for the siblings groups. Increasing the number
of participant, specifically males and siblings, would increase the construct and external
validity of this study. Despite the problems with sample size, the current study is one of
the largest, if not the largest, to date of face processing study of family members of
people with ASD (Adolph et al., 2008; Baron-Cohen et al., 1997; Bolte et al. 2003;
Dalton et al., 2007; Dorris et al., 2007; Dawson et al., 2005; Losh et al, 2007; Losh et al., 2009; Smalley et al., 1990; Wilson et al., 2010; Wallace et al., 2010).

Another study limitation concerned the fact that the BAPQ was administered as a self-report survey only and not with an accompanying informant version (Hurley et al., 2007; Sasson et al., 2013a; Sasson et al., 2013b). While the BAPQ does have validated self-report, as well as informant, cutoff scores (Hurley et al., 2007; Sasson et al., 2013a), there is reason to believe that Relatives of people with ASD provide lower ratings for themselves on the BAPQ compared to when the BAPQ is filled out by a spouse or other family member. These lower BAPQ self-reports may result in people who should be classified as positive for the BAP being labeled as negative. Giving the informant BAPQ along with the self-report version would provide some indication of incorrect BAPQ classification. However, there are strong reasons using the self-recent research shows that the self-report and informant versions correlate well with one another (Sasson et al., 2013a). The merits of the self report version of the BAPQ is that it can be given faster than informant and interview BAP measures, involves no clinical training, and is less cost prohibitive (Sasson et al., 2013). Finally, all analysis of BAPQ data utilized the standardized BABQ cutoff scores that are unique to the self-report version and take into account differences between self and informant report versions (Hurley et al., 2007; Sasson et al., 2013a).

A further limitation was that there was a significant difference between the BAP positive and negative groups, as well as between males and females, on age, and a difference approaching significance between males and females on IQ (Table 6). Preferably, participants should be matched on these variables. Appropriate matching on
subject variable would also eliminate the need to rely upon covariate analysis. In order to
deal with these group differences, outliers were removed from the data. Age and IQ were
used as covariates to deal with the correlations of Age and IQ to the LFI tests.

Next, additional face processing strategies often linked to the atypical face
processing found in people with ASD, such as reliance on mouth and eyes and
differences in recognizing specific emotions, were not examined (Wolfe et al., 2008;
Tanaka et al., 2012). While the LFI test does provide look at some of these processes,
the additional statistical breakdown of a number of the LFI subtests was beyond the scope
of this present work. Not examining specific face processing may have resulted in not
detecting enough group differences. However, all of the main LFI tests were analyzed
through MANCOVA tests. Only when there was an overall effect for any of the test
groupings of discrimination, emotion recognition, and non-face tests were individual tests
examined. Based on the MANCOVA testing further breakdown of individual tests into
the subscores that indicate more face processing intricacies did not appear to be
warranted.

An additional problem with the current study was that the creators of the LFI
(Wolfe et al., 2008; Tanaka et al., 2012) have not yet provided norms and means specific
for adults with ASD. It would have been helpful to know how well the current
participants were performing on the LFI compared to older adults with ASD. However,
this was not a direct question of any of the hypotheses, so it did not have to be considered
in the present study.

Finally, a potential problem may have involved the use of online resources to do
recruitment, testing, and measuring. While the use of online tests and assessments made
the process faster and made it possible to obtain participants from across the United States, it made the monitoring of these tests and assessment to be more difficult. Additionally, the online methods made it more difficult to encourage participants to complete all of the assessments, which resulted in decreased numbers. In response, research indicates that the ASD report status reported on the Interactive Autism Network is valid (Rosenberg et al., 2009). Also, the ability to participate from the comfort of home, at one’s own pace, may have provided a less threatening and less intrusive environment for participants than the sterile environment of a lab.

Future Research

The present findings, which highlighted the role of the BAP Rigidity component in determining group differences and predictive models of face processing, point to the need for further investigation of the Rigidity component of the BAP. The current study, combined with recent research maintaining that the BAP Rigidity component is one component that relatives of people with ASD can most readily and accurately identify in themselves (Sasson et al., 2014), sheds light on a distinct and perhaps underestimated role that the BAP Rigidity component plays in the lives of people with ASD and their immediate relatives. Therefore, future research should examine the relationship of the BAP Rigidity levels in relatives of people with ASD to the rigid and ritualistic behavior levels observed in the probands with ASD, as well as what this might mean for family interventions and family decision making.

The current research involved group comparisons of BAP level and gender. Previous research indicates that simplex and multiplex families differ in terms of general BAP distribution (Piven & Folstein, 1994; Constantino et al, 2010), as well as face
processing (Bolte et al., 2003; Wallace et al., 2010). New studies should compare face processing ability in relatives from both simplex and multiplex families, as well as the possible interaction of BAP level and simplex/multiplex classification of family members. Since the BAP has been found to be at higher rates and levels in multiplex families (Piven et al., 1994; Piven et al., 1997; Losh et al., 2008; Murphy et al., 2000; Constantino et al., 2010), the present findings would suggested more robust differences in this group, as well as an even stronger influences of the BAP Rigidity component. Even using simplex/multiplex comparisons, recent research (Davidson et al., 2014) indicates that different BAP assessment tools may be measuring different constructs. Therefore, new research on BAP and face processing may benefit from using more that one measure of BAP in order to see if the same face processing results would be obtained based on different BAP criteria. Since different BAP measures may be measuring different innate characteristics (Davidson et al., 2014) and these different measures have different reliability/validity (Ingersoll et al., 2010), there may be a need for more objective BAP measures in the form of neuropsychological correlates measures by neurophysiological assessment (Dawson et al., 2005; Dalton et al., 2007). This would go well with face processing research, since much of the current research on face processing in people with ASD has uncovered many novel findings using advance electrophysiological, eye tracking, and brain imaging technologies (Schultz et al., 2005; Corbett et al., 2009; Kleinhaus et al., 2009; Perlman et al., 2011) it would be worthwhile to incorporate this technology into BAP face processing studies.

Whereas the present study was able to examine BAP level and gender differences in relatives of people with ASD, further analysis needs to be done to examine these
difference separately in fathers, mothers, and siblings. In addition, as there are many ASD face processing studies on children (Chawarska et al., 2010; Joseph & Tanaka, 2003; Kikuchi et al., 2009; Klin et al, 2002; Osterling et al., 1994), future BAP face processing studies should explore how the BAP, particularly the Rigidity component, and face processing relate to one another in child siblings of people with ASD.

Developmental trajectories of both the BAP and face processing abilities in young unaffected sibling of people with ASD should be examined as they may detect the age at which the BAP and facial processing problems begin in relatives of people with ASD and what the overall development of facial processing abilities look like in this population compared to the developmental trajectories of people with ASD (Annaz et al., 2009; Karmiloff-Smith et al., 2004; Thomas et al., 2009). Besides these direct relatives, there is research showing the extension of BAP characteristics in the general population (Constantino & Todd, 2003; Sasson, Nowlin, & Pinkham, 2013c; Wainer, Ingersoll, & Hopwood, 2011). Face processing and its relationship to the BAP should also be examined further in the general population looking for similar difference by BAP level and gender.

There are two final aspects of BAP and face processing that need further examination. First, future research needs to examine parents and siblings of people with ASD on face processing measures that are even more precise in measuring the specific atypical strategies that people with ASD use in face deciphering faces. These additional strategies include reliance on mouth vs. eyes (Tanaka & Farah, 1993), whole face vs. parts of face (Annaz et al., 2009; Behrmann et al., 2006; Lahaie, et al., 2006; and, Gauthier et al., 2009), and difference in recognizing specific emotions (Harms et al.,
2010; Tanaka et al., 2012). A final area that requires more investigation based on the results of the present study the relationship of the severity of the ASD proband and the Relatives of people with ASD’ face processing ability. ASD severity level has now become an integral part of the ASD diagnosis (APA, 2014). Hence, the relationship of this factor to the BAP, as well as face processing, may be examined with greater interest (Halliday et al., 2014).

