Social Functioning and Facial Expression Recognition in Survivors of Pediatric Brain Tumors*

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Objective  To assess social functioning and facial expression recognition skill in survivors of pediatric brain tumors (BT) as compared to children with juvenile rheumatoid arthritis (JRA).  Methods  The social functioning of 51 survivors of BT and 31 children with JRA was assessed using a facial expression recognition task, questionnaire ratings of social functioning, and an IQ screener.  Results  After controlling for estimated IQ, survivors of BT made significantly more errors interpreting adult facial expressions as compared to children with JRA. Additionally, history of therapy and diagnosis age predicted performance on the child portion of the facial recognition task. Finally, survivors of BT demonstrated significantly impaired social functioning across multiple measures when compared to children with JRA.  Conclusions  Survivors of pediatric BT showed significant deficits in social functioning as compared to an illness comparison group. Errors in facial expression recognition represent another method for evaluating deficits that contribute to social outcomes.

Key words  late effects; pediatric brain tumors; social functioning; survivorship.

With survival rates for most childhood cancers increasing markedly to >75% over the last few decades (American Cancer Society, 2007), the focus of medical professionals is starting to shift towards the “quality of survival.” As such, new treatment modalities are currently being tested that aim to reduce the significant late effects which go hand-in-hand with surviving childhood cancer, particularly those cancers that affect the central nervous system (CNS), such as brain tumors (BT). Survivors of pediatric BT are at high risk for a plethora of late effects, including those—such as neurocognitive and social deficits—that can have an extraordinary impact on quality of life (Mulhern & Palmer, 2003). The repercussions of these deficits can be far-reaching and may affect multiple aspects of a survivor’s life, with a notable proportion of survivors of pediatric BT never achieving the normal milestones of adulthood, including graduating from college and getting married (Maddrey et al., 2005; Zebrack et al., 2004). The precursors for attaining many of these milestones are related to the social functioning these adults experienced and displayed as children. Indeed, peer relationships are an integral part of a child’s development (Asher & Coie, 1990; Hartup, 1983; La Greca, Bearman, & Moore, 2004). Children spend the majority of their waking hours in school or other social settings and are constantly expected to interact with other children. Children who struggle with social functioning, and in turn, with peer interactions—those who are shy, withdrawn, lonely, or inhibited—may find it difficult to take part in the interactions that are an essential part of our social world. Moreover, other children may recognize these difficulties and shy away from these children, excluding them from conversations and not inviting them to play, or even teasing or bullying them. When children have difficulties with social functioning, they are at risk for a number of different adjustment problems, both currently and later in life (Brendgen, Vitaro, Turgeon, & Poulin, 2004).

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Effective social interaction requires split-second attention to and interpretation of complex and varied social cues including facial expressions, body language, and tone of voice. These nonverbal cues allow for a more complex interpretation of a social interaction that goes beyond what has been said aloud, to inform a greater appreciation of the implied meaning of the conversation. As such, these nonverbal social cues are an integral component of proficient social communication and interaction. Facial expressions, in particular, are one of the richest sources of nonverbal social information (Blair, 2003; Erickson & Schulkin, 2003). Indeed, facial expressions are critical for social reciprocity in that they both communicate information to a recipient and provide information back to the source (Ekman & Friesen, 1969; Fridlund, 1994; Lazarus, 1991). Therefore, errors in facial expression recognition and interpretation (e.g., such as mistaking a smile of polite interest for one of genuine enjoyment), can have a detrimental effect on the outcome of the social interaction.

Crick and Dodge’s (1994) Social Information Processing Model (SIP) provides an algorithm for how appropriate and effective social behavior