Emotion Recognition/Understanding Ability in Hearing or Vision-Impaired Children: Do Sounds, Sights, or Words Make the Difference?

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Running head: EMOTION RECOGNITION ABILITY

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Abstract

This study was designed to assess whether children with a sensory disability have consistent delays in acquiring emotion recognition and emotion understanding abilities. Younger (6 – 11 years) and older (12 – 18 years) hearing-impaired children (HI; n = 49), vision-impaired children (VI; n = 42), and children with no sensory impairment (NSI; n = 72) were assessed with the Emotion Recognition Scales (ERS), which include two tests of the ability to recognize vocal expressions of emotion, two tests of the ability to recognize facial expressions of emotion, and three tests of emotion understanding. Results indicate that when compared with age-peers, HI children and adolescents have significant delays or deficits on all ERS, but VI children and adolescents are delayed only on emotion recognition tasks. When compared with children group-matched for verbal ability (Wechsler verbal scales), the achievement of HI children on ERS equals or exceeds that of controls; VI children underachieve on an emotion recognition task and overachieve on an emotion vocabulary task compared to verbal ability matched peers. We conclude that VI children have a specific emotion recognition deficit, but among HI children, performance on emotion recognition and emotion understanding tasks reflects delayed acquisition of a broad range of language-mediated abilities.

Emotion Recognition/Understanding Ability in Hearing or Vision-Impaired Children: Do Sounds, Sights, or Words Make the Difference?

Children with a severe hearing (Peterson & Siegal, 1995, 1998) or vision impairment (McAlpine & Moore, 1995; Minter, Hobson, & Bishop, 1998) have been observed to be profoundly delayed in acquiring some social cognitive abilities. However, the causes of these delays are not known, and we do not know whether the delays are specific to the acquisition of a narrowly defined "theory of mind," whether they also include acquisition of broader abilities to recognize and understand the emotional experience of other people, or even whether children with a sensory impairment are more delayed in the acquisition of social cognition than they are in the acquisition of language and language-mediated abilities. Discovering this knowledge is essential if we are to understand the role that these delays may play in mediating the social and behavioral problems of children with a sensory disability.

The Ability to Read Minds

"Mind-reading" (Baron-Cohen, 1994; Whiten, 1991) is one of several generic terms used to describe a set of social cognitive abilities which enable one person to "conceptualize other people's inner worlds and to reflect on their thoughts and feelings" (Gillberg, 1992, p. 835). In very young children, mind-reading ability may be inferred from a child's use of internal state words (Bretherton & Beeghly, 1982), including words referring to emotional states (Youngblade & Dunn, 1995), from emotion understanding tasks that depend on perspective-taking ability (Hughes & Dunn, 1998), or from a child's performance on false belief tasks assessing the ability to "represent the difference between one's own and somebody else's relation to the same propositional content" (Wimmer & Perner, 1983, p. 105; emphasis in original).

At more advanced levels, mind-reading ability is operationally defined by the ability to understand subtle variations in the emotional expressions of other people (Baron-Cohen, 2002; Baron-Cohen, Wheelwright, Hill, Raste, & Plumb, 2001).

In the context of developmental disorders, mind-reading ability has been used to describe the performance deficits of people with an autism spectrum disorder. Whereas people with severe autism frequently fail elementary theory of mind tasks (Phillips, Baron-Cohen, & Rutter, 1998; Ziatas, Durkin, & Pratt, 1998), high-functioning people with autism or Asperger's Disorder demonstrate an impaired ability to infer the mental states of people participating in social situations (Heavey, Phillips, Baron-Cohen, & Rutter, 2000), to correctly label the emotions being experienced by other people (Yirmiya, Sigman, Kasari, & Mundy, 1992), or to infer mental states from vocalizations (Rutherford, Baron-Cohen, & Wheelwright, 2002).

Mind-Reading Deficits of Hearing-Impaired Children

Children with a severe hearing impairment (HI) were first observed to be delayed in acquiring a theory of mind by Peterson and Siegal (1995, 1998), but deficits in the ability of children with HI to recognize emotions had been demonstrated earlier (Bachara, Raphael, & Phelan, 1980; Schiff, 1973). Subsequent research has shown that the initial findings cannot be generalized to all social cognitive tasks, nor to all people with HI.

Early research on the theory of mind deficits (Peterson & Siegal, 1995) or delays (Russell, Hosie, Gray, et al., 1998) of HI children made use of the standard false belief tasks that had been used in early research on theory of mind deficits in children with autism. Gray and Hosie (1996) warned against relying on a single measure of the theory of mind construct, and other investigators have demonstrated that theory of mind deficits can be reduced (Steeds, Rowe, & Dowker, 1997), eliminated (Marschark, Green, Hindmarsh, & Walker, 2000), and even reversed (HI children exceed controls; Peterson, 2002, Experiment 2) when theory of mind is operationalized as the inference of intention, the use of mental state terms in narratives, or the understanding of one’s own intentions and others’ false beliefs on misleading drawing tasks, respectively. Whether, and to what extent, HI children are delayed or have deficits in mind-reading abilities partly depends on how the ability is measured.

There is persuasive evidence that the condition which determines when a child with HI acquires mind-reading ability (on tasks where deficits are evident) is when the child is exposed to a natural language. Several researchers (Courtin, 2000; Peterson & Siegal, 1999; Woolfe, Want, & Siegal, 2002) have now shown that the HI children of hearing parents show large delays in acquiring a theory of mind, but the HI children of HI parents—children who were exposed, from infancy, to a sign language-rich environment—show no delays in acquiring a theory of mind. In other words, children with severe HI may be delayed in acquiring a theory of mind because their exposure to a natural language has been delayed, not because they have a hearing impairment.

Peterson and Siegal (1995, 1999; see also Garfield, Peterson, & Perry, 2001) have proposed that children with any disorder that severely limits the child's access to information about other people's mental states—including HI children who do not receive early exposure to a natural language—may be expected to delay the child's acquisition of a theory of mind. For children with HI, access to conversation about unobservable mental states would be limited by delays in acquiring language and/or by a dearth of conversation partners (persons fluent in sign language) with whom unobservable events can be discussed. Russell et al. (1998) observed that among HI children from hearing families, theory of mind deficits decreased with age. They argued that increased opportunities for social interaction in older children facilitated the continuing, if delayed, acquisition of theory of mind ability. Jackson (2001) observed that among hearing children and HI children from HI families, the strong positive correlation between language and theory of mind measures was due to a partial correlation with age; in other HI children, the correlation between language and theory of mind was not mediated by age. These results suggest that among children not exposed to a natural language from infancy, the acquisition of mind-reading ability is directly limited by delayed acquisition of language.