Overall, BAP research on face processing (Adolphs et al., 2008; Baron-Cohen et al., 1997; Bolte et al. 2003; Dawson et al., 2005; Losh et al., 2007; Losh et al., 2009; Smalley et al., 1990; Wilson et al., 2010; Wallace et al., 2010) reveals how the frequently documented face processing impairments of people with ASD (Harms et al., 2010; Weigelt et al., 2012) are related to the core ASD components as they manifest themselves in isolation in the inheritable traits that comprise the BAP (Gottesman & Gould, 2003; Losh & Piven, 2007; Pickles et al., 2000; Piven et al., 1997). Those working to develop face processing interventions (Golan et al, 2008; Tanaka et al., 2010) can use this information to improve face processing of people with ASD by focusing on the unique ASD component traits that BAP face processing studies reveal are linked to specific face processing impairments. In addition, this study, along with previous BAP research (Losh et al., 2009; Losh & Piven, 2007; Pickles et al., 2000; Piven et al., 1997; Smalley et al., 1990; Wallace et al., 2010; Wilson et al., 2010), calls the attention of clinicians to the importance of family profiles of people with ASD, as well as the often sub-clinically delayed family environment that people with ASD are born into above and beyond their own diagnosis of ASD.
### Table 1

*LFI Identity Skills Battery*

<table>
<thead>
<tr>
<th>Subtest</th>
<th># of questions</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Matchmaker ID</td>
<td>55</td>
<td>Matching identity across masked features: full face is shown, then three faces shown in 45 degree rotation with either mouth covered, eyes covered, or no obstruction. Time factor.</td>
</tr>
<tr>
<td>Matchmaker Across</td>
<td>29</td>
<td>Matching identity across expressions: target face shown with three test faces with a varying expressions shown above, must be matched by identity. Time factor.</td>
</tr>
<tr>
<td>Expression</td>
<td>29</td>
<td>Matching identity across expressions: target face shown with three test faces with a varying expressions shown above, must be matched by identity. Time factor.</td>
</tr>
<tr>
<td>Same Difference (Face Dimensions)</td>
<td>76</td>
<td>Featural and configural face dimensions: two faces shown next to each other and must be described as identical or different. Unlimited time</td>
</tr>
<tr>
<td>Part/Whole ID</td>
<td>51</td>
<td>Parts/ whole identity: face is shown and then either two faces are shown, one identical and one with changed part, or two parts of the face are shown, one identical and one different. Time factor.</td>
</tr>
<tr>
<td>Immediate Memory for Faces</td>
<td>14</td>
<td>Face shown for short time, then three faces angled at ¾ orientation shown, one identical. Time factor.</td>
</tr>
</tbody>
</table>
Table 2

*LFI Emotion Battery*

<table>
<thead>
<tr>
<th>Subtest</th>
<th># of questions</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name Game</td>
<td>66</td>
<td>Face expressing an emotion is shown with name of six emotions next to image, correct name of emotion that is shown must be chosen. No time factor.</td>
</tr>
<tr>
<td>Matchmaker Expression</td>
<td>29</td>
<td>Face showing expression displayed for one second, then three new faces displayed with an identical expression and two new expressions, face with identical expression must be chosen. No time factor.</td>
</tr>
<tr>
<td>Part/Whole Expression</td>
<td>41</td>
<td>Test face, either with a consistent expression or inconsistent, is shown for two seconds and then replaced with either a whole face or part of a face, must identify which is from test face. Time factor.</td>
</tr>
</tbody>
</table>
Table 3

*LFI Object Battery*

<table>
<thead>
<tr>
<th>Subtest</th>
<th># of questions</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Immediate Memory for Cars</td>
<td>14</td>
<td>Test car is shown, then three cars at a ¾ angle orientation are shown, must match one car to test car. Time factor.</td>
</tr>
<tr>
<td>Same Difference Houses</td>
<td>16</td>
<td>Featural and configural house dimensions: two houses next to each other and must be classified as identical or not. No time factor.</td>
</tr>
</tbody>
</table>
Table 4

*Group Characteristics I*

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>Males</th>
<th>Females</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>178</td>
<td>62</td>
<td>116</td>
</tr>
<tr>
<td>Age</td>
<td>38.20 (9.50)</td>
<td>38.84 (9.70)</td>
<td>37.85 (9.42)</td>
</tr>
<tr>
<td>IQ</td>
<td>109.63 (7.61)</td>
<td>111.34 (6.85)</td>
<td>108.77 (7.86)</td>
</tr>
<tr>
<td>SCQ</td>
<td>20.37 (4.40)</td>
<td>20.97 (4.44)</td>
<td>20.04 (4.36)</td>
</tr>
<tr>
<td>BAPQ Total +/- (% of +)</td>
<td>37/141 (21%)</td>
<td>11/51 (18%)</td>
<td>26/90 (22%)</td>
</tr>
<tr>
<td>Aloofness +/- (% of +)</td>
<td>48/130 (27%)</td>
<td>11/51 (18%)</td>
<td>37/79 (32%)</td>
</tr>
<tr>
<td>Pragmatic +/- (% of +)</td>
<td>19/159 (11%)</td>
<td>10/52 (16%)</td>
<td>9/107 (8%)</td>
</tr>
<tr>
<td>Rigidity +/- (% of +)</td>
<td>29/148 (16%)</td>
<td>9/53 (15%)</td>
<td>20/96 (17%)</td>
</tr>
</tbody>
</table>

BAPQ self report cutoff scores: BAPQ Total = 3.63, Aloofness = 4.19, Pragmatic = 3.29, Rigidity = 4.20 (Sasson et al., 2013a)

+ = positive on BAPQ, cutoff and above
- = negative on BAPQ, below cutoff
Table 5

*Group Characteristics II*

<table>
<thead>
<tr>
<th></th>
<th>Fathers</th>
<th>Mothers</th>
<th>Sisters</th>
<th>Brothers</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>52</td>
<td>98</td>
<td>18</td>
<td>10</td>
</tr>
<tr>
<td>Age (SD)</td>
<td>42.50 (5.16)</td>
<td>41.11 (5.60)</td>
<td>20.11 (5.17)</td>
<td>19.8 (2.70)</td>
</tr>
<tr>
<td>IQ (SD)</td>
<td>111.53 (6.83)</td>
<td>109.08 (8.21)</td>
<td>107.17 (5.62)</td>
<td>110.38 (7.28)</td>
</tr>
<tr>
<td>SCQ (SD)</td>
<td>20.96 (4.65)</td>
<td>19.77 (4.21)</td>
<td>21.56 (4.94)</td>
<td>21.0 (3.30)</td>
</tr>
<tr>
<td>BAPQ Total +/- (% of +)</td>
<td>11/41 (21%)</td>
<td>25/73 (26%)</td>
<td>1/17 (5%)</td>
<td>0/10 (0)</td>
</tr>
<tr>
<td>Aloofness +/- (% of +)</td>
<td>11/41 (21%)</td>
<td>36/62 (37%)</td>
<td>1/17 (5%)</td>
<td>0/10 (0)</td>
</tr>
<tr>
<td>Pragmatic +/- (% of +)</td>
<td>9/43 (17%)</td>
<td>8/89 (8%)</td>
<td>1/17 (5%)</td>
<td>1/9 (10%)</td>
</tr>
<tr>
<td>Rigidity +/- (% of +)</td>
<td>8/44 (15%)</td>
<td>17/81 (17%)</td>
<td>3/15 (17%)</td>
<td>1/9 (10%)</td>
</tr>
</tbody>
</table>

BAPQ self report cutoff scores: BAPQ Total = 3.63, Aloofness = 4.19, Pragmatic = 3.29, Rigidity = 4.20 (Sasson et al., 2013a)

+ = positive on BAPQ, cutoff and above
- = negative on BAPQ, below cutoff
Table 6

*Group Characteristics III*

<table>
<thead>
<tr>
<th></th>
<th>BAPQ Total</th>
<th>Aloofness</th>
<th>Pragmatic Language</th>
<th>Rigidity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>N (%)</td>
<td>37 (21%)</td>
<td>141 (79%)</td>
<td>48 (27%)</td>
<td>130 (73%)</td>
</tr>
<tr>
<td>Age (SD)</td>
<td>41.08 (5.61)*</td>
<td>37.44 (10.16)</td>
<td>41.00 (5.63)*</td>
<td>37.16 (10.41)</td>
</tr>
<tr>
<td>N (IQ)</td>
<td>36</td>
<td>131</td>
<td>45</td>
<td>122</td>
</tr>
<tr>
<td>IQ (SD)</td>
<td>110.62 (6.26)</td>
<td>109.36 (7.94)</td>
<td>110.43 (6.63)</td>
<td>109.34 (7.95)</td>
</tr>
</tbody>
</table>

BAPQ self report cutoff scores: BAPQ Total = 3.63, Aloofness = 4.19, Pragmatic = 3.29, Rigidity = 4.20 (Sasson et al., 2013a)

