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# Emotion Perception in Asperger's Syndrome and High-functioning Autism: The Importance of Diagnostic Criteria and Cue Intensity

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**Abstract** This study compared emotion perception accuracy between children with Asperger's syndrome (AS) and high-functioning autism (HFA). Thirty children were diagnosed with AS or HFA based on empirically supported diagnostic criteria and administered an emotion perception test consisting of facial expressions and tone of voice cues that varied in intensity. Participants with AS and the typically developing standardization sample of the emotion perception instrument had the same mean emotion perception accuracy, whereas participants with HFA performed significantly worse. Results also provided preliminary evidence for a difference in accuracy perceiving low-intensity tone of voice cues between participants with HFA and AS. Future research to build on these initial findings should include attention to tone of voice, underlying processing, and cue intensity.

**Keywords** Emotion · Nonverbal cues · Asperger's syndrome · High-functioning autism · Diagnosis

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## Introduction

Few studies of emotion perception have focused on individuals with Asperger's syndrome (AS) despite numerous clinical accounts of difficulty with nonverbal communication (e.g. Asperger, 1944; Volkmar, Klin, Schultz, Rubin, & Bronen, 2000; Wing, 1981). Discerning whether individuals with AS have an emotion perception deficit may help clarify one of the underlying processes of the characteristic social dysfunction in this population. For example, studies have found that children with classic autism have a marked deficit in their ability to perceive nonverbal cues of emotions (e.g. Hobson, 1986a, b; Hobson, Ouston, & Lee, 1989; Tantam, Monoghan, Nicholson, & Stirling, 1989) that is related to their level of social dysfunction (Braverman, Fein, Lucci, & Waterhouse, 1989). This relationship is not surprising given that an adaptive response to a social situation incorporates the other person's perspective and the true meaning of the situation, both of which require the accurate perception of nonverbal emotional cues (Klin, Jones, Schultz, Volkmar, & Cohen, 2002). In fact, difficulty with the perception of emotional cues has been related to various peer and social difficulties in typically developing children as well (e.g. Baum & Nowicki, 1998; Nowicki & Duke, 1992). This speaks of the importance of clarifying whether children with AS have an emotion perception deficit.

Studies that have addressed emotion perception in individuals with AS or high-functioning autism (HFA) have yielded inconsistent findings. Some studies have found that individuals with AS and HFA are impaired in their emotion perception abilities. For example,

three case studies found that children with AS were impaired in their ability to match two similar facial expressions and identify emotions depicted by digital photographs on a computer screen (Nijiokiktjien et al. 2001). Koning and Magill-Evans (2001) asked 21 adolescent boys with AS and 21 typically developing adolescent boys matched on cognitive ability to identify emotions from videotaped vignettes of children in typical social interactions that were filtered so that the words were unintelligible but the tone of voice was retained. The results indicated that those with AS focused mostly on facial expression cues and were deficient in their ability to identify and label the characters' emotions, performing more than one standard deviation below the mean. Macdonald et al. (1989) similarly found that adults with HFA performed more than one standard deviation below the mean for typically developing controls in their ability to match photographs of facial expression to contexts and their ability to label facial expressions of emotion.

On the other hand, some studies have found that individuals with AS and HFA are not impaired compared to typically developing controls in their emotion perception abilities. Adolphs, Seers, and Piven (2001) summarized findings from a series of four studies of eight participants with HFA in which they were asked to identify emotions from facial expressions. Although participant performance was heterogeneous, Adolphs et al. (2001) found that, overall, the participants performed similarly to typically developing peers in the recognition of basic emotions from facial expressions. Serra, Minderaa, van Geert, and Jackson (1999) did not find significant differences between children with "lesser variants of autism," including those with AS, and typically-developing controls in their ability to infer emotions of others from stories and recognize facial expressions in photographs. Fein, Lucci, Braverman, and Waterhouse (1992) found that children with various pervasive developmental disorders (PDDs) did not differ from typically developing children in their ability to match photographed facial expressions of emotion to photographs of affect-laden contexts.