Early findings on the emotion recognition deficits of children with HI have been brought into question by more recent investigations. For example, children with HI can perform as well as hearing children on emotion recognition tasks when the tasks require emotion matching rather than language production (Hosie, Gray, Russell, Scott, & Hunter, 1998; Weisel, 1985). The importance of conversation about emotions in determining achievement on emotion understanding tasks is suggested by research on children with HI who have received education about the emotions. Rieffe and Terwogt (2000) reported that 6-year old and 10-year old children with HI who had been trained in emotion labeling and emotional awareness were about as accurate at predicting typical emotional responses and in explaining atypical emotional responses as hearing children. Dyck and Denver (in press; see also Greenberg & Kusche, 1998) reported a significant improvement in the emotion vocabulary and emotion knowledge of children with HI following completion of a program designed to increase their understanding of emotions. These results imply that children with HI do not have specific deficits in either theory of mind or emotion understanding abilities. Rather, the underachievement of these children on mind reading tasks is consistent with their underachievement on all tasks that depend on language and language-mediated instruction, including informal instruction by means of conversation.

Mind-Reading Deficits of Vision-Impaired Children

Apart from the studies reporting that children with VI are delayed in acquiring a theory of mind (McAlpine & Moore, 1995; Minter et al., 1998; Peterson, Peterson, & Webb, 2000), almost nothing is known about the mind-reading abilities of these children. The only research on the emotion recognition abilities of children with VI was conducted by Minter, Hobson and Pring (1992), who found that children with VI aged 6 to 12 years were less able to understand emotion sounds than were controls, a deficit that was specific to emotion sounds (rather than nonemotion sounds).

Peterson et al. (2000) have proposed that theory of mind deficits in children with VI, like those in children with HI, are caused by restricted access to the early social and conversational experiences that facilitate the acquisition of a theory of mind in sighted and hearing children. But in this case, access to conversational experience is not simply a function of delayed acquisition of language and a lack of conversation partners. Rather, "restricted access to the non-verbal cues that betray such critical conversational information on speakers' attentional directions and emotional feelings may limit the blind child's access to what is in others' minds, even in the context of perfect linguistic comprehension" (Peterson et al., 2000, p. 445). In children with VI, there is an apparent discrepancy between what is actually understood about the experience of another person and what would be expected on the basis of verbal competence.

Peterson et al. (2000, p. 444) note that in their study, children with VI "were socially responsive, socially engaged, well-motivated and well-equipped for participating in social interaction with teachers and peers in the classroom and on the playground." The theory of mind deficits of these children were not due to a dearth of conversational opportunities per se, but to their inability to perceive important elements within a given conversation. The suggestion by Peterson et al. (2000) that visually available emotion cues are part of what is missed implies that in children with VI, mind reading deficits are directly related to vision impairment rather than to language or superficial access to conversation.

Differences Between Vision-Impaired Children and Hearing-Impaired Children

It is clear that ‘access to conversational opportunities’ means something very different for HI and VI children. In the case of HI children, it is difficult to separate access to conversation from the acquisition of language in determining the acquisition of mind-reading abilities, and leads to the prediction that the mind-reading ability of HI children will be commensurate with their overall verbal ability. But in the case of VI children, we can expect that delays in the acquisition of mind-reading ability will exceed any delays in the acquisition of language, that is, that the verbal ability of VI children will exceed their mind-reading ability. Minter et al. (1992) observed that the emotion recognition deficits of VI children were disproportionate to their language ability.

What is less clear is how any differences in the verbal abilities of adolescents with HI or VI will affect their performance on emotion recognition and understanding tasks. Although children with VI, like children with HI, are substantially delayed in acquiring expressive language (McConachie & Moore, 1994), language-mediated abilities (Dimcovic & Tobin, 1995), and other cognitive abilities (Bigelow, 1990, 1992; Markoulis, 1988), these initial delays are not reflected in the performance of adults with VI who do not differ from sighted peers on relevant tasks (Juurmaa, 1964, 1968). The implication of this pattern of results is that persons with VI experience a “developmental spurt” between early childhood and adulthood. If such a spurt applies to emotion recognition and understanding tasks, then the performance of adolescents with VI will exceed the performance of adolescents with HI when the participants have not been matched on verbal ability.

This study examines the emotion recognition and understanding abilities of vision-impaired, hearing-impaired, and non-impaired children and adolescents to assess how verbal ability and/or sensory impairment relate to performance. We aim to assess whether HI or VI children and adolescents have deficits in emotion recognition and understanding compared to peers with no sensory impairment. We expect that among younger children with either a hearing or a vision impairment, emotion recognition and understanding deficits will be evident; among adolescents, the performance of adolescents with VI is expected to exceed that of adolescents with HI. We also aim to assess whether expected delays in acquiring mind-reading abilities are commensurate with delays in acquiring language. Following Peterson and Siegal (1995, 1998, 1999), we expect that children with HI and children with no sensory impairment (NSI) will not differ in emotion recognition and understanding ability when these groups are matched on verbal ability. Following Peterson et al. (2000), we expect that VI children will be delayed in acquiring emotion recognition and understanding abilities when compared with NSI children when these groups are matched on verbal ability.

Method

Participants: Main Sample

Participants were 163 children and adolescents recruited from schools in the Brisbane metropolitan region. Participants with HI (n = 49) or VI (n = 42) were identified by special education teachers within the Department of Education. The Education Department rates the severity of disability of children with a sensory impairment on a 6-point scale, and 81 participants (HI = 46; VI = 35) had received the highest ranking. The remaining 10 participants (HI = 3; VI = 7) had received the second highest rating. Using this severity measure, participants with HI and VI did not differ in the severity of their sensory impairment [χ^2 (2) = 0.53, ns]. Participants with no sensory impairment (NSI) were recruited from the same schools from which disabled participants were recruited.