+ = positive on BAPQ, cutoff and above
- = negative on BAPQ, below cutoff

Note: *p < .05, **p < .01
Table 7

Correlations of Age and IQ with LFI Measures for Total Sample

<table>
<thead>
<tr>
<th>Measures</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. IQ</td>
<td>1</td>
<td>.154*</td>
<td>.232**</td>
<td>.278**</td>
<td>.030</td>
<td>.092</td>
<td>.064</td>
<td>-.003</td>
<td>.180*</td>
<td>.014</td>
<td>.218**</td>
<td>.009</td>
</tr>
<tr>
<td>2. Age</td>
<td>.154*</td>
<td>1</td>
<td>-.093</td>
<td>-.010</td>
<td>-.019</td>
<td>.016</td>
<td>.007</td>
<td>-.070</td>
<td>.108</td>
<td>-.180*</td>
<td>.100</td>
<td>.001</td>
</tr>
<tr>
<td>3. Immediate Memory Cars</td>
<td>.232**</td>
<td>-.093</td>
<td>1</td>
<td>.153</td>
<td>.176*</td>
<td>.153</td>
<td>.046</td>
<td>.016</td>
<td>.151</td>
<td>.127</td>
<td>.193*</td>
<td>.033</td>
</tr>
<tr>
<td>4. Same Difference House</td>
<td>.278**</td>
<td>-.010</td>
<td>.153</td>
<td>1</td>
<td>.098</td>
<td>.361**</td>
<td>.188*</td>
<td>.372**</td>
<td>.183*</td>
<td>.110</td>
<td>.212**</td>
<td>.125</td>
</tr>
<tr>
<td>5. Immediate Memory Faces</td>
<td>.030</td>
<td>-.019</td>
<td>.176*</td>
<td>.098</td>
<td>1</td>
<td>.423**</td>
<td>.383**</td>
<td>.295**</td>
<td>.451**</td>
<td>.126</td>
<td>.239**</td>
<td>.212**</td>
</tr>
<tr>
<td>6. Match Maker Identity</td>
<td>.092</td>
<td>.016</td>
<td>.153</td>
<td>.361**</td>
<td>.423**</td>
<td>1</td>
<td>.613**</td>
<td>.432**</td>
<td>.507**</td>
<td>.245**</td>
<td>.210**</td>
<td>.365**</td>
</tr>
<tr>
<td>7. Match Maker Identity Across Expression</td>
<td>.064</td>
<td>.007</td>
<td>.046</td>
<td>.188*</td>
<td>.383**</td>
<td>.613**</td>
<td>1</td>
<td>.290**</td>
<td>.440**</td>
<td>.255**</td>
<td>.232**</td>
<td>.301**</td>
</tr>
<tr>
<td>8. Same Different Face</td>
<td>-.003</td>
<td>-.070</td>
<td>.016</td>
<td>.372**</td>
<td>.295**</td>
<td>.432**</td>
<td>.290**</td>
<td>1</td>
<td>.216**</td>
<td>.140</td>
<td>.148</td>
<td>.345**</td>
</tr>
<tr>
<td>9. Part Whole Identity</td>
<td>.180*</td>
<td>.108</td>
<td>.151</td>
<td>.183*</td>
<td>.451**</td>
<td>.507**</td>
<td>.440**</td>
<td>.216**</td>
<td>1</td>
<td>.156*</td>
<td>.424**</td>
<td>.387**</td>
</tr>
<tr>
<td>10. Name Game</td>
<td>.014</td>
<td>-.180*</td>
<td>.127</td>
<td>.110</td>
<td>.126</td>
<td>.245**</td>
<td>.255**</td>
<td>.140</td>
<td>.156*</td>
<td>1</td>
<td>.199*</td>
<td>.289**</td>
</tr>
<tr>
<td>11. Part Whole Expression</td>
<td>.218**</td>
<td>.100</td>
<td>.193*</td>
<td>.212**</td>
<td>.239**</td>
<td>.210**</td>
<td>.232**</td>
<td>.148</td>
<td>.424**</td>
<td>.199*</td>
<td>1</td>
<td>.243**</td>
</tr>
<tr>
<td>12. Match Maker Expression</td>
<td>.009</td>
<td>.001</td>
<td>.033</td>
<td>.125</td>
<td>.212**</td>
<td>.365**</td>
<td>.301**</td>
<td>.345**</td>
<td>.387**</td>
<td>.289**</td>
<td>.243**</td>
<td>1</td>
</tr>
</tbody>
</table>

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).
Table 8

**MANOVA Results for BAPQ Level on LFI Scores**

<table>
<thead>
<tr>
<th>Let’s Face It tests</th>
<th>BAPQ Level</th>
<th>Aloofness Level</th>
<th>Pragmatic Language</th>
<th>Rigidity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pillai's trace V</td>
<td>F (df)</td>
<td>Pillai's trace V</td>
<td>F (df)</td>
</tr>
<tr>
<td>Face Discrimination</td>
<td>V=.011</td>
<td>F(5, 139)=.298</td>
<td>V=.009</td>
<td>F(5, 139)=.253</td>
</tr>
<tr>
<td>Emotion Recognition</td>
<td>V=.016</td>
<td>F(3, 143)=.791</td>
<td>V=.007</td>
<td>F(3,143)=.352</td>
</tr>
<tr>
<td>Non-face</td>
<td>V=.023</td>
<td>F(2, 150)=1.79</td>
<td>V=.006</td>
<td>F(2, 150)=.429</td>
</tr>
</tbody>
</table>

Note: * p < .05, ** p < .01, *** p < .001.
Table 9

*Estimated Margins of Means LFI scores for Rigidity Positive vs. Negative, All Participants*

<table>
<thead>
<tr>
<th>Let’s Face It tests</th>
<th>Rigidity + (Std. Error)</th>
<th>Rigidity - (Std. Error)</th>
<th>F-value</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Face Discrimination</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Immediate Memory Faces</td>
<td>81.0 (.026)</td>
<td>83.4 (.011)</td>
<td>.689</td>
<td>.408</td>
</tr>
<tr>
<td>Match Maker Identity</td>
<td>87.0 (.015)</td>
<td>91.9 (.006)</td>
<td>9.452</td>
<td>.003**</td>
</tr>
<tr>
<td>Match Maker Identity Across Expressions</td>
<td>85.1 (.023)</td>
<td>87.6 (.010)</td>
<td>.977</td>
<td>.325</td>
</tr>
<tr>
<td>Same Different Face</td>
<td>94.2 (.011)</td>
<td>95.2 (.005)</td>
<td>.749</td>
<td>.388</td>
</tr>
<tr>
<td>Part Whole Identity</td>
<td>85.2 (.014)</td>
<td>88.5 (.006)</td>
<td>4.536</td>
<td>.035*</td>
</tr>
<tr>
<td><strong>Emotion Recognition</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Part Whole Expression</td>
<td>96.0 (.010)</td>
<td>95.4 (.004)</td>
<td>.254</td>
<td>.615</td>
</tr>
<tr>
<td>Match Maker Expression</td>
<td>90.5 (.016)</td>
<td>88.9 (.007)</td>
<td>.763</td>
<td>.384</td>
</tr>
<tr>
<td>Name Game</td>
<td>93.0 (.009)</td>
<td>94.4 (.004)</td>
<td>2.084</td>
<td>.151</td>
</tr>
<tr>
<td><strong>Non-Face</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Immediate Memory Cars</td>
<td>82.1 (.025)</td>
<td>80.7 (.011)</td>
<td>.245</td>
<td>.621</td>
</tr>
<tr>
<td>Same Different Houses</td>
<td>79.5 (.019)</td>
<td>86.3 (.008)</td>
<td>10.922</td>
<td>.001***</td>
</tr>
</tbody>
</table>

Note: Margin of Means scores presented as percentage correct on test
Covariates: IQ for all comparisons, Age added for Name Game
Note: * p < .05, ** p < .01, *** p < .001
### Table 10