Most studies of the emotion perception abilities of higher-functioning individuals with PDDs, such as those with AS, have combined individuals with AS and HFA into one group due to the difficulties in clearly differentiating the two disorders (see Schopler, Mesibov, & Kunce, 1998; Macintosh & Dissanayake, 2004, for reviews of diagnostic criteria findings). A direct comparison of individuals with AS and HFA, diagnosed using empirically supported criteria, would help clarify whether combining diagnostically distinct groups has contributed to the inconsistent findings. For example, Klin, Pauls, Schultz, and Volkmar (2005) developed a new set of diagnostic criteria that better differentiates between AS and autism, and that could be used to help clarify this issue. The greater detail in the new AS diagnostic criteria developed by Klin et al. (2005) reflect commonly accepted conceptualizations of AS (Smith-Myles & Simpson, 2002; Volkmar et al., 2000; Wing, 1981) and better follow Asperger's (1944) original description. The Klin et al. (2005) criteria are also consistent with changes made in the written description of AS in the text revision of the *DSM-IV* (American Psychiatric Association, 2000).

Inconsistencies in the findings regarding emotion perception development in individuals with AS may also be related to cue intensity. This issue is particularly important because, in typically-developing populations, accuracy in the perception of low intensity cues is more closely related to social functioning, compared to accuracy in the perception of high intensity cues (Baum & Nowicki, 1998; Nowicki & Carton, 1993). Individuals with AS and HFA may have difficulty with low intensity cues based on evidence that individuals with PDDs tend to ignore emotion information communicated through the eyes (Klin et al., 2002), an area of the face which is critical for perceiving low intensity cues of emotion (Baron-Cohen, Wheelwright, & Jolliffe, 1997; Eckman, Friesen, & Ellsworth, 1972 ). In addition, children with HFA may have *even more* difficulty perceiving low intensity cues than children with AS because, although largely innate (Eckman et al., 1972; Izard 1972, 1977), some of the more sensitive emotion perception skills are influenced by parental socialization (Denham, 1998). It is likely that parents engage in even *less* discourse about emotions with young children with HFA than with children with AS due to the presence of more social isolation and language delays in those with HFA (Klin et al., 2005).

A final important consideration related to clarifying emotion perception skills in AS is the mode of nonverbal cues. Koning and Magill-Evans (2001) found that children with PDDs largely ignored tone of voice when attempting to decode emotions in others, but it is unclear whether this is due to difficulty perceiving emotional information from tone of voice and whether children with AS and HFA differ in this skill. Therefore, it will be important to clarify not only how children with AS and HFA differ in the perception of facial expressions, but also how they differ in the perception of tone of voice.

This study examined the ability of children with AS and HFA to perceive nonverbal cues of emotion. Empirically-supported criteria were used to establish

diagnoses. A standardized, reliable, and valid measure of nonverbal communication decoding accuracy that presents facial expressions and voices conveying different emotions that systematically vary in intensity was used to test emotion perception. The following hypotheses were tested:

1. Due to the social difficulties that characterize AS and HFA and the importance of emotion understanding in social functioning, it was expected that children with AS and HFA would have poorer emotion perception skills than typically-developing children (as represented by the normative means provided in the manual of the emotion perception measure).
2. A main effect of diagnosis was expected for accuracy perceiving both facial expressions and tone of voice. Specifically, because the literature on classic autism has found a significant deficit in emotion perception, it was hypothesized that the HFA group would have more difficulty with emotion perception than participants with AS.
3. An interaction effect was hypothesized such that nonverbal cue intensity would moderate the relation between diagnosis and emotion perception accuracy; A stronger association between diagnosis and emotion perception was expected for low-than high-intensity emotional cues because of the likely differences in the socialization of more sensitive emotion perception development between diagnostic groups.

## Methods

### Participants

Participants included 26 males and 4 females between the ages of 8 and 15 years old ($M_{AS}$ = 11.47, $SD_{AS}$ = 2.06; $M_{HFA}$ = 11.00, $SD_{HFA}$ = 2.66) recruited through word of mouth and the use of a flyer that was distributed to local autism resource agencies and professionals who work with children with PDDs across the state. The majority of participants were Caucasian (24), three were African-American, two were biracial, and one was Asian-American. All participants received written feedback on all study assessments as well as the opportunity to participate in a free social skills group.

The first author conducted a diagnostic evaluation for each child. The diagnostic algorithm used in this study replicates the new diagnostic system developed by Klin et al. (2005). These diagnostic criteria for AS have greater face and discriminative validity than the DSM-IV criteria and reflect changes in the text describing AS in the DSM-IV text revision (American Psychiatric Association, 2000). Sixteen participants met study criteria for AS (following Klin et al., 2005) and 14 met criteria for HFA. The diagnostic protocol is described in detail below.