Participants were assigned to one of six groups. The HI adolescent (n = 33) group were 15 girls and 18 boys aged between 12 and 18 years (mean = 15.28, sd = 2.36). The HI children (n = 16) group were 8 girls and 8 boys aged between 6 and 11 years (mean = 9.29, sd = 1.14). Hearing impairment was defined when it had been diagnosed by an otolaryngologist or an audiologist. For HI children, average hearing loss in the left ear was 95dB (sd = 16.39) and in the right ear was 99dB (sd = 15.95); 1 child was classified as ‘moderately’ hearing-impaired (51 – 70dB hearing loss), 4 children were classified as ‘severely’ hearing-impaired (71 – 90dB hearing loss), and the remaining 11 hearing-impaired children were classified as ‘profoundly’ hearing-impaired (> 90dB hearing loss). For HI adolescents, average hearing loss in the left ear was 94dB (sd = 20.80) and in the right ear was 100dB (sd = 18.19); 2 adolescents were classified as ‘mildly’ hearing-impaired (21 – 50dB hearing loss), 2 were classified as ‘moderately’ hearing-impaired, 5 were classified as ‘severely’ hearing-impaired, and the remaining 24 adolescents were classified as ‘profoundly’ hearing-impaired. The severity of hearing loss did not differ for HI children and adolescents [left ear: $F(1, 41) = 0.05$, ns; right ear: $F(1, 41) = 0.08$, ns]. Across both groups, hearing loss in the right ear was significantly greater than in the left ear [$t(40) = 2.36$, $p < .05$].

The VI adolescent (n = 18) group were 6 girls and 12 boys aged between 12 and 18 years (mean = 13.97, sd = 1.50). The VI children (n = 24) group were 12 girls and 12 boys aged between 6 and 11 years (mean = 8.12, sd = 1.68). Vision-impairment was defined when it had been diagnosed by an ophthalmologist, sometimes confirmed by a report from a neurologist or paediatrician. A vision impairment was considered to exist when visual acuity was 6/18 or less after correction, a field loss impairs visual functioning, or there is a degenerative visual condition. We categorized participants as totally vision impaired (scored 1), severe vision impairment (< 6/120 corrected vision; scored 2), moderate vision impairment (6/50 to 6/120 corrected vision; scored 3), or low vision impairment (< 6/30 to 6/50 corrected vision; scored 4). VI children had an average impairment of 2.41 (sd = 1.22; totally vision impaired = 6, severe = 8, moderate = 1, low = 7) while VI adolescents had an average impairment of 2.83 (sd = 1.34; totally vision impaired = 5, severe = 2, moderate = 2, low = 9); these values did not differ significantly from each other [F (1, 39) = 1.09, ns].

The adolescents with NSI (n = 42) group were 23 girls and 19 boys aged between 12 and 18 years (mean = 14.58, sd = 1.75). The children with NSI (n= 30) group were 16 girls and 14 boys aged between 6 and 11 years (mean = 8.77, sd = 1.70). There was no significant age difference among participants in the three child groups [F (2, 67) = 2.73, ns] or among participants in the three adolescent groups [F (2, 90) = 2.75, ns], nor in the gender balance of the groups [χ^2 (2) = 1.48, ns].

Participants: Matched for Verbal Ability

In order to compare the emotion recognition and understanding abilities of persons with and without sensory disabilities but with comparable levels of verbal ability (see Measures below), three sub-samples of HI, VI, and NSI children and adolescents were selected from the main samples. Selection was based on absolute levels of achievement (raw scores rather than age-referenced scaled scores) on verbal ability measures. The use of raw scores, which is analogous to matching for mental age, was necessary because appropriate age norms for children with sensory disabilities are not available. We reviewed the distribution of Wechsler Comprehension raw scores across the three sensory impairment groups and observed that low scores were overrepresented among persons with a sensory impairment and high scores were overrepresented among persons with no sensory impairment. We excluded all participants with Wechsler Comprehension raw scores less than 9 (below which only children with a sensory impairment achieved) or greater than 27 (above which only children with no sensory impairment achieved). We then reviewed the distribution of Wechsler Similarities raw scores and observed that low scores were overrepresented among persons with a sensory impairment and high scores were overrepresented among persons with no sensory impairment. We excluded participants with a Wechsler Similarities raw score less than 7 or more than 21. Finally, we reviewed the distribution of Wechsler Information raw scores and observed that no group was overrepresented at the extremes of the distribution. These exclusions left us with 23 HI (female = 13), 26 VI (female = 11), and 34 NSI (female = 18) participants. A multivariate analysis of variance comparing the three groups on the three Wechsler scales confirmed that the groups did not differ significantly in Wechsler measured verbal ability [$\Lambda = .907$, $F(6, 156) = 1.30$, ns]. The three groups also did not differ in gender balance [$\chi^2(2) = 1.11$, ns], but they did differ significantly in age. HI children were significantly older (mean = 14.23 years, sd = 3.31 years) than VI children [mean = 11.28 years, sd = 2.68 years; $F(1, 47) = 11.81$, $p < .01$] and NSI children [mean = 10.30 years, sd = 2.70 years; $F(1, 55) = 24.16$, $p < .001$], but VI children were not significantly older than NSI children [$F(1, 58) = 1.97$, ns].

Materials and Procedure

Participants were assessed with individually administered tests drawn from the Wechsler Intelligence Scale for Children, 3rd edition (WISC; Wechsler, 1991) and the Emotion Recognition Scales (ERS; Dyck, Ferguson, & Shochet, 2001). All testing of

HI or VI participants was conducted at the place of recruitment by the same researcher. Participants with NSI were tested at the place of recruitment by one of four researchers.

Performances on the WISC Information, Similarities, and Comprehension scales were used to estimate verbal ability. Although these scales are defined as measuring 'intelligence' rather than verbal ability, Wechsler (1991) has cautioned that these scales are not appropriate for estimating the intelligence of hearing-impaired persons. Unlike normative samples, the correlation between performance IQ and verbal IQ is weak (r = .09 to .52) in samples of hearing-impaired children (Brinich, 1981; Kusche, Greenberg & Garfield, 1983; Phelps & Branyan, 1990) because the verbal scales are measuring the language ability of the children rather than their intelligence (Brinich, 1981; Isham & Kamin, 1993; Watson, Sullivan, Moeller, & Jensen, 1982). Recent research on a normative sample of 449 children aged 3 to 14 years indicates that Wechsler verbal scales are as highly correlated (r = .69) with a measure of language ability (Clinical Evaluation of Language Fundamentals) as measures of intelligence are correlated with each other (r = .54 between Culture Fair Test of Intelligence and Wechsler Intelligence Scale for Children; Dyck, Anderson, Hallmayer, Hay, & Piek, unpublished data). Across samples of children with and without sensory impairments, the Wechsler verbal scales appear to be a good proxy for language ability.