**Correlations Matrix of BAPQ Scores and LFI Scores, All Participants**

<table>
<thead>
<tr>
<th>Measures</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. BAPQ Total</td>
<td>1</td>
<td>.902**</td>
<td>.776**</td>
<td>.823**</td>
<td>.116</td>
<td>.023</td>
<td>-.099</td>
<td>-.209**</td>
<td>-.097</td>
<td>-.067</td>
<td>-.253**</td>
<td>-.057</td>
<td>.093</td>
<td>-.108</td>
</tr>
<tr>
<td>2. Aloofness</td>
<td>.902**</td>
<td>1</td>
<td>.591**</td>
<td>.612**</td>
<td>.073</td>
<td>.103</td>
<td>-.107</td>
<td>-.143*</td>
<td>-.084</td>
<td>-.059</td>
<td>-.159*</td>
<td>-.058</td>
<td>.154*</td>
<td>-.061</td>
</tr>
<tr>
<td>3. Pragmatic Language</td>
<td>.776**</td>
<td>.591**</td>
<td>1</td>
<td>.439**</td>
<td>.094</td>
<td>.061</td>
<td>-.060</td>
<td>-.197**</td>
<td>-.097</td>
<td>-.100</td>
<td>-.281**</td>
<td>.029</td>
<td>.061</td>
<td>-.153*</td>
</tr>
<tr>
<td>4. Rigidity</td>
<td>.823**</td>
<td>.612**</td>
<td>.439**</td>
<td>1</td>
<td>.129*</td>
<td>-.116</td>
<td>-.071</td>
<td>-.194**</td>
<td>-.064</td>
<td>-.016</td>
<td>-.221**</td>
<td>-.098</td>
<td>.001</td>
<td>-.074</td>
</tr>
<tr>
<td>5. Immediate Memory Cars</td>
<td>.116</td>
<td>.073</td>
<td>.094</td>
<td>.129*</td>
<td>1</td>
<td>.153*</td>
<td>.176*</td>
<td>.153*</td>
<td>.046</td>
<td>.016</td>
<td>.151*</td>
<td>.127</td>
<td>.193**</td>
<td>.033</td>
</tr>
<tr>
<td>6. Same Different House</td>
<td>.023</td>
<td>.103</td>
<td>.061</td>
<td>-.116</td>
<td>.153*</td>
<td>1</td>
<td>.098</td>
<td>.361**</td>
<td>.188**</td>
<td>.372**</td>
<td>.183**</td>
<td>.110</td>
<td>.212**</td>
<td>.125</td>
</tr>
<tr>
<td>7. Immediate Memory Faces</td>
<td>-.099</td>
<td>-.107</td>
<td>-.060</td>
<td>-.071</td>
<td>.176*</td>
<td>.098</td>
<td>1</td>
<td>.423**</td>
<td>.383**</td>
<td>.451**</td>
<td>.216**</td>
<td>.140*</td>
<td>.148*</td>
<td>.345**</td>
</tr>
<tr>
<td>8. Match Maker Identity</td>
<td>-.209**</td>
<td>-.143*</td>
<td>-.197**</td>
<td>-.194**</td>
<td>.153*</td>
<td>.361**</td>
<td>.423**</td>
<td>1</td>
<td>.613**</td>
<td>.432**</td>
<td>.507**</td>
<td>.245**</td>
<td>.210**</td>
<td>.365**</td>
</tr>
<tr>
<td>9. Match Maker Identity Across Expression</td>
<td>-.097</td>
<td>-.084</td>
<td>-.097</td>
<td>-.064</td>
<td>.046</td>
<td>.188**</td>
<td>.383**</td>
<td>.613**</td>
<td>1</td>
<td>.290**</td>
<td>.440**</td>
<td>.255**</td>
<td>.232**</td>
<td>.301**</td>
</tr>
<tr>
<td>10. Same Different Face</td>
<td>-.067</td>
<td>-.059</td>
<td>-.100</td>
<td>-.016</td>
<td>.016</td>
<td>.372**</td>
<td>.295**</td>
<td>.432**</td>
<td>.290**</td>
<td>1</td>
<td>.216**</td>
<td>.140*</td>
<td>.148*</td>
<td>.345**</td>
</tr>
<tr>
<td>11. Part Whole Identity</td>
<td>-.253**</td>
<td>-.159*</td>
<td>-.281**</td>
<td>-.221**</td>
<td>.151*</td>
<td>.183**</td>
<td>.451**</td>
<td>.507**</td>
<td>.440**</td>
<td>.216**</td>
<td>1</td>
<td>.156*</td>
<td>.424**</td>
<td>.387**</td>
</tr>
<tr>
<td>12. Name Game</td>
<td>-.057</td>
<td>-.058</td>
<td>.029</td>
<td>-.098</td>
<td>.127</td>
<td>.110</td>
<td>.126</td>
<td>.245**</td>
<td>.255**</td>
<td>.140*</td>
<td>.156*</td>
<td>1</td>
<td>.199**</td>
<td>.289**</td>
</tr>
<tr>
<td>13. Part Whole Expression</td>
<td>.093</td>
<td>.154*</td>
<td>.061</td>
<td>.001</td>
<td>.193**</td>
<td>.212**</td>
<td>.239**</td>
<td>.210**</td>
<td>.232**</td>
<td>.148*</td>
<td>.424**</td>
<td>.199**</td>
<td>1</td>
<td>.243**</td>
</tr>
<tr>
<td>14. Match Maker Expression</td>
<td>-.108</td>
<td>-.061</td>
<td>-.153*</td>
<td>-.074</td>
<td>.033</td>
<td>.125</td>
<td>.212**</td>
<td>.365**</td>
<td>.301**</td>
<td>.345**</td>
<td>.387**</td>
<td>.289**</td>
<td>.243**</td>
<td>1</td>
</tr>
</tbody>
</table>

**Correlation is significant at the 0.01 level (1-tailed).**
*Correlation is significant at the 0.05 level (1-tailed).*

Table 11

*BAPQ Scores Compared by Gender*

<table>
<thead>
<tr>
<th>BAPQ measure</th>
<th>Males</th>
<th>Females</th>
<th>F-Value</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>BAPQ Total</td>
<td>2.98(.674)</td>
<td>2.66(.691)</td>
<td>10.05</td>
<td>0.002</td>
</tr>
<tr>
<td>Aloofness</td>
<td>3.19(.952)</td>
<td>2.83(.982)</td>
<td>7.02</td>
<td>0.009</td>
</tr>
<tr>
<td>Pragmatic Language</td>
<td>2.56(.769)</td>
<td>2.21(.609)</td>
<td>11.14</td>
<td>0.001</td>
</tr>
<tr>
<td>Rigidity</td>
<td>3.19(.809)</td>
<td>2.94(.819)</td>
<td>4.44</td>
<td>0.037</td>
</tr>
</tbody>
</table>
Table 12

*2x2 MANOVA (Gender x BAPQ level)*

<table>
<thead>
<tr>
<th>Let’s Face It tests</th>
<th>Pillai’s trace V</th>
<th>F (df)</th>
<th>F (df)</th>
<th>Pillai’s trace V</th>
<th>F (df)</th>
<th>F (df)</th>
<th>Note: * p &lt; .05, ** p &lt; .01, *** p &lt; .001</th>
</tr>
</thead>
<tbody>
<tr>
<td>Face Discrimination</td>
<td>V=0.094</td>
<td>F (5, 136)=2.81*</td>
<td>0.015</td>
<td>F (5, 136)=.403</td>
<td>0.034</td>
<td>F (5, 136)=.558</td>
<td></td>
</tr>
<tr>
<td>Emotion Recognition</td>
<td>V=0.032</td>
<td>F (3, 140)=1.54</td>
<td>0.013</td>
<td>F (3, 140)=.403</td>
<td>0.004</td>
<td>F (3, 140)=.558</td>
<td></td>
</tr>
<tr>
<td>Non-face</td>
<td>V=0.005</td>
<td>F (2, 147)=.367</td>
<td>0.029</td>
<td>F (2, 147)=2.19</td>
<td>0.02</td>
<td>F (2, 147)=1.46</td>
<td></td>
</tr>
</tbody>
</table>
Table 13

*Univariate ANOVA Results for Gender When Analyzed with BAPQ Total Level*

<table>
<thead>
<tr>
<th>Face Discrimination test</th>
<th>Male(Std. Error)</th>
<th>Female(Std. Error)</th>
<th>F Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Immediate Memory Faces</td>
<td>78.1(.023)</td>
<td>84.4(.016)</td>
<td>5.02*</td>
</tr>
<tr>
<td>Match Maker Identity</td>
<td>89.7(.014)</td>
<td>91.1(.009)</td>
<td>.766</td>
</tr>
<tr>
<td>Match Maker Identity Across Expressions</td>
<td>84.0(.021)</td>
<td>87.9(.014)</td>
<td>2.36</td>
</tr>
<tr>
<td>Same Different Face</td>
<td>94.2(.010)</td>
<td>94.9(.007)</td>
<td>.362</td>
</tr>
<tr>
<td>Part Whole Identity</td>
<td>83.9(.012)</td>
<td>89.3(.008)</td>
<td>12.63**</td>
</tr>
</tbody>
</table>

Note: LFI score are *Estimated Margins of Means expressed as percentage correct on test*
* p < .05, ** p < .01, *** p < .001
Table 14

2x2 MANOVA (Gender x Aloofness Level)

<table>
<thead>
<tr>
<th>Let’s Face It tests</th>
<th>Main effect gender</th>
<th>Main effect Aloofness</th>
<th>Interaction Gender x Aloofness level</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pillai’s trace V</td>
<td>F (df)</td>
<td>Pillai’s trace V</td>
</tr>
<tr>
<td>Face Discrimination</td>
<td>V=.074</td>
<td>F (5, 136)= 2.18a</td>
<td>V=.020</td>
</tr>
<tr>
<td>Emotion Recognition</td>
<td>V=.029</td>
<td>F (3, 140)= 1.39</td>
<td>V=.009</td>
</tr>
<tr>
<td>Non-face</td>
<td>V=.002</td>
<td>F (2, 147)=.151</td>
<td>V=.006</td>
</tr>
</tbody>
</table>

Note: * p < .05, ** p < .01, *** p < .001.
a: approached significance at .059
Table 15

*Univariate ANOVA Results for Gender when Analyzed with Aloofness Level*

<table>
<thead>
<tr>
<th>Face Discrimination test</th>
<th>Male (Std. Error)</th>
<th>Female (Std. Error)</th>
<th>F Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Immediate Memory Faces</td>
<td>0.788 (.022)</td>
<td>0.842 (.014)</td>
<td>4.27*</td>
</tr>
<tr>
<td>Match Maker Identity</td>
<td>0.898 (.013)</td>
<td>0.915 (.008)</td>
<td>1.23</td>
</tr>
<tr>
<td>Match Maker Identity Across Expressions</td>
<td>0.844 (.020)</td>
<td>0.883 (.013)</td>
<td>2.81</td>
</tr>
<tr>
<td>Same Different Face</td>
<td>0.947 (.009)</td>
<td>0.952 (.006)</td>
<td>.200</td>
</tr>
<tr>
<td>Part Whole Identity</td>
<td>0.848 (.012)</td>
<td>0.892 (.007)</td>
<td>9.96**</td>
</tr>
</tbody>
</table>

Note: LFI score are *Estimated Margins of Means expressed as percentages*

* p < .05, ** p < .01, *** p < .001
Table 16

2x2 MANOVA (Gender x Pragmatic Language Level)

<table>
<thead>
<tr>
<th>Let’s Face It tests</th>
<th>Main effect gender</th>
<th>Main effect Pragmatic</th>
<th>Interaction Gender x Pragmatic level</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pillai’s trace V</td>
<td>F (df)</td>
<td>Pillai’s trace V</td>
</tr>
<tr>
<td>Face Discrimination</td>
<td>V=.091</td>
<td>F (5, 136)= 2.73*</td>
<td>V=.035</td>
</tr>
<tr>
<td>Emotion Recognition</td>
<td>V=.012</td>
<td>F (3, 140)=.554</td>
<td>V=.018</td>
</tr>
<tr>
<td>Non-face</td>
<td>V=.015</td>
<td>F (2, 147)=1.12</td>
<td>V=.003</td>
</tr>
</tbody>
</table>