*Diagnostic criteria for HFA*. The following criteria were used to assign a diagnosis of HFA:

1. Participant exceeds ADI cutoffs for autism in all domains.
2. Participant exceeds the ADOS cutoffs for autism in all domains.
3. Participant must not meet study criteria for AS. The DSM-IV criteria require a diagnosis of autism to be given if all criteria for autism are met even if criteria are met for AS. Based on Klin et al.'s (2005) criteria, this ''precedence'' rule of the DSM-IV is reversed, that is, if the participant met criteria for AS, the diagnosis of AS is made rather than autism.
4. Participant must have enough language skills to meet the communication requirements for module 3 of the ADOS (Lord et al., 2000). These criteria require ''verbal fluency'' and state: ''Verbal fluency is broadly defined as having the expressive language of a typical 4-year-old child: producing a range of sentence types and grammatical forms, using language to provide information about events out of context and producing some logical connections within sentences ( e.g. ''but'' or ''though''). There may be some continued grammatical errors.'' This criterion was added to operationally define *high-functioning* and was not part of Klin et al.'s (2005) criteria.

In summary, to meet criteria for HFA, a participant must have evidence of social dysfunction, communication impairment, and repetitive behaviors to the degree that ADOS and ADI scores exceed all of the autism cutoffs. In addition, the participant must not meet AS criteria. Finally, language skills must be high enough to complete module three of the ADOS.

*Diagnostic criteria for AS*: The following criteria were used to assign a diagnosis of AS:

1. Participant exceeds the cutoff for autism on the ADI and ADOS social domains.
2. Participant must be reported to be socially motivated during the ''most abnormal period'' (ADI defined as between the ages of 4–5 years); Social motivation is defined as absence of social isolation and presence of frequent verbal social approaches to adults and peers regardless of social appropriateness or effectiveness; Specifically, although the

participant may avoid peers or approach them in inappropriate ways, he is not socially isolated (e.g. seeking and relating with family members).
3. Participant may or may not exceed cutoffs in the communication domains of the ADI and ADOS, but there is presence of *verbosity* (e.g. reports that the child ''talks too much'') and *pragmatic deficits* (e.g. one-sided style, tangential content).
4. Participant meets onset criteria for AS only if language concerns were restricted to pragmatic deficits (i.e. speech and formal language skill acquisition was intact) or language patterns are reported to have been precocious, with early achievement of milestones.
5. Participant may or may not exceed cutoffs in the interests domain of the ADI, but there is presence of a circumscribed interest of a factual nature (e.g. a topic about which one can acquire a great deal of factual information), that is all-absorbing (e.g. the person spends a great portion of free time involved with the topic) thus interfering with learning of other things, and which has a deleterious impact on reciprocal conversation because the person tends to frequently insert it in conversations with others.
6. Participant's problems in pretend play must be restricted to the content of play (i.e., pretend play is observed but it may involve unusual objects or themes).
7. There must be an absence of unusual sensory seeking/reactions and motor stereotypes.

In summary, to meet criteria for AS, a participant must have evidence of social dysfunction, social motivation, verbosity, pragmatic language deficits, normal speech development milestones, circumscribed and interfering interests, the use of pretend play, and the absence of motor stereotypes. Information on these characteristics is gathered from items on the ADOS, ADI, and Yale Special Interests Survey, though the only scale cutoffs that the participant must exceed are the social scales of the ADOS and ADI (participant may or may not exceed the communication and behavior cutoffs). Meeting all of these criteria excludes a diagnosis of HFA. Six of the 16 participants with AS would have been classified as HFA if the DSM-IV criteria for AS had been used (an agreement of 63% for AS diagnoses between diagnostic systems).

## Measures

All participants were administered the *Wechsler Intelligence Scale for Children—Third Edition* (WISC-III, Wechsler, 1991), which is the most widely-used measure of intelligence in children. It provides an estimate of overall (full scale), verbal, and nonverbal (performance) intelligence. The WISC-III was standardized on a sample of 2,000 children representative of the US Census, has excellent internal consistency reliability (0.91–0.96), test-retest reliability (0.86–0.95), and strong evidence for concurrent and construct validity (Wechsler, 1991).

Parents completed the *Child Behavior Checklist* (CBCL; Achenbach & Rescorla, 2001), a questionnaire designed to obtain ratings of behavioral and emotional problems of children, including a total behavior problem score, an externalizing score, an internalizing score, competence scores, and several syndrome scale scores. The CBCL was standardized with a sample of 2,368 children who were representative of the US population, including both children referred for psychiatric treatment and non-referred children, and has extensive evidence of internal consistency (0.88–0.96), construct, discriminant, content, and criterion-related validity (Achenbach & Rescorla, 2001).