The ERS were designed to measure emotion recognition and understanding ability. The ERS consist of five tests that comprise 9 scales.

The Fluid Emotions Test (FET) is a 32-item scale that was designed to measure the ability to recognize facial expresions of emotion, and the speed and accuracy with which a person can recognize changing/changed facial expressions of emotion. This is a computer-presented test and items are drawn from Matsumoto and Ekman's (1995) color slides of Japanese and Caucasian subjects expressing one of seven emotions (anger, contempt, disgust, fear, happiness, sadness, surprise) or a neutral expression. Each FET item consists of two head and shoulders pictures of a Japanese or Caucasian male or female expressing one of the 7 emotions or a neutral expression. The test-taker is asked to identify what emotion is being expressed in the first picture. After responding, the initial image is then gradually (over 4 seconds) transformed by morphing software into the picture of another person expressing a different emotion. Subjects are asked to indicate, as quickly as they can, the second emotion being depicted. The speed of response is measured with a stop-watch. The FET yields four measures: initial accuracy (ACC-1; total pre-morph emotions correctly identified); final accuracy (ACC-2; total post-morph number correct), speed (SPD; average post-morph response time regardless of accuracy), and speed given accuracy (SGA). The SGA scale is based on categorizing the speed of accurate post-morph responses into one of eight categories. Response latencies greater than 12 seconds result in a score of 0 whether the response is accurate or not. Latencies of 9 – 12 seconds are scored 1, and each subsequent 1 second decrease in latency results in an incremental score of 1. Latencies of less than 4 seconds are scored 7. Because the SGA incorporates information from the ACC-2 and SPD scales, only ACC-1 (range = 0 to 32) and SGA (range = 0 to 224) are used as FET variables in this study.

Preliminary data on the reliability and the validity of the FET were obtained in a study of 174 children, including 138 children diagnosed with one of five psychological disorders (see Dyck et al., 2001). Reliability was observed to be .74 for the ACC-1 scale, .80 for the ACC-2, .82 for the SPD scale, and .85 for the SGA scale.

The two accuracy scales are strongly related to each other (r = .82), and are moderately related to other ERS and to measures of intelligence.

The Comprehension Test (CT) is an 11-item ordinal measure of the ability to understand the emotional consequences of exposure to a given emotion-eliciting context (e.g., Susan is given a new bicycle for her birthday. What will Susan feel?). CT items sample the 7 emotion categories represented in the FET, 'social variants' of the basic emotions (e.g., pride, embarrassment, shame, pity) and variations in the intensity of a basic emotion (e.g., terror versus fear). The emotion causes include 'material causes' of an emotion (e.g., loss/gain of an object), 'social causes' of an emotion (e.g., interpersonal rejection), and 'intrapsychic causes' of an emotion (e.g., failure to achieve one's goals). The CT is untimed. Answers are recorded on the test form and are scored on a 3-point (0, 1, 2) scale, allowing for a maximum score of 22. The test is discontinued if a subject makes 3 consecutive incorrect (0) answers. The CT has acceptable reliability (α = .64) and is moderately related to other ERS and to measures of intelligence (Dyck et al., 2001).

The Unexpected Outcomes Test (UOT) is a 12-item ordinal measure of a person's ability to apply reasoning skills and knowledge of the causes of emotions to explaining apparent incongruities between an emotion-eliciting context and the emotion elicited by the context. Like the CT, UOT items provide information about a situation that is likely to cause an emotional response by a protagonist (e.g., John finally persuades Susan to go to the movies with him). Unlike the CT, the UOT items indicate what emotion is experienced by the protagonist. In each case, however, the emotion is not an emotion that would usually be expected to occur in the situation (e.g., On the way to the movies, John can hardly contain his anger). The test-taker is asked to provide additional situational information that would make the apparent incongruity explicable. The UOT is an untimed task. Answers are recorded on the test booklet and are scored on a 3-point (0, 1, 2) scale, allowing for a maximum score of 24. The test is discontinued if the subject provides 3 consecutive incorrect answers. The UOT has adequate reliability (α = .73) and is moderately to strongly related to other ERS and to measures of intelligence (Dyck et al., 2001). Pilot-testing suggests that inter-rater reliability is high (kappa = .83).

The Emotion Vocabulary Test (EVT) is a 24-item ordinal test of a person's ability to define emotion words (e.g., what does the word "angry" mean?). Based on the recognition that emotion vocabulary represents a limit to an individual's performance on other ERS, the specific words chosen for inclusion in the EVT are taken from the words required for maximum performance (i.e., taken from the scoring keys) on the other ERS. The response format of the EVT is open-ended and, similar to the test administration procedure of standard individual intelligence tests, initial responses may be queried by the examiner in order to resolve ambiguities in the initial response. Responses are then scored on a 3-point scale: a score of 0 is given for an incorrect response, a score of 1 is given for a partially correct response, and a score of 2 is given for a satisfactory response (maximum = 48). The EVT is reliable (α = .82), is moderately related to other ERS, and is strongly related to other measures of vocabulary (Dyck et al., 2001).

The Vocal Cues Test (VCT) was designed to measure the ability to recognize vocal intonations specific to different categories of emotion. The VCT has two separate scales. The VCT-Real consists of 45 items in which different emotions are expressed using the same words, namely, "I can't believe it." The VCT-Unreal consists of 43 items in which different emotions are expressed using non-semantic content, either numerals, letters, or nonsense syllables. In both cases, the emotions sampled are identical to those used in the FET, namely, anger, contempt, disgust, fear, happiness, sadness, and surprise, in addition to neutral expressions. The items are approximately balanced for gender of the speaker and for emotion category. Each item is scored correct (1) when the emotion is accurately identified (the defined emotion or a close synonym) or incorrect (0). Item scores are summed for each scale to yield a total score for each scale.

In a pilot study based on an adult sample, coefficient alpha for the VCT-Real scale was .63 and for the VCT-Unreal scale was .74. Convergence between the VCT-Unreal and other ERS was moderate.

Changes to Standard Procedure

Different combinations of ERS were administered to the respective groups. Participants with NSI completed the three Wechsler scales and all ERS. HI participants completed the Wechsler scales and all ERS except the Vocal Cues Test. VI participants completed the Wechsler scales and all the ERS except the Fluid Emotions Test.