Note: * p < .05, ** p < .01, *** p < .001
Table 17

Univariate ANOVA Results for Gender when Analyzed with Pragmatic Language Level

<table>
<thead>
<tr>
<th>Face Discrimination test</th>
<th>Male(Std. Error)</th>
<th>Female(Std. Error)</th>
<th>F-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Immediate Memory Faces</td>
<td>0.79(.024)</td>
<td>0.877(.024)</td>
<td>6.43*</td>
</tr>
<tr>
<td>Match Maker Identity</td>
<td>0.891(.014)</td>
<td>0.904(.014)</td>
<td>.439</td>
</tr>
<tr>
<td>Match Maker Identity Across Expressions</td>
<td>0.84(.022)</td>
<td>0.885(.022)</td>
<td>2.10</td>
</tr>
<tr>
<td>Same Different Face</td>
<td>0.938(.010)</td>
<td>0.959(.010)</td>
<td>2.10</td>
</tr>
<tr>
<td>Part Whole Identity</td>
<td>0.834(.013)</td>
<td>0.891(.013)</td>
<td>10.04**</td>
</tr>
</tbody>
</table>

Note: LFI score are Estimated Margins of Means expressed as percentages
* p < .05, ** p < .01, *** p < .001
Table 18

2x2 MANOVA (Gender x Rigidity Level)

<table>
<thead>
<tr>
<th>Let’s Face It tests</th>
<th>Main effect gender</th>
<th>Main effect Rigidity</th>
<th>Interaction Gender x Rigidity level</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pillai’s trace V</td>
<td>F (df)</td>
<td>Pillai’s trace V</td>
</tr>
<tr>
<td>Face Discrimination</td>
<td>V=.092</td>
<td>F (5, 136)= 2.77*</td>
<td>V=.101</td>
</tr>
<tr>
<td>Emotion Recognition</td>
<td>V=.035</td>
<td>F (3, 140)=1.69</td>
<td>V=.026</td>
</tr>
<tr>
<td>Non-face</td>
<td>V=.001</td>
<td>F (2, 147)=.055</td>
<td>V=.070</td>
</tr>
</tbody>
</table>

Note: * p < .05, ** p < .01, *** p < .001
Table 19

*Univariate ANOVA Results for Gender when Analyzed with Rigidity Level*

<table>
<thead>
<tr>
<th>Face Discrimination test</th>
<th>Male(Std. Error)</th>
<th>Female(Std. Error)</th>
<th>F-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Immediate Memory Faces</td>
<td>0.782(.024)</td>
<td>0.843(.017)</td>
<td>4.12*</td>
</tr>
<tr>
<td>Match Maker Identity</td>
<td>0.868(.014)</td>
<td>0.908(.010)</td>
<td>5.75*</td>
</tr>
<tr>
<td>Match Maker Identity Across Expressions</td>
<td>0.831(.022)</td>
<td>0.879(.016)</td>
<td>3.13</td>
</tr>
<tr>
<td>Same Different Face</td>
<td>0.939(.010)</td>
<td>0.95(.007)</td>
<td>.874</td>
</tr>
<tr>
<td>Part Whole Identity</td>
<td>0.839013)</td>
<td>0.887(.009)</td>
<td>13.09***</td>
</tr>
</tbody>
</table>

Note: LFI score are *Estimated Margins of Means expressed as percentages*

* p < .05, ** p < .01, *** p < .001
### Table 20

Correlations Matrix for Regression Analysis Variables: BAPQ +/- level, Gender, SCQ, and LFI Scores, All Participants

<table>
<thead>
<tr>
<th>Measures</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
<th>16</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. BAPQ Total +/- level</td>
<td>1</td>
<td>.749**</td>
<td>.495**</td>
<td>.486**</td>
<td>-.055</td>
<td>.081</td>
<td>.107</td>
<td>.046</td>
<td>.050</td>
<td>.090</td>
<td>.039</td>
<td>-.131</td>
<td>.040</td>
<td>-.157*</td>
<td>.031</td>
<td></td>
</tr>
<tr>
<td>2. Aloofness +/- level</td>
<td>.749**</td>
<td>1</td>
<td>.329**</td>
<td>.418**</td>
<td>-.152*</td>
<td>.085</td>
<td>.021</td>
<td>.003</td>
<td>-.032</td>
<td>-.022</td>
<td>-.06</td>
<td>-.103</td>
<td>-.019</td>
<td>-.015</td>
<td>.027</td>
<td></td>
</tr>
<tr>
<td>3. Pragmatic Language +/- level</td>
<td>.495**</td>
<td>.329**</td>
<td>1</td>
<td>.290**</td>
<td>.128*</td>
<td>-.009</td>
<td>.173*</td>
<td>.044</td>
<td>.195**</td>
<td>.021</td>
<td>.013</td>
<td>-.131*</td>
<td>.093</td>
<td>-.076</td>
<td>.012</td>
<td></td>
</tr>
<tr>
<td>4. Rigidity +/- level</td>
<td>.486**</td>
<td>.418**</td>
<td>.290**</td>
<td>1</td>
<td>-.035</td>
<td>.110</td>
<td>.227**</td>
<td>.075</td>
<td>.142*</td>
<td>.038</td>
<td>.098</td>
<td>-.048</td>
<td>-.044</td>
<td>-.067</td>
<td>.201**</td>
<td></td>
</tr>
<tr>
<td>5. Gender</td>
<td>-.055</td>
<td>-.152*</td>
<td>.128*</td>
<td>-.035</td>
<td>1</td>
<td>-.100</td>
<td>.078</td>
<td>.136*</td>
<td>.159*</td>
<td>.316**</td>
<td>.069</td>
<td>.176*</td>
<td>-.035</td>
<td>.200**</td>
<td>-.016</td>
<td>-.030</td>
</tr>
<tr>
<td>6. SCQ</td>
<td>.081</td>
<td>.085</td>
<td>.007</td>
<td>.110</td>
<td>-.100</td>
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<td>.004</td>
<td>-.019</td>
<td>.008</td>
<td>-.055</td>
<td>-.133*</td>
<td>-.008</td>
<td>-.041</td>
<td>-.093</td>
<td>.048</td>
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<tr>
<td>7. Immediate Memory Faces</td>
<td>.052</td>
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<td>-.009</td>
<td>.090</td>
<td>.078</td>
<td>.006</td>
<td>1</td>
<td>.419**</td>
<td>.383**</td>
<td>.453**</td>
<td>.302**</td>
<td>.137*</td>
<td>.237**</td>
<td>.212**</td>
<td>.176*</td>
<td>.102</td>
</tr>
<tr>
<td>8. Match Maker Identity</td>
<td>.107</td>
<td>.021</td>
<td>.173*</td>
<td>.227**</td>
<td>.136*</td>
<td>.004</td>
<td>.419**</td>
<td>1</td>
<td>.609**</td>
<td>.502**</td>
<td>.434**</td>
<td>.245**</td>
<td>.206**</td>
<td>.366**</td>
<td>.156*</td>
<td>.353**</td>
</tr>
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<td>9. Match Maker ID Across Expression</td>
<td>.046</td>
<td>.003</td>
<td>.044</td>
<td>.075</td>
<td>.159*</td>
<td>-.019</td>
<td>.383**</td>
<td>.609**</td>
<td>1</td>
<td>.437**</td>
<td>.293**</td>
<td>.260**</td>
<td>.230**</td>
<td>.303**</td>
<td>.048</td>
<td>.187**</td>
</tr>
<tr>
<td>10. Part Whole Identity</td>
<td>.050</td>
<td>-.032</td>
<td>.195**</td>
<td>.142*</td>
<td>.316**</td>
<td>.008</td>
<td>.453**</td>
<td>.502**</td>
<td>.437**</td>
<td>1</td>
<td>.225**</td>
<td>.164*</td>
<td>.422**</td>
<td>.385**</td>
<td>.152*</td>
<td>.185**</td>
</tr>
<tr>
<td>11. Same Difference Face</td>
<td>.090</td>
<td>-.022</td>
<td>.021</td>
<td>.038</td>
<td>.069</td>
<td>.005</td>
<td>.302**</td>
<td>.434**</td>
<td>.293**</td>
<td>.225**</td>
<td>1</td>
<td>.138*</td>
<td>.147*</td>
<td>.349**</td>
<td>.020</td>
<td>.373**</td>
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<tr>
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<td>-.006</td>
<td>.013</td>
<td>.098</td>
<td>.176*</td>
<td>-.133*</td>
<td>.137*</td>
<td>.245**</td>
<td>.260**</td>
<td>.164*</td>
<td>.138*</td>
<td>1</td>
<td>.205**</td>
<td>.289**</td>
<td>.124</td>
<td>.107</td>
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<td>13. Part Whole Expression</td>
<td>-.131</td>
<td>-.103</td>
<td>-.131*</td>
<td>-.048</td>
<td>-.035</td>
<td>-.008</td>
<td>.237**</td>
<td>.206**</td>
<td>.230**</td>
<td>.422**</td>
<td>.147*</td>
<td>.205**</td>
<td>1</td>
<td>.240**</td>
<td>.201**</td>
<td>.211**</td>
</tr>
<tr>
<td>14. Match Maker Expression</td>
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<td>-.019</td>
<td>.093</td>
<td>-.044</td>
<td>.200**</td>
<td>-.041</td>
<td>.212**</td>
<td>.366**</td>
<td>.303**</td>
<td>.385**</td>
<td>.349**</td>
<td>.289**</td>
<td>1</td>
<td>.033</td>
<td>.125</td>
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</tr>
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<td>-.157*</td>
<td>-.015</td>
<td>-.076</td>
<td>-.067</td>
<td>-.016</td>
<td>-.093</td>
<td>.176*</td>
<td>.156*</td>
<td>.048</td>
<td>.152*</td>
<td>.020</td>
<td>.124</td>
<td>.201**</td>
<td>.033</td>
<td>1</td>
<td>.150*</td>
</tr>
<tr>
<td>16. Same Difference House</td>
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<td>.027</td>
<td>.012</td>
<td>.201**</td>
<td>-.030</td>
<td>.048</td>
<td>.102</td>
<td>.353**</td>
<td>.187**</td>
<td>.185**</td>
<td>.373**</td>
<td>.107</td>
<td>.211**</td>
<td>.125</td>
<td>.150*</td>
<td>1</td>
</tr>
</tbody>
</table>