Parents also completed the *Scales of Independent Behavior—Revised* (SIB-R; Bruininks, Woodcock, Weatherman, & Hill, 1996), a 259-item caretaker report designed to assess adaptive behavior skills that impact adjustment across environments, including: motor skills, social interaction and communication skills, personal living skills, and community living skills. The SIB-R was standardized with a sample of 2,182 participants (representative of the US 1990 census) and has extensive evidence of construct and criterion-related validity, internal consistency, and test-retest reliability (Bruininks et al., 1996).

Participants completed Module Three of the *Autism Diagnostic Observation Schedule-Generic* (ADOS; Lord et al., 2000), a semi-structured play assessment designed to elicit behaviors that are important to the diagnosis of PDDs for children and adolescents with fluent speech (Lord et al., 2000). Although the ADOS scoring algorithm was not designed to differentiate AS, it allows for the observation of behaviors necessary for a diagnosis of AS and the diagnostic algorithm used in this study was formulated based on ADOS scores. The ADOS requires a skilled examiner to initiate a hierarchy of planned social contexts. Item scores are summed regarding social behavior, communication, play, and stereotyped behaviors and represent dysfunction in these areas. The ADOS has adequate interrater reliability (kappas of 0.66–0.78) and internal consistency (alphas of 0.63–0.91), and, in clinical trials, correctly identified 95% of those with autism and 92% of those without a PDD (Lord et al., 2000).

Parents were interviewed with the *Autism Diagnostic Interview—Revised* (ADI; Lord, Rutter, & Couteur, 1994), a standardized caregiver interview designed to elicit information necessary for the differential diagnosis of PDDs (Lord, Storoschuck, Rutter, & Pickles, 1993). Although the ADI scoring algorithm also was not designed to differentiate AS, it gathers the information necessary for a diagnosis of AS and is part of this study's diagnostic algorithm. The item scores are summed in the areas of communication, social interaction, and restricted, repetitive behavior and represent dysfunction in these areas. Information on the age at onset is also gathered. The ADI has adequate internal consistency (Cronbach's alpha 0.69–0.95), interrater reliability (mean kappa of 0.70), and mean scores for the children with autism significantly differed compared to children who were diagnosed as mentally handicapped or language-impaired (Lord et al., 1994).

Parents completed the *Yale Special Interests Survey* (Volkmar & Klin, 1996), a caregiver questionnaire on special interests associated with the PDD diagnoses, was used to determine whether participants met criteria for AS regarding circumscribed interests. Information on special interests was gathered separately by developmental period. Items were rated as ''sometimes,'' ''quite a bit,'' or ''almost always'' and qualitative information was also gathered.

Participants were administered four subtests from the *Diagnostic Analysis System of Nonverbal Accuracy Scale—2* (DANVA) as a measure of emotion perception, including: Adult Facial Expressions, Child Facial Expressions, Adult Paralanguage, and Child Paralanguage (Nowicki, 2003). Each DANVA subtest was constructed independently and stimuli were selected on the basis of a preset percentage (70%) of judges agreeing on the identification of a particular emotion. The facial expression tasks were based on 48 photographs of an equal number of male and female children and adults of varying ethnicities. The paralanguage tasks required the participant to listen to 56 audiotaped presentations of the sentences, ''I am going out of the room now. I will be back later,'' as read by male and female child and adult professional actors. For both the facial expression and paralanguage tasks, the participant was asked to identify the facial expression or tone of voice depicted as ''happy,'' ''sad,'' ''angry,'' or ''scared.'' All subtests had an equal number of cues that were low and high intensity. The DANVA has been standardized with participants differing in age, sex, race, cultural background, intellectual ability, and psychological adjustment (Nowicki, 2003). The manual provides normative means and standard deviations for child and adult faces and voices based on a compilation of over 20 studies of typically developing children broken down by age (Nowicki, 2003). The DANVA has evidence for good internal consistency (Cronbach's alphas 0.77–0.88) and 4-week test–retest reliabilities (0.74–0.90).