In several instances, test administration procedures had to be modified to make them appropriate for administration to children with a sensory impairment. Hearing-impaired children varied greatly in their ability to read and write, to lip read and speak, to use Auslan (Australian sign language), and to use signed English. In order to maximize test performance, test items were presented in whatever format best facilitated effective understanding. For example, on the Emotion Vocabulary Test, test words were presented on large print cue cards in addition to being mouthed and signed by the researcher.

Results

Before conducting our main analyses, we assessed whether the three emotion understanding tasks can be reliably scored. The responses to the Comprehension Test, Emotion Vocabulary Test, and Unexpected Outcomes Test for 30 children from each group were scored independently of each other by two raters. The results, reported in Table 1, show that agreement between raters is high in each case.

Insert Table 1 and Table 2 about here

Having observed that our matched samples differ significantly from each other in age, we assessed how strongly age is related to performance on the set of emotion recognition and understanding tasks in each of the three sensory impairment groups. The results, reported in Table 2, show that with a single exception, performance on all emotion recognition and understanding tasks is significantly, and usually moderately, related to age.

Differences Between HI and NSI Children/Adolescents: Main Sample

We tested whether HI children differ from NSI children in emotion recognition and understanding abilities by conducting a multivariate analysis of variance (MANOVA) in which the five ERS completed by both groups of children were the dependent variables. The results indicate that the two groups differ on the linear combination of ERS [$\Lambda = .750$, $F(5, 40) = 2.66$, $p < .05$] and on each of the ERS except the Emotion Vocabulary Test [CT: $F(1, 44) = 5.10$, $p < .05$; EVT: $F(1, 44) = 1.16$, ns; UOT: $F(1, 44) = 4.81$, $p < .05$; ACC1: $F(1, 44) = 7.40$, $p < .01$; SGA: $F(1, 44) = 8.43$, $p < .01$]. Table 3 reports the mean scores obtained by each group of children on each test, and shows that HI children achieved lower scores than NSI children.

We used the same procedure to test whether HI and NSI adolescents differ in emotion recognition and understanding ability. The results indicate that the two groups differ on the linear combination of ERS [$\Lambda = .527$, $F(5, 69) = 12.37$, $p < .001$] and on each ERS [CT: $F(1, 73) = 21.58$, $p < .001$; EVT: $F(1, 73) = 14.15$, $p < .001$; UOT: $F(1, 73) = 14.00$, $p < .001$; ACC1: $F(1, 73) = 9.10$, $p < .01$; SGA: $F(1, 73) = 45.53$, $p < .001$]. Table 4 reports the mean scores obtained by each group of adolescents on each test, and shows that HI adolescents achieved lower scores than NSI adolescents. Both children and adolescents with HI are delayed in acquiring emotion recognition and understanding abilities.

Insert Table 3 and Table 4 about here

Differences Between VI and NSI Children/Adolescents: Main Sample

We tested whether VI children differ from NSI children in emotion recognition and understanding abilities by conducting a MANOVA in which the five ERS completed by both groups of children were the dependent variables. The results (see Table 3 for group means) indicate that the two groups differ on the linear combination of ERS [$\Lambda = .608$, $F(5, 48) = 6.20$, $p < .001$], on both of the emotion recognition measures [VCTR: $F(1, 52) = 10.36$, $p < .01$; VCTU: $F(1, 52) = 10.07$, $p < .01$], but on only one of three emotion understanding tasks [CT: $F(1, 52) = 11.08$, $p < .01$; EVT: $F(1, 52) = 0.01$, ns; UOT: $F(1, 52) = 1.64$, ns]. We used the same procedure to test whether VI and NSI adolescents differ in emotion recognition and understanding ability. The results (see Table 4) indicate that the two groups differ on the linear combination of ERS [$\Lambda = .652$, $F(5, 54) = 5.75$, $p < .001$] and on the two emotion recognition scales [VCTR: $F(1, 58) = 7.71$, $p < .01$; VCTU: $F(1, 58) = 4.89$, $p < .05$], but do not differ on any measure of emotion understanding [CT: $F(1, 58) = 3.65$, ns; EVT: $F(1, 58) = 3.37$, ns; UOT: $F(1, 58) = 0.32$, ns]. Across childhood and adolescence, VI children are delayed in acquiring emotion recognition ability, but are not significantly delayed in acquiring emotion understanding.

Differences Between HI and VI Children/Adolescents: Main Sample

We tested whether HI children differ from VI children in emotion understanding abilities by conducting a MANOVA in which the three emotion understanding measures were the dependent variables. The results (see Table 3 for group means) indicate that the two groups do not differ on the linear combination of ERS [Λ = .934, $F(3, 36) = 0.85$, ns]. We used the same procedure to test whether HI and VI adolescents differ in emotion understanding ability. The results (see Table 4) indicate that the two groups differ on the linear combination of ERS [Λ = .653, $F(3, 47) = 8.32$, $p < .001$] and on two of the three emotion understanding scales [CT: $F(1, 49) = 3.91$, ns; EVT: $F(1, 49) = 19.71$, $p < .001$; UOT: $F(1, 49) = 14.41$, $p < .001$]. The emotion understanding ability of VI adolescents exceeds that of HI adolescents.

Covariation with Verbal Ability

Tables 3 and 4 suggest that children with HI or VI obtain lower scores than their NSI peers on measures of verbal ability (the Wechsler scales) and that these verbal ability deficits may be comparable to their deficits on emotion recognition and understanding tasks. We tested whether these differences in verbal ability are significant by conducting two MANOVAs, one for children and one for adolescents, in which the Wechsler scales were the dependent variables. For children, the result indicated that the groups differ significantly on the linear combination of Wechsler scales [Λ = .664, $F(6, 130) = 4.91$, $p < .001$]. Post hoc comparisons using the Bonferroni method indicated that children with HI or VI never differed significantly from each other. Children with HI obtained significantly lower scores than children with NSI on all three Wechsler scales, and children with VI obtained significantly lower scores than children with NSI on the Comprehension and Similarities scales. For adolescents, the result indicated that the groups differ significantly on the linear combination of Wechsler scales [Λ = .516, $F(6, 176) = 11.48$, $p < .001$]. Post hoc comparisons using the Bonferroni method indicated that adolescents with HI obtained significantly lower scores than adolescents with VI or NSI on each Wechsler scale. Adolescents with VI did not differ from adolescents with NSI on any Wechsler scale.