**. Correlation is significant at the 0.01 level (1-tailed). 
*. Correlation is significant at the 0.05 level (1-tailed).
### Table 21

**BAPQ Total Prediction Model for LFI Discrimination Tests**

<table>
<thead>
<tr>
<th>Discrimination</th>
<th>Immediate Memory for Faces</th>
<th>Matchmaker Identification</th>
<th>Matchmaker ID Across Expression</th>
<th>Part Whole Identity</th>
<th>Same Different Face</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Predictors</strong></td>
<td>R^2</td>
<td>ΔR^2</td>
<td>β</td>
<td>R^2</td>
<td>ΔR^2</td>
</tr>
<tr>
<td><strong>Step 1</strong></td>
<td>0.001</td>
<td>0.001</td>
<td>.008</td>
<td>0.004</td>
<td>-.002</td>
</tr>
<tr>
<td>Constant</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IQ</td>
<td>.030</td>
<td>.092</td>
<td>.064</td>
<td>.180</td>
<td>-0.003</td>
</tr>
<tr>
<td><strong>Step 2</strong></td>
<td>0.016</td>
<td>0.016</td>
<td>.044</td>
<td>0.038</td>
<td>0.012</td>
</tr>
<tr>
<td>Constant</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IQ</td>
<td>.051</td>
<td>.125</td>
<td>.097</td>
<td>.242***</td>
<td>.016</td>
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<tr>
<td>BAPQ Total</td>
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<td>.125</td>
<td>.046</td>
<td>.87</td>
<td>.104</td>
</tr>
<tr>
<td>Gender</td>
<td>.106</td>
<td>.140</td>
<td>0.179*</td>
<td>.341***</td>
<td>.064</td>
</tr>
<tr>
<td>SCQ</td>
<td>-0.003</td>
<td>.026</td>
<td>.009</td>
<td>.054</td>
<td>-.057</td>
</tr>
</tbody>
</table>

Note: * p < .05, ** p < .01, *** p < .001
Table 22

*BAPQ Total Prediction Model for LFI Emotion Tests*

<table>
<thead>
<tr>
<th>Predictors</th>
<th>Emotion</th>
<th>Name Game</th>
<th>Part Whole Expression</th>
<th>Matchmaker Expression</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>R²</td>
<td>ΔR²</td>
<td>β</td>
<td>R²</td>
</tr>
<tr>
<td>Step 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>0.03</td>
<td>.018</td>
<td></td>
<td>0.047**</td>
</tr>
<tr>
<td>IQ</td>
<td></td>
<td></td>
<td></td>
<td>0.036</td>
</tr>
<tr>
<td>Age (Name Game)</td>
<td>.036</td>
<td>0.175*</td>
<td>0.218**</td>
<td>0.009</td>
</tr>
<tr>
<td>Step 2</td>
<td>0.065</td>
<td>.032</td>
<td>0.065*</td>
<td>0.039</td>
</tr>
<tr>
<td>Constant</td>
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<td></td>
</tr>
<tr>
<td>IQ</td>
<td>0.057</td>
<td></td>
<td>0.207</td>
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<tr>
<td>Age (Name Game)</td>
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</tr>
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<td>BAPQ Total</td>
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<tr>
<td>Gender</td>
<td>.39</td>
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<td></td>
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<tr>
<td>SCQ</td>
<td>-1.09</td>
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<td></td>
</tr>
</tbody>
</table>

Note: * p < .05, ** p < .01, *** p < .001
Table 23

*BAPQ Total Prediction Model for LFI Non-Face Tests*

<table>
<thead>
<tr>
<th>Predictors</th>
<th>Non-Face</th>
<th>Immediate Memory for Cars</th>
<th>Same Different Houses</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>R²</td>
<td>ΔR²</td>
<td>β</td>
</tr>
<tr>
<td>Step 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>0.054**</td>
<td>0.047**</td>
<td>0.077***</td>
</tr>
<tr>
<td>IQ</td>
<td>.232**</td>
<td>.278***</td>
<td></td>
</tr>
<tr>
<td>Step 2</td>
<td>0.078*</td>
<td>.053</td>
<td>0.084**</td>
</tr>
<tr>
<td>Constant</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>IQ</td>
<td>0.221**</td>
<td>.284***</td>
<td></td>
</tr>
<tr>
<td>BAPQ Total</td>
<td>-.122</td>
<td>.047</td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td>.005</td>
<td>.019</td>
<td></td>
</tr>
<tr>
<td>SCQ</td>
<td>-.085</td>
<td>.064</td>
<td></td>
</tr>
</tbody>
</table>

Note: * p < .05, ** p < .01, *** p < .001
Table 24

*Aloofness Prediction Model for LFI Discrimination Tests*

<table>
<thead>
<tr>
<th>Discrimination</th>
<th>Immediate Memory for Faces</th>
<th>Matchmaker Identification</th>
<th>Matchmaker ID Across Expression</th>
<th>Part Whole Identity</th>
<th>Same Different Face</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Predictors</strong></td>
<td><strong>R²</strong></td>
<td><strong>ΔR²</strong></td>
<td><strong>β</strong></td>
<td><strong>R²</strong></td>
<td><strong>ΔR²</strong></td>
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<td>.008</td>
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<tr>
<td>Constant</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IQ</td>
<td>.030</td>
<td>0.092</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Step 2</td>
<td>0.015</td>
<td>.014</td>
<td></td>
<td>0.031</td>
<td>.023</td>
</tr>
<tr>
<td>Constant</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IQ</td>
<td>.052</td>
<td>.121</td>
<td></td>
<td>.095</td>
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<tr>
<td>Aloofness</td>
<td>.056</td>
<td>.053</td>
<td></td>
<td>.009</td>
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</tr>
<tr>
<td>Gender</td>
<td>.111</td>
<td>.146</td>
<td></td>
<td>.181*</td>
<td></td>
</tr>
<tr>
<td>SCQ</td>
<td>-.003</td>
<td>.032</td>
<td></td>
<td>.013</td>
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</tr>
</tbody>
</table>

Note: * p < .05, ** p < .01, *** p < .001
Table 25

Aloofness Prediction Model for LFI Emotion Tests

<table>
<thead>
<tr>
<th>Predictors</th>
<th>Emotion</th>
<th>Name Game</th>
<th>Part Whole Expression</th>
<th>Matchmaker Expression</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>R²</td>
<td>ΔR²</td>
<td>β</td>
<td>R²</td>
</tr>
<tr>
<td>Step 1</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>0.03</td>
<td>.030</td>
<td></td>
<td>0.047**</td>
</tr>
<tr>
<td>IQ</td>
<td>.036</td>
<td></td>
<td>0.218***</td>
<td></td>
</tr>
<tr>
<td>Age (Name Game)</td>
<td>0.175*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Step 2</td>
<td>0.064</td>
<td>.034</td>
<td>0.054</td>
<td>0.007</td>
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<td>-.083</td>
<td></td>
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<tr>
<td>Gender</td>
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<td></td>
<td>-.012</td>
<td></td>
</tr>
<tr>
<td>SCQ</td>
<td>-.105</td>
<td></td>
<td>.013</td>
<td></td>
</tr>
</tbody>
</table>

Note: * p < .05, ** p < .01, *** p < .001
### Table 26

*Aloofness Prediction Model for LFI Non-Face Tests*

<table>
<thead>
<tr>
<th>Predictors</th>
<th>Non-Face Immediate Memory for Cars</th>
<th>Same Different Houses</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$R^2$</td>
<td>$\Delta R^2$</td>
</tr>
<tr>
<td>Step 1</td>
<td>0.054**</td>
<td>0.054**</td>
</tr>
<tr>
<td>Constant</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IQ</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Step 2</td>
<td>0.063*</td>
<td>0.01</td>
</tr>
<tr>
<td>Constant</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IQ</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aloofness</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SCQ</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: * $p < .05$, ** $p < .01$, *** $p < .001$
Table 27