### Procedure

Each child was individually administered the DANVA by an individual who was blind to diagnosis, prior to the diagnostic evaluation, using the standardized administration procedures described in the DANVA manual. Participants were provided with a piece of paper listing the four possible answers: happy, sad, mad, and scared. The child was able to respond verbally or point to the answer sheet, and the examiner recorded responses. The facial expression and paralanguage task order of presentation was counterbalanced across participants. For the facial expression tasks, photographs were presented, one at a time, each for no more than a 2-s exposure period. If, after a photograph had been taken away, the child said that he or she did not see the photograph, the photograph was not re-administered. Instead, the child was urged to make a guess. The tone of voice task was administered with a tape recorder. The tape included a pause of approximately 4 s between each trial, but was sometimes paused in order to allow sufficient time for the participant to respond. Similar to the procedures for the test of facial expressions, if a participant said that he or she did not hear a given trial after it had been administered, he was urged to guess. For all tests, if the participant indicated that he or she thought it was a ''tie'' or was not one of the possible four answer options, he or she was urged to provide the best answer of the four possible options.

## Results

### Descriptive Statistics

Both groups had mean scores in the *Clinical* range on the Internalizing, Social, Thought, and Attention Problems Scales of the *Child Behavior Checklist*. In addition, the HFA group's Total Competence mean score and the AS group's Total Problem mean score were in the *Clinical* range, and the HFA group's Total Problems score was in the *Borderline Clinical* range. All mean scores on the *Scales of Independent Behavior—Revised* were at least one standard deviation below the standardization mean of 100, with the exception of the Motor and Community Living scales for the AS group. There was a large amount of

**Table 1** Means and standard deviations for WISC-III scores ($n$ = 29)

| | AS ($N$=15) Mean (SD) | HFA ($N$=14) Mean (SD) | Cohen's $d$ | $F$ |
|---|---|---|---|---|
| Full scale IQ | 113.07 (14.57) | 84.21 (18.80) | 1.71 | 21.51** |
| Verbal IQ | 117.20(15.77) | 85.50 (23.43) | 1.58 | 18.51** |
| Performance IQ | 105.73 (18.63) | 85.86 (13.29) | 1.22 | 10.79* |

*Note*: IQ scores are from the WITC-III and are based on a mean of 100 and standard deviation of 15. **Significant at $p < 0.001$, *Significant at $p < 0.01$

variability in adaptive behavior scores for both groups in all categories.

Means and standard deviations of WISC-III scale scores are shown in Table 1 by diagnostic group, including statistical test results of group comparisons. A Multivariate Analysis of Variance (MANOVA) indicated that the mean vector of IQ scores differed between those with AS and HFA, Wilks' Lamba $F$ (3,25) = 6.82, $p < 0.01$. Specific contrast results suggested that participants with AS had significantly higher Full Scale, Verbal, and Performance IQs than the HFA group with Cohen's $d$ effect sizes of greater than one (see Table 1). WISC-III Full Scale scores were therefore used as a covariate in subsequent analyses. The Verbal-Performance IQ differences were also explored in order to determine if the trend of greater verbal than performance scores for the AS group found in Klin et al.'s (2005) study was replicated in the current study. There was a trend for participants with AS to have a greater positive difference between their Verbal and Performance IQ (VIQ–PIQ $M$ = 11.45, SD = 20.05) than the HFA group ($M$ = –0.35, SD = 17.74), but this difference was not statistically significant, $t$ (27) = 1.67, $p > 0.05$. This may have been due to limited power to detect this difference. Post-hoc power analyses indicated a power for this test of approximately 0.35.

## Test of Emotion Perception

Table 2 shows the mean, standard deviation, and range for all DANVA subscales by diagnosis. The normality of these distributions was examined separately by diagnosis given the assumption that the diagnostic groups would perform differently on tests of emotion perception using strategies outlines by Cohen, Cohen, West, and Aiken (2003). In addition, Cohen et al.'s (2003) guidelines for examining the influence of outliers were followed and adjustments were made for two cases that exceeded the guidelines for proposed cutoffs signifying cases with an atypical amount of influence by over five times, suggesting that these outliers had an abnormally large amount of global influence.

*Comparisons to DANVA normative means.* The first set of analyses tested the hypothesis that children with AS and HFA would be less accurate in their perception of facial expressions and tone of voice than typically developing children by comparing scores from the AS and HFA groups to the normative means from the DANVA manual. Comparisons were based on mean scores for overall facial expression and tone of voice scores, because normative means were not available broken down by intensity. The results indicated that the AS group's mean percent of facial expressions correct ($M$ = 82.05, SD = 8.73) did not significantly differ from the standardization sample ($M$ = 81.85, SD = 5.44), $t$ (15) = 0.09, $p > 0.05$. On the other hand, one-sample $t$-tests revealed that the HFA group had a significantly lower mean percent of facial expressions correct ($M$ = 74.87, SD = 8.90), compared to the standardization sample ($M$ = 81.85, SD = 5.44), $t$ (13) = –2.93, $p < 0.05$, and compared to participants with AS ($M$ = 82.05, SD = 8.73), $t$ (28) = 2.23, $p < 0.05$. Figure 1 shows this effect.