To control for these group differences in verbal ability, we repeated our main analyses with the children who had been group-matched for verbal ability. We tested whether HI children have disproportionate deficits in emotion recognition and understanding abilities by conducting a MANOVA comparing HI and NSI children; the five ERS completed by these children were the dependent variables. The results indicate a marginally significant effect [Λ = .812, $F(5, 51) = 2.38$, $p = .053$], but in this case, the result does not suggest a deficit for HI children. As Table 5 shows, the marginally significant multivariate result is due to the significantly higher scores of HI children on one emotion understanding task [EVT: $F(1, 55) = 5.75$, $p < .05$].

Insert Table 5 about here

We tested whether VI children have disproportionate deficits in emotion recognition and understanding abilities by conducting a MANOVA comparing VI and NSI children; the five ERS completed by these children were the dependent variables. The results indicate a significant effect [Λ = .473, $F(5, 54) = 12.03$, $p < .001$]. In this case (see Table 5), univariate analyses show that VI children obtain significantly higher scores than NSI children on an emotion understanding task [EVT: $F(1, 58)$ =

24.90, $p < .001$] and significantly lower scores than NSI children on an emotion recognition task [VCTR: F (1, 58) = 4.84, $p < .05$].

Finally, we tested whether VI children differ from HI children in emotion understanding abilities by conducting a MANOVA in which the three ERS completed by both groups were the dependent measures. The results indicate a marginally significant main effect for sensory impairment [Λ = .845, F(3, 45) = 2.75, p = .053], but, in univariate analyses, the two groups do not differ on any variable.

Discussion

Are Children With a Sensory Impairment Delayed in Acquiring Emotion Recognition and Understanding Abilities?

Our first aim was to assess whether HI or VI children and adolescents are delayed in acquiring emotion recognition and understanding abilities compared to sighted and hearing peers. Both groups are delayed, but the pervasiveness of the delay differs as a function of sensory disability. In HI children and adolescents, the delays are evident across emotion recognition and understanding tasks, but in VI children and adolescents, the delays are specific to the emotion recognition tasks. On emotion understanding tasks, the performance of VI adolescents does not differ from sighted and hearing peers and significantly exceeds the performance of HI adolescents.

Where delays in acquiring mind-reading abilities were observed, they were substantial. Although the absolute magnitude of differences between adolescents with and without a sensory disability may appear small, this merely reflects the fact that the ERS were designed to measure a large range of difficulty with the smallest number of items. For example, in unpublished data from a recent norming study (Dyck, Hay, Anderson et al., 2003), although the performance of 4-year-olds significantly exceeded the performance of 3-year-olds only on the ERS Emotion Vocabulary and

Comprehension tests, the performance of 5-year-olds significantly exceeded the performance of 4-year-olds on all ERS. The ERS are sensitive to differences between groups even at quite low levels of ability.

Comparison of Tables 3 and 4 shows that the achievement of HI adolescents (mean age = 15.28 years) on the set of emotion recognition and understanding tasks is approximately equal to that of NSI children (mean age = 8.77 years). The implied delay of six or so years is broadly consistent with what has been observed with other, younger, samples of HI children assessed with theory of mind tasks. In these studies, HI children aged 8.4 years (Peterson & Siegal, 1998), 9.4 years (Peterson & Siegal, 1999), 9.6 years (Steeds, Rowe, & Dowker, 1997), or 10.7 years (Peterson & Siegal, 1995) did not attain the standard typically achieved by NSI children aged 4 or 5 years. A six year delay is less marked than that observed by Russell et al. (1998), who found that some 40% of HI children aged 13 to 16 years failed theory of mind tasks that are typically passed by NSI children aged 4 to 5 years. Some researchers have not observed delays of this magnitude (Steeds et al., 1997) or any delay at all (Marsharck et al., 2000), but our findings support a conclusion that delay on mind-reading tasks is the rule, and tasks which do not reveal delay may measure circumscribed social cognitive abilities which the person is unable to generalize across contexts (Peterson, 2002).

Although their delays are less pervasive than those of HI children and adolescents, the specific delay of VI children and adolescents in acquiring emotion recognition ability may be as great as are the delays of HI children and adolescents in acquiring both emotion recognition and understanding abilities (compare Table 3 and Table 4). This result is consistent with the one other study of emotion recognition ability in VI children (Minter et al., 1992), and we now know that the initial delays in developing emotion recognition ability are also evident during adolescence. The fact that we did not observe delays in acquiring emotion understanding ability among VI children and adolescents may imply that initial delays in acquiring the social cognitive abilities measured by theory of mind tasks have been overcome. The VI children in the McAlpine and Moore (1995) study had a mean age of 6 years, and in Minter et al.'s (1998) study had a mean age of 6:11 years, about two years younger than in our sample of VI children. Consistent with our results, Peterson et al. (2000) showed that the marked theory of mind deficits of 6 year-old VI children are significantly lessened in 7:6 to 9:10 year-olds, and have disappeared in 11:3 to 12:10 year-olds.

Are Delays in Acquiring Mind-Reading Abilities Comparable to Delays in Acquiring Other Verbal Abilities?

Children with a severe sensory impairment are typically delayed in acquiring a range of abilities, including those language-dependent abilities measured by the Wechsler verbal scales. Our observation that VI and HI children underachieved on the set of Wechsler tests compared with NSI children is consistent with this well-established result. It is because this general pattern of underachievement exists that it is important to assess whether any given 'deficit' is greater than would be expected on the basis of the general pattern of underachievement. Only if a given deficit exceeds the baseline deficit can we infer that it is, in fact, a specific deficit.

In the case of HI children and adolescents, there was no evidence that underachievement on emotion recognition and understanding tasks exceeded underachievement on other verbal tasks. When compared with NSI children group-matched for verbal ability, the performance of HI children equalled or exceeded that of their hearing peers. This consistency in performance across different ability domains was not evident in previous research, mainly because HI and NSI children were matched on non-verbal measures of IQ rather than on verbal ability. Although matching on non-verbal IQ increased the likelihood that participants had equivalent general cognitive ability, it also entailed that HI children appeared to have a specific mind-reading delay rather than a generalized verbal ability delay which encompassed mind-reading ability. In one recent study in which the verbal ability of HI children was assessed, it appeared that differences between groups on theory of mind measures (e.g., between native and non-native signers) were comparable to differences between the same groups in receptive language ability (Jackson, 2001).