**Pragmatic Language Prediction Model for LFI Discrimination Tests**

<table>
<thead>
<tr>
<th>Discrimination</th>
<th>Immediate Memory for Faces</th>
<th>Matchmaker Identification</th>
<th>Matchmaker ID Across Expression</th>
<th>Part Whole Identity</th>
<th>Same Different Face</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Predictors</strong></td>
<td>R^2</td>
<td>ΔR^2</td>
<td>β</td>
<td>R^2</td>
<td>ΔR^2</td>
</tr>
<tr>
<td>Step 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>0.001</td>
<td>0.001</td>
<td>.008</td>
<td>.002</td>
<td>0.004</td>
</tr>
<tr>
<td>IQ</td>
<td>.030</td>
<td>.092</td>
<td>.064</td>
<td>.18</td>
<td>0.003</td>
</tr>
<tr>
<td>Step 2</td>
<td>0.013</td>
<td>0.012</td>
<td>.057</td>
<td>.032</td>
<td>0.036</td>
</tr>
<tr>
<td>Constant</td>
<td>.046</td>
<td>.124</td>
<td>.095</td>
<td>.241***</td>
<td>.010</td>
</tr>
<tr>
<td>Pragmatic</td>
<td>-.021</td>
<td>0.172*</td>
<td>.018</td>
<td>0.175**</td>
<td>.009</td>
</tr>
<tr>
<td>Gender</td>
<td>.111</td>
<td>.114</td>
<td>0.178*</td>
<td>0.314***</td>
<td>.057</td>
</tr>
<tr>
<td>SCQ</td>
<td>.003</td>
<td>.030</td>
<td>.013</td>
<td>.054</td>
<td>-.050</td>
</tr>
</tbody>
</table>

Note: * p < .05, ** p < .01, *** p < .001
### Table 28

**Pragmatic Language Prediction Model for LFI Emotion Tests**

<table>
<thead>
<tr>
<th>Emotion</th>
<th>Name Game</th>
<th>Part Whole Expression</th>
<th>Matchmaker Expression</th>
</tr>
</thead>
<tbody>
<tr>
<td>Predictors</td>
<td>$R^2$</td>
<td>$\Delta R^2$</td>
<td>$\beta$</td>
</tr>
<tr>
<td>Step 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>0.03</td>
<td>0.018</td>
<td>0.047**</td>
</tr>
<tr>
<td>IQ</td>
<td>0.036</td>
<td>0.218</td>
<td>0.045</td>
</tr>
<tr>
<td>Age (Name Game)</td>
<td>-.175*</td>
<td>0.099</td>
<td>0.045</td>
</tr>
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<td>Step 2</td>
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<td>0.033</td>
<td>0.062</td>
</tr>
<tr>
<td>Constant</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IQ</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age (Name Game)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pragmatic</td>
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<td></td>
</tr>
<tr>
<td>Gender</td>
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<td></td>
</tr>
<tr>
<td>SCQ</td>
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<td></td>
</tr>
</tbody>
</table>

Note: * $p < .05$, ** $p < .01$, *** $p < .001$
Table 29

Pragmatic Language Prediction Model for LFI Non-Face Tests

<table>
<thead>
<tr>
<th></th>
<th>Immediate Memory for Cars</th>
<th>Same Different Houses</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>R²</td>
<td>ΔR²</td>
</tr>
<tr>
<td>Step 1</td>
<td>0.054**</td>
<td>0.047**</td>
</tr>
<tr>
<td>Constant</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IQ</td>
<td></td>
<td>0.232**</td>
</tr>
<tr>
<td>Step 2</td>
<td>0.066*</td>
<td>.041</td>
</tr>
<tr>
<td>Constant</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IQ</td>
<td></td>
<td>0.227**</td>
</tr>
<tr>
<td>Pragmatic</td>
<td></td>
<td>-.056</td>
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<tr>
<td>Gender</td>
<td></td>
<td>.012</td>
</tr>
<tr>
<td>SCQ</td>
<td></td>
<td>-.095</td>
</tr>
</tbody>
</table>

Note: * p < .05, ** p < .01, *** p < .001
Table 30

*Rigidity Prediction Model for LFI Discrimination Tests*

<table>
<thead>
<tr>
<th>Predictors</th>
<th>Immediate Memory for Faces</th>
<th>Matchmaker Identification</th>
<th>Matchmaker ID Across Expression</th>
<th>Part Whole Identity</th>
<th>Same Different Face</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>R²</td>
<td>ΔR²</td>
<td>β</td>
<td>R²</td>
<td>ΔR²</td>
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<tr>
<td>Step 1</td>
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<tr>
<td>Constant</td>
<td>0.001</td>
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<td>.008</td>
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<td>.004</td>
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<tr>
<td>IQ</td>
<td>.030</td>
<td>.092</td>
<td>0.098**</td>
<td>0.074**</td>
<td>.043</td>
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<tr>
<td>Step 2</td>
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<td>0.098**</td>
<td>0.074**</td>
<td>.043</td>
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<tr>
<td>Constant</td>
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<td></td>
</tr>
<tr>
<td>IQ</td>
<td>.052</td>
<td>.137</td>
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<td>.267**</td>
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<tr>
<td>Rigidity</td>
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<td>.178*</td>
<td>.342***</td>
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<tr>
<td>Gender</td>
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<tr>
<td>SCQ</td>
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Note: * p < .05, ** p < .01, *** p < .001
### Rigidity Prediction Model for LFI Emotion Tests

<table>
<thead>
<tr>
<th>Predictors</th>
<th>Emotion</th>
<th>Name Game</th>
<th>Part Whole Expression</th>
<th>Matchmaker Expression</th>
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<td></td>
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<td>R²</td>
</tr>
<tr>
<td>Step 1</td>
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<td>0.047**</td>
<td>0.047**</td>
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<td>Constant</td>
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<td></td>
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<tr>
<td>IQ</td>
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<td>.218**</td>
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<tr>
<td>Age (Name Game)</td>
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<td></td>
<td></td>
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<tr>
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<tr>
<td>IQ</td>
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<tr>
<td>Age (Name Game)</td>
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<td>Rigidity</td>
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<td>SCQ</td>
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<td>.011</td>
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</tbody>
</table>

Note: * p < .05, ** p < .01, *** p < .001
Table 32

*Rigidity Prediction Model for LFI Non-Face Tests*

<table>
<thead>
<tr>
<th>Predictors</th>
<th>Non-Face</th>
<th>Immediate Memory for Cars</th>
<th>Same Different Houses</th>
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<td>R²</td>
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<td>β</td>
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<td>Step 1</td>
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<td>IQ</td>
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<tr>
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<td>IQ</td>
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<td>Rigidity</td>
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<td>.241**</td>
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<tr>
<td>Gender</td>
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</tr>
<tr>
<td>SCQ</td>
<td>-.094</td>
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<td>.035</td>
</tr>
</tbody>
</table>

Note: * p < .05, ** p < .01, *** p < .001
Examples from the Identity Matching Tests: (a) matching identity across changes in expression, (b) matching identity with eyes masked, (c) matching identity with mouths masked, (d) matching identity across changes in orientation (Wolfe et al., 2008)
(a) Face Dimensions Test item depicting a featural change in the mouth size, (b) Face Dimensions Test item depicting a configural change in inter-eye distance, (c) House Dimensions Test item showing a featural change in the size of large window and (d) House Dimensions Test item depicting a configural change in inter-window distance (Wolfe et al., 2008).
Parts/Whole Test of holistic processing: (a) whole face target item, (b) Isolated Eye Test item and (c) Whole Face Test item (Wolfe et al., 2008).
Figure 4

(A) Name Game assessment: emotional face test. (B) Matchmaker Expression assessment test using images from the NonStim face database (Tanaka et al., 2012)
Consistent and inconsistent expressions from the Parts–Wholes Expression assessment test (Tanaka et al., 2012).
Appendix A

Background/ Demographic Questions

1. Normal vision with or without corrective eyewear is required for this study. Do you have normal vision with or without glasses or contact lenses? If you have any eye problems not corrected when wearing glasses or contact lenses, please check 'No'.
   Yes
   No

2. This study requires you to be at least a fluent English speaker. Is English your primary language or are you at least fluent in English?
   Yes
   No

3. Please enter your first and last name.
   First Name:
   Last Name:

4. Please enter your complete mailing address.
   Note: State only needs a two-letter code.
   Address:
   City
   State
   Postal Code

5. Please enter your telephone number (s).
   Home:
   Cell or Other Contact Number:

6. Please enter your e-mail address:
   E-mail:
   Retype e-mail:

7. Please enter your age and date of birth
   Age:
   Date of birth (mm/dd/yyyy):

8. What is your gender?
   Male
   Female

9. What is your ethnicity
   Hispanic or Latino
   Not Hispanic or Latino
10. What is your race?
   - American Indian or Alaskan Native
   - Asian
   - Black of African American
   - Native Hawaiian or Other Pacific Islander
   - White/ Caucasian
   - Other