A similar pattern resulted when the AS and HFA groups were compared to the normative means from

**Table 2** DANVA means, standard deviations, and ranges by diagnosis

| Scale | Asperger's ($n$ = 16) | | | Autism ($n$ = 14) | | |
|---|---|---|---|---|---|---|
| | $M$ | SD | Range | $M$ | SD | Range |
| Low intensity faces | 71.33 | 12.04 | 45.8–87.5 | 64.57 | 13.15 | 41.6–87.5 |
| High intensity faces | 92.69 | 7.08 | 79.2–100.0 | 84.40 | 5.54 | 75.0–95.8 |
| Low intensity voices[a] | 68.99 | 11.25 | 37.5–83.0 | 46.75 | 16.06 | 20.8–75.0 |
| High intensity voices | 74.49 | 11.07 | 54.1–91.7 | 59.21 | 20.50 | 25.0–87.5 |

*Note*: All means represent percent correct

[a] After correcting for outliers, the mean for the AS group is 71.70, the standard deviation is 7.67, and the range is 58.8–83.0

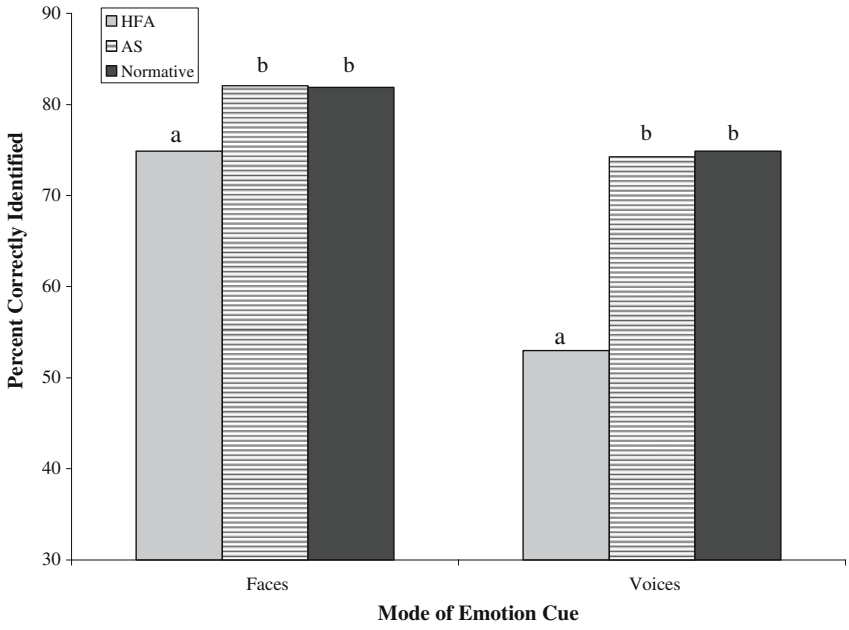


**Fig. 1** Mean percent of DANVA total faces and total voices correct across study groups and the normative sample; HFA = high functioning autism and AS = Asperger's syndrome; Analyses were conducted within, and not across, cue mode. Bars with subscripts that are different significantly differ from each other at $p \leq 0.05$

the DANVA manual for Total Voices. The results indicated that the AS group's mean percent of voices correct ($M = 71.73$, SD = 9.19) did not significantly differ from the normative means ($M = 74.87$, SD = 7.08), $t$ (15) = –0.36, $p > 0.05$. In contrast, a one-sample $t$-test revealed that the HFA group had a significantly lower mean percent of tone of voice cues correct ($M = 52.98$, SD = 17.68) than the normative sample ($M = 74.87$, SD = 7.08), $t$ (13) = –4.11, $p = 0.001$ and participants with AS ($M = 71.73$, SD = 9.19), $t$ (26) = 4.23, $p < 0.01$ (see Fig. 1).