The pattern is different for VI children. Compared with verbal ability matched NSI children, VI children have a specific deficit in recognizing emotions from tones of voice modifying the meaning of semantic content. Consistent with the expectation of Peterson et al. (2000) and the previous findings of Minter et al. (1991), the emotion recognition ability of VI children is less than would be expected on the basis of their general verbal competence, and is markedly less than would be expected on the basis of their emotion vocabulary. The reason for this discrepancy is not clear. Peterson et al. (2000) argued that the fact of visual impairment precluded VI children from gaining access to important visual cues within conversations about internal mental and emotional states, and this lack of access resulted in delayed acquisition of a theory of mind. However, our results indicate that VI children are delayed in acquiring an ability that depends directly on their intact sense, the recognition of emotion vocalizations, and also indicate that this specific deficit has no affect on our set of emotion understanding tests.

How the inability of vision-impaired persons to perceive important visual cues in conversations affects their ability to recognize vocal emotion cues is an interesting puzzle. Given the reliance of vision-impaired persons on audition for information about the world, we might have expected that they would be especially good at making effective discriminations of vocal emotion cues. However, although vision-impaired children can clearly learn to enhance their ability to discriminate pitch and volume and their memory for sounds as a function of training (Izumiyama, 1957), if feedback from other sources (e.g., vision) is not available to reinforce correct responses, learning is not likely to occur. Alternatively, the reliance on auditory cues appears to result in precocious language development (relative to the development of their other abilities; Juurmaa, 1964; Wilson & Halverson, 1947) and a greater tendency to represent the world in terms of semantic structures (which differ from those of sighted people; Nelson & MacDonald, 1973). Although the hypothesis has not been tested, a vision-impaired person may attend preferentially to semantic content and be less attentive to tone of voice cues that modify the meaning of speech. Our finding that VI children achieved lower scores than verbal ability matched controls on the vocal cues task involving real words, but not 'unreal' words, is consistent with this hypothesis.

Differences Between HI and VI Adolescents in Verbal and Emotion Understanding Abilities

Differences in the pattern of achievement between children/adolescents with HI, VI, or NSI underscore the importance of Gray and Hosie's (1996) contention that the mind-reading abilities of persons with a sensory impairment need to be assessed with a range of measures. Our finding that VI persons have specific delays in emotion recognition, but not emotion understanding, ability indicates that these are distinct abilities: achievement in one domain need not be isomorphic with achievement in the other domain. This result is analogous to the observation that despite a strong association between theory of mind and emotion understanding abilities (e.g., Hughes

& Dunn, 2002), they appear also to be distinct components of social cognition (Cutting & Dunn, 1999; Dyck et al., 2001).

Emotion recognition and understanding abilities also have different relations to verbal ability. Whereas the emotion recognition ability of VI children/adolescents was less than expected on the basis of verbal ability, the performance of both HI and VI children on the emotion vocabulary test exceeded that of verbal ability matched NSI peers. This result has an important implication for our understanding of the "conversation hypothesis." If knowledge within a domain is a function of a child's opportunity to converse about the topic, then, compared with other topics, because children with a sensory impairment exceed their verbal ability matched peers in emotion vocabulary, they would appear to have had privileged access to conversations about emotional states. We have been unable to locate any research that directly addresses this question, but it may be the case that parents and educators of children with a sensory impairment spend a greater proportion of their total conversation time on the topic of internal psychological states than do the people who care for NSI children. One of the very few studies assessing differences in the parenting practices of persons with and without a hearing impaired child reported that the parents of HI children are more involved in their child's life (Brubaker & Szakowski, 2000). Involvement meant that these parents were more likely to "ask your child about his/her day in school, … ask your child what his/her plans are for the coming day, [and] … talk with your child about his/her friends" (Brubaker & Szakowski, 2000, p. 21). It is hard to conceive of these conversations not referring to the internal psychological states of the HI child and his/her peers.

Limitations and Conclusions

In most research on children with a sensory impairment, it is standard procedure to match children with and without an impairment on general intelligence. In research on children with HI, this is achieved by matching children's performance IQ, and in research on children with VI, this is achieved by matching children's verbal IQ. For research involving children with HI and children with VI, there is no single procedure that can be validly used to assess the general intelligence of all children. This means that in our research, we cannot exclude the possibility that group differences in intelligence, and not only group differences in verbal ability, account for apparent differences in emotion recognition or emotion understanding abilities. The issue is further complicated by the fact that among persons with VI, children, but not adolescents, achieve significantly lower verbal ability scores than do their sighted peers. If our samples are representative of VI children and adolescents, the Wechsler verbal scales may be less valid markers of verbal intelligence in VI children than they are of VI adolescents. Because our research is cross-sectional, our conclusions on this and other developmental hypotheses are speculative.

The emotion recognition and emotion understanding delays of HI children are pervasive and relatively severe, but they are broadly consistent with the delays that these children show in acquiring a range of language-mediated abilities. This consistency implies that HI children do not have a specific problem with mind-reading, and that the conversation hypothesis explains nothing additional to what is explained by delayed acquisition of language. If anything, HI children's acquisition of an emotion vocabulary appears to be less affected by delayed acquisition of language than are many other language-mediated abilities. Because we know that emotion understanding deficits are significantly lessened by targeted education programs (Dyck & Denver, in press), we have reason to hope that the social and behavioral problems of

HI children which may be mediated by delays in acquiring mind-reading ability will be alleviated by providing them with appropriate education about mental states.

Delays in acquiring mind-reading abilities are, in VI children, less pervasive than in HI children, but the ability to recognize emotional tones of voice does appear to constitute a specific and enduring ability deficit. There is no research indicating whether these emotion recognition deficits can be lessened as a function of education, nor is it clear from our research what mechanisms are responsible for the specific deficits of VI children and adolescents. What is clear is that these abilities increase with age, and this fact implies that these abilities may prove to be remediable as a function of relevant experience.