11. Are you a biological parent or sibling of someone with autism spectrum disorder?
   - Yes
   - No

12. You responded that you are a parent or a sibling of a person with autism spectrum disorder. Which are you?
   - Parent
   - Sibling

13. How many people in your immediate family (parents and siblings) are diagnosed with autism spectrum disorder?
   - 1
   - 2
   - 3
   - 4
   - 5 or >

14. Is your family member with Autism Spectrum Disorder registered with the Interactive Autism Network (IAN) of the Kennedy Krieger Center in Baltimore, MD?
   - Yes
   - No

15. Do you currently live with a child (ren) or sibling with autism spectrum disorder?
   - Yes
   - No

16. Do you now have or have you ever had a diagnosis of autism spectrum disorder?
   - Yes
   - No

17. Do you have any learning, cognitive, or developmental disability?
   - Yes
   - No
18. In the last year (2012-13), have you had an active psychiatric diagnosis or taken psychiatric medication? If you have had a history of a psychiatric diagnosis that is in remission or you are no longer diagnosed with it, please check "No".
   Yes
   No

19. Please list current medications you are taking.

20. What is your highest level of education completed?
   Elementary
   Middle/ Junior
   High School
   College
   Graduate School
Appendix B

The Social Communication Questionnaire (SCQ) (Rutter et al., 2003) SCQ
Instructions
You are about to answer questions about your relative who is diagnosed with autistic spectrum disorder. Please answer each question either yes or no. A few questions ask about related types of behavior; please answer yes if any of these behaviors have ever been present. Although you may be uncertain about whether some behaviors were ever present or not, please answer yes or no to every question on the basis of what you think.

Q1 Is she/he now able to talk using short phrases or sentences? If no, skip to question 8
☐ Yes (1)
☐ No (2)

Q2 Can you have a to and fro "conversation" with her/him that involves taking turns or building on what you have said?
☐ Yes (1)
☐ No (2)

Q3 Has she/he ever used odd phrases or said the same thing over and over in almost exactly the same way (either phrases that she/he has heard other people use or ones that she/he has made up)?
☐ Yes (1)
☐ No (2)

Q4 Has she/he ever used socially inappropriate questions or statements? For example, has she/he ever regularly asked personal questions or made personal comments at awkward times?
☐ Yes (1)
☐ No (2)

Q5 Has she/he ever got her/his pronouns mixed up (e.g., saying you or she/he for I)?
☐ Yes (1)
☐ No (2)

Q6 Has she/he ever used words that she/he seemed to have invented or made up her/himself; put things in odd, indirect ways; or used metaphorical ways of saying things (e.g., saying hot rain for steam)?
☐ Yes (1)
☐ No (2)
Q7 Has she/he ever said the same thing over and over in exactly the same way or insisted that you say the same thing over and over again?
○ Yes (1)
○ No (2)

Q8 Has she/he ever had things that she/he seemed to have to do in a very particular way or order or rituals that she/he insisted that you go through?
○ Yes (1)
○ No (2)

Q9 Has her/his facial expression usually seemed appropriate to the particular situation, as far as you could tell?
○ Yes (1)
○ No (2)

Q10 Has she/he ever used your hand like a tool or as if it were part of her/his own body (e.g., pointing with your finger, putting your hand on the a doorknob to get you to open the door)?
○ Yes (1)
○ No (2)

Q11 Has she/he ever had any interests that preoccupy her/him and might seem odd to other people (e.g., traffic lights, drainpipes, or timetables)?
○ Yes (1)
○ No (2)

Q12 Has she/he ever seemed to be more interested in parts of a toy or an object (e.g., spinning the wheels of a car), rather than using the object as it was intended?
○ Yes (1)
○ No (2)

Q13 Has she/he ever had any special interests that were unusual in their intensity but otherwise appropriate for her/his age and peer group (e.g., trains, dinosaurs)?
○ Click to write Choice 1 (1)
○ Click to write Choice 2 (2)
○ Click to write Choice 3 (3)

Q14 Has she/he ever seemed to be unusually interested in the sight, feel, sound, taste, or smell of things or people?
○ Yes (1)
○ No (2)
Q15 Has she/her ever had any mannerisms or odd ways of moving her/his hands or fingers, such as flapping or moving her/his fingers in front of her/his eyes?
  ● Yes (1)
  ● No (2)

Q16 Has she/he ever had any complicated movements of her/his whole body, such as spinning or repeatedly bouncing up and down?
  ● Yes (1)
  ● No (2)

Q17 Has she/he ever injured herself deliberately, such as by biting her/his arm or banging her/his head?
  ● Yes (1)
  ● No (2)

Q18 Has she/he ever had any objects (other than a soft toy or comfort blanket) that she/he had to carry around?
  ● Yes (1)
  ● No (2)

Q19 Does she/he have any particular friends or a best friend?
  ● Yes (1)
  ● No (2)

Q20 When she/he was 4 to 5, did she/he ever talk with you just to be friendly (rather than to get something)?
  ● Yes (1)
  ● No (2)

Q21 When she/he was 4 to 5, did she/he ever spontaneously copy you (or other people) or what you were doing (such as vacuuming, gardening, or mending things)?
  ● Yes (1)
  ● No (2)

Q22 When she/he was 4 to 5, did she/he ever spontaneously point at things around her/him to show you things (not because she/he wanted them)?
  ● Yes (1)
  ● Click to write Choice 2 (2)
  ● Click to write Choice 3 (3)
Q23 When she/he was 4 to 5, did she/he ever use gestures, other than pointing or pulling your hand, to let you know what she/he wanted?
   ○ Yes (1)
   ○ No (2)

Q24 When she/he was 4 to 5, did she/he nod her/his head to mean yes?
   ○ Yes (1)
   ○ No (2)

Q25 When she/he was 4 to 5, did she/he shake her/his head to mean no?
   ○ Yes (1)
   ○ No (2)

Q26 When she/he was 4 to 5, did she/he usually look at you directly in the face when doing things with you or talking with you?
   ○ Yes (1)
   ○ No (2)

Q27 When she/he was 4 to 5, did she/he smile back if someone smiled at her/him?
   ○ Yes (1)
   ○ No (2)

Q28 When she/he was 4 to 5, did she/he ever show you things that interested him/her to engage your attention?
   ○ Yes (1)
   ○ No (2)

Q29 When she/he was 4 to 5, did she/he ever offer to share things other than food with you?
   ○ Yes (1)
   ○ No (2)

Q30 When she/he was 4 to 5, did she/he ever seem to want you to join in her/his enjoyment of something?
   ○ Yes (1)
   ○ No (2)

Q31 When she/he was 4 to 5, did she/he ever try to comfort you if you were sad or hurt?
   ○ Yes (1)
   ○ No (2)
Q32 When she/he was 4 to 5, when she/he wanted something or wanted help, did she/he look at you and use gestures with sounds or words to get your attention?
- Yes (1)
- No (2)

Q33 When she/he was 4 to 5, did she/he show a normal range of facial expressions?
- Yes (1)
- No (2)

Q34 When she/he was 4 to 5, did she/he spontaneously join in and try to copy the actions in social games, such as The Mulberry Bush or London Bridge Is Falling Down?
- Yes (1)
- No (2)

Q35 When she/he was 4 to 5, did she/he play any pretend or make-believe games?
- Yes (1)
- No (2)

Q36 When she/he was 4 to 5, did she/he seem interested in other children of approximately the same age whom she/he did not know?
- Yes (1)
- No (2)

Q37 When she/he was 4 to 5, did she/he respond positively when another child approached her/him?
- Yes (1)
- No (2)

Q38 When she/he was 4 to 5, did she/he, if you came into a room and started talking to her/him without calling her/his name, did she/he usually look up and pay attention to you?
- Yes (1)
- No (2)

Q39 When she/he was 4 to 5, did she/he ever play imaginative games with another child in such a way that you could tell they each understood what the other was pretending?
- Yes (1)
- No (2)

Q40 When she/he was 4 to 5, did she/he play cooperatively in games that required joining in with a group of other children, such as hide-and-seek or ball games?
- Yes (1)
- No (2)
Appendix C

Broader Autistic Phenotype Questionnaire – BAPQ (Hurley et al., 2007)

Instructions
You are about to fill out a series of statements related to personality and lifestyle. For each question, circle that answer that best describes how often that statement applies to you. Many of these questions ask about your interactions with other people. Please think about the way you are with most people, rather than special relationships you may have with spouses or significant others, children, siblings, and parents. Everyone changes over time, which can make it hard to fill out questions about personality. Think about the way you have been the majority of your adult life, rather than the way you were as a teenager, or times you may have felt different than normal. You must answer each question, and give only one answer per question. If you are confused, please give it your best guess.

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

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

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

Scoring Instructions
Reverse scored items (1 becomes 6, 5 becomes 2, etc.):
1, 3, 7, 9, 12, 15, 16, 19, 21, 23, 25, 28, 30, 34, 36.

Items by Subscale:
Aloof (1, 5, 9, 12, 16, 18, 23, 25, 27, 28, 31, 36)
Pragmatic Language (2, 4, 7, 10, 11, 14, 17, 20, 21, 29, 32, 34)
Rigid (3, 6, 8, 13, 15, 19, 22, 24, 26, 30, 33, 35)
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