*Comparisons between AS and HFA by cue intensity.* Next, analyses were conducted to test the hypothesis that there would be an interaction between diagnosis and cue intensity. A Multivariate Analysis of Covariance (MANCOVA) was used to examine differences between the AS and HFA groups in low intensity faces, high intensity faces, low intensity voices, and high intensity voices, controlling for IQ. The results indicated a significant effect of diagnosis on the mean vector of dependent variables, Wilks Lamda $F$ (1, 24) = 3.25, $p < 0.05$. Contrary to hypotheses, the specific contrast results did not indicate any significant differences in the perception of facial expressions between participants with AS and HFA when examined separately by cue intensity ($p > 0.05$). On the other hand, a significant effect was found for low intensity tone of voices, $F$ (1, 24) = 6.11, $p < 0.05$. Therefore, post-hoc analyses were conducted for tone of voice cues to further examine the hypotheses regarding main effects and interactions of diagnosis and cue intensity on tone of voice perception.

The results of a Mixed Effects ANCOVA controlling for IQ indicated that participants with AS were significantly more accurate in their perception of *low* intensity voices (Estimated Marginal Mean = 66.84) than participants with HFA (Estimated Marginal Mean = 51.92), $F(1, 24) = 6.11$, $p < 0.05$. On the other hand, those with AS and HFA did not significantly differ in their perception of *high* intensity voices, $F$ (1, 24) = 0.13, $p > 0.05$. These analyses suggest that participants with AS and HFA were similarly accurate in their perception of emotion for high intensity voices but children with AS were significantly more accurate in their perception of low intensity tone of voice cues than children with HFA.

## Discussion

This study sought to examine differences in the emotion perception accuracy of children with AS and HFA when diagnosed using empirically supported diagnostic criteria. The results indicated that the mean score for children with AS did not differ from normative means for typically developing children on a test of the perception of emotions in facial expressions and tone of voice. In contrast, participants with HFA were significantly less accurate in emotion perception, compared to both the normative sample and participants with AS. Participants with AS and HFA did not significantly differ from each other in their perception of facial expressions when examined separately by cue intensity, controlling for IQ. Similarly, children with AS and

HFA perceived high intensity tone of voice cues with similar accuracy. On the other hand, participants with HFA had significantly more difficulty with low intensity tone of voice cues, compared to participants with AS.

The finding that children with HFA performed worse than the standardization sample in their emotion perception is consistent with the literature that suggests a deficit in these skills for children with *classic* autism (e.g. Braverman et al., 1989; Hobson, 1986a, b). In fact, the extent of emotion perception limitations for the HFA group in this study was similar to studies of children with classic autism (Hobson et al., 1989; Macdonald et al., 1989) and some of the research on individuals with HFA that found emotion perception deficits of greater than one standard deviation below the mean of typically-developing controls (Macdonald et al., 1989).

On the other hand, the current results conflict with some earlier studies of higher-functioning individuals with PDDs that found no difference in emotion perception abilities when compared to typically-developing controls (e.g. Adolphs et al., 2001). Previous studies that have examined these skills with higher-functioning individuals with PDDs often used poorly defined diagnostic groups (such as ''lesser variants of autism'') or a heterogeneous group of children with various PDDs (e.g. Fein et al., 1992; Serra et al., 1999). Unlike these previous studies, the current study used empirically supported diagnostic criteria (Klin et al., 2005) to more clearly define AS. Using these more specific diagnostic criteria, those with AS were significantly more accurate in their emotion perception than participants with HFA, and children with AS did not differ from the normative sample of the instrument in the perception of facial expressions or tone of voice cues whereas those with HFA did. This may explain some of the inconsistent findings from studies that combined these groups in their comparison to typical populations.

Two aspects of the diagnostic criteria that were used to distinguish AS and HFA in the present study provide a possible explanation for this finding. In order to meet diagnostic criteria for AS, participants had to have displayed social interest during the preschool years and speech milestones within normal limits (Klin et al., 2005). In contrast, those with HFA may have had language delays and greater social withdrawal and isolation (Klin et al., 2005). These language and social differences during the preschool years may be critical in understanding differences in emotion perception development given the importance of this time period for emotion perception development (Brown & Dunn, 1996; Denham, 1998). Although a large degree of emotion perception skill is thought to be innate (Eckman et al., 1972; Izard 1972, 1977), evidence also suggests that sensitivity to expressions of emotions can be socialized through parent–child interaction (Denham, 1998). It is possible that the increased withdrawal and decreased language in children with HFA during their early years may lead to decreased parental interaction, which could explain the greater limitations in emotion perception abilities in children with HFA.