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Table 1

Inter-rater reliability (Pearson correlations) of emotion understanding tasks, by sensory impairment category

	CT	EVT	UOT
Hearing-Impaired (n = 30)	.80	.94	.87
Vision-Impaired (n = 30)	.91	.97	.84
No Impairment (n = 30)	.89	.93	.84
All Children (n = 90)	.84	.94	.85

CT = Comprehension Test, EVT = Emotion Vocabulary Test, UOT = Unexpected Outcomes Test

Table 2

Correlations between emotion recognition scales and age, by sensory impairment category

	CT	EVT	UOT	ACC-1	SGA	VCT-R	VCT-U
Hearing-Impaired	.46*	.48*	.43*	.53*	.33*		
Vision-Impaired	.62*	.72*	.67*			.39*	.62*
No Impairment	.54*	.64*	.44*	.16	.44*	.36*	.40*
All Children	.48*	.52*	.42*	.25*	.26*	.42*	.52*

* Significant at .01 level, two-tailed

Abbreviations: ACC-1 = Fluid Emotions Test Accuracy; SGA = Fluid Emotions Test Speed Given Accuracy; CT = Comprehension Test; UOT = Unexpected Outcomes Test; EVT = Emotion Vocabulary Test; VCT-R = Vocal Cues Test, Real Words; VCT-U = Vocal Cues Test, Unreal Words

Table 3

Means and Standard Deviations (in parentheses) by Sensory Impairment Category: Full Sample, Children

	Hearing-Impaired (n = 16)	Vision-Impaired (n = 24)	Not Impaired (n = 30)
Variable (Max Score)	Mean (sd)	Mean (sd)	Mean (sd)
ACC-1 (32)	14.44 (4.55)[a]		17.73 (3.54)[a]
SGA (224)	72.94 (25.88)[a]		96.53 (26.44)[a]
CT (11)	6.44 (2.68)	5.96 (2.07)[a]	8.97 (4.01)[a]
UOT (12)	2.25 (2.24)[a]	3.21 (3.31)	4.43 (3.62)[a]
EVT (24)	10.38 (6.13)[a]	12.88 (8.59)	12.63 (7.08)[a]
VCT-R (45)		13.71 (3.79)[a]	17.10 (3.89)[a]
VCT-U (43)		14.17 (4.44)[a]	17.50 (3.28)[a]
WInf (30)	9.44 (2.63)[a]	10.63 (4.74)	13.30 (4.58)[a]
WComp (36)	8.25 (4.68)[a]	10.67 (6.24)[b]	15.50 (5.15)[ab]
WSim (33)	6.38 (4.67)[a]	9.42 (4.95)[b]	15.03 (6.11)[ab]

Abbreviations: ACC-1 = Fluid Emotions Test Accuracy; SGA = Fluid Emotions Test Speed Given Accuracy; CT = Comprehension Test; UOT = Unexpected Outcomes Test; EVT = Emotion Vocabulary Test; VCT-R = Vocal Cues Test, Real Words; VCT-U = Vocal Cues Test, Unreal Words; Winf = Wechsler Information; WComp = Wechsler Comprehension; WSim = Wechsler Similarities.

* All scores are raw scores.

** Groups sharing a superscript differ significantly from each other.

Table 4

Means and Standard Deviations (in parentheses) by Sensory Impairment Category: Full Sample, Adolescents

	Hearing-Impaired (n = 33)	Vision-Impaired (n = 18)	Not Impaired (n = 42)
Variable (Max Score)	Mean (sd)	Mean (sd)	Mean (sd)
ACC-1 (32)	16.94 (2.88)[a]		18.83 (2.55)[a]
SGA (224)	82.52 (19.75)[a]		112.19 (18.22)[a]
CT (11)	8.85 (3.06)[a]	10.67 (3.27)	12.64 (3.82)[a]
UOT (12)	4.64 (3.49)[ab]	9.00 (4.63)[b]	8.26 (4.62)[a]
EVT (24)	15.42 (8.53)[ab]	26.56 (8.61)[b]	22.45 (7.62)[a]
VCT-R (45)		17.00 (4.43)[a]	19.57 (2.67)[a]
VCT-U (43)		18.94 (3.81)[a]	21.48 (4.16)[a]
WInf (30)	13.52 (4.54)[ab]	18.06 (3.57)[b]	19.74 (4.35)[a]
WComp (36)	16.09 (7.93)[ab]	22.33 (3.18)[b]	26.07 (4.73)[a]
WSim (33)	10.70 (7.03)[ab]	19.22 (4.39)[b]	21.74 (4.32)[a]

Abbreviations: ACC-1 = Fluid Emotions Test Accuracy; SGA = Fluid Emotions Test Speed Given Accuracy; CT = Comprehension Test; UOT = Unexpected Outcomes Test; EVT = Emotion Vocabulary Test; VCT-R = Vocal Cues Test, Real Words; VCT-U = Vocal Cues Test, Unreal Words; WInf = Wechsler Information; WComp = Wechsler Comprehension; WSim = Wechsler Similarities.

* All scores are raw scores

** Groups sharing a superscript differ significantly from each other.

Table 5

Means and Standard Deviations (in parentheses) by Sensory Impairment Category: Verbal Ability Matched Sample

	Hearing-Impaired (n = 23)	Vision-Impaired (n = 26)	Not Impaired (n = 34)
Variable (Max Score)	Mean (sd)	Mean (sd)	Mean (sd)
ACC-1 (32)	17.91 (2.42)		17.79 (2.92)
SGA (224)	88.35 (17.87)		95.59 (20.62)
CT (11)	8.78 (2.84)	8.19 (3.32)	8.91 (3.54)
UOT (12)	4.57 (3.30)	6.12 (4.38)	4.47 (3.76)
EVT (24)	17.52 (8.53)[a]	21.81 (7.58)[b]	12.76 (6.43)[ab]
VCT-R (45)		15.65 (4.33)[a]	17.97 (3.80)[a]
VCT-U (43)		16.77 (3.19)	18.15 (4.35)
WInf (30)	14.26 (3.74)	15.19 (4.06)	13.68 (4.01)
WComp (36)	17.52 (5.51)	18.50 (5.50)	17.00 (4.36)
WSim (33)	13.48 (3.50)	14.65 (4.24)	14.74 (4.32)

Abbreviations: ACC-1 = Fluid Emotions Test Accuracy; SGA = Fluid Emotions Test Speed Given Accuracy; CT = Comprehension Test; UOT = Unexpected Outcomes Test; EVT = Emotion Vocabulary Test; VCT-R = Vocal Cues Test, Real Words; VCT-U = Vocal Cues Test, Unreal Words; WInf = Wechsler Information; WComp = Wechsler Comprehension; WSim = Wechsler Similarities.

* All scores are raw scores.

** Groups sharing a superscript differ significantly from each other.