Despite this hypothesis regarding why individuals with HFA may have less opportunity to benefit from the socialization of more sensitive emotion perception skills, it is still somewhat surprising that the mean for the AS group did not differ from the normative means for typically-developing children. Given the extent of social difficulties in children with AS (e.g. Asperger, 1944; Wing, 1981) and the link between emotion perception abilities and social functioning (e.g. Baum & Nowicki, 1998; Denham, 1998), those with AS would be expected to have poorer emotion perception abilities than typically developing children. The current finding that their ability to read expressions of emotion is similar to their peers suggests that their difficulties may stem from deficits in more advanced emotion understanding skills. It is also possible that children with AS are compensating for an emotion perception deficit through different processing mechanisms, based on evidence that children with autism spectrum disorders may process faces differently than typically-developing children (e.g. Deruelle, Rondan, Gepner, & Tardif , 2004).

Although the intensity of the emotion cue has not received as much attention in the autism-related literature as it has for typically-developing children, the current results provide preliminary evidence to suggest that cue intensity warrants further research focus. Specifically, whereas a significant group difference was not found for high intensity tone of voice cues, participants with AS and HFA differed in their perception of low intensity cues. This finding is important given that accuracy in the perception of low intensity cues is more closely related to social functioning than the perception of high intensity cues in typically-developing populations (Baum & Nowicki, 1998; Nowicki & Carton, 1993). However, further research is needed to clarify this preliminary finding given the small sample size in the current study.

There are some important considerations for interpretation of the results. First, the participant's attention was specifically drawn to the emotion cue and the cues consisted of photographs and audiotapes. It is therefore difficult to generalize findings to how they use these skills in daily social interactions. However,

this was an effective method to determine whether individuals with AS and HFA have deficits in this foundational skill before exploring its use in a more natural framework. It is also somewhat difficult to compare this study to other studies given the use of different diagnostic criteria for AS. However, there are some benefits to having used the Klin et al. (2005) criteria for AS. First, they have more empirical support than the DSM-IV criteria (Klin et al., 2005), which have been shown to be inadequate in several studies (see, e.g. Macintosh & Dissanayake, 2004). The criteria used in this study are also more consistent with Asperger's (1944) original descriptions of the disorder, commonly accepted conceptualizations of AS (Smith-Myles & Simpson, 2002; Volkmar et al., 2000) and the description of AS in the text-revision of the DSM (American Psychiatric Association, 2000). In addition, because the criteria are based on the use of standardized diagnostic measures, it facilitates replication. Furthermore, comparisons between this sample and Klin et al.'s (2005) study indicate the diagnostic criteria can be reliably applied across different investigators and sites. In the current study, when DSM-IV diagnostic criteria were applied, 6 of the 16 children with AS in this study would have been diagnosed with HFA. This agreement rate of 63% between diagnostic systems is the same as Klin et al. (2005) found when they compared diagnostic systems (63%). In addition, the mean difference between Verbal and Performance IQ scores for the AS group was 11 in both studies (Klin et al., 2005). The fact that this difference was not significant in the present study is likely due to low power. Finally, the large IQ difference between groups must be considered when interpreting present results. The current study used ANCOVA as opposed to matching and there are varying perspectives on the utility of these approaches (e.g. Miller, 2001; Mottron, 2004; Ross & Klin, 1988). One limitation to the statistical control approach used in the present study is decreased power. Controlling for IQ, through ANCOVA or matching procedures, allows one to discuss emotion perception abilities above and beyond IQ. However, results with IQ controlled statistically or matched do not necessarily translate into how specific individuals might function in day to day interactions when the IQ difference exists.

This study has several unique features that suggest directions and opportunities for future research. First, this study was one of the first to examine the ability to perceive tone of voice cues in these populations. Therefore, future research should expand on this foundation by continued investigation of tone of voice perception in PDDs with larger samples and methods to clarify specific aspects of tone of voice processing. In addition, this was the first study, to our knowledge, to directly compare HFA and AS in emotion perception. Future studies should build on this foundation to test potential explanations for differences between HFA and AS in emotion perception. Specifically, it will be important to test whether decreased socialization of emotion perception skills is one of the underlying reasons for the emotion perception deficit in HFA. Studies should clarify whether parental discourse on emotions does mediate the relation between diagnosis and emotion perception accuracy. It will also be important to determine if there was an aspect of the task demand that led to the current results; an analogous control task with similar demands would clarify this issue. Future studies should also focus on how children with AS and HFA use or do not use emotion perception skills in their everyday social interactions. It will be important to discern whether they pay attention to emotional cues when they are not being asked to do so. In addition, future studies should explore whether children with AS and HFA have an understanding of how to modify their interaction based on the emotion information and if they are able to do so. Finally, given that the AS group did surprising well in their emotion perception, various aspects of processing that could have led to their success should be further assessed.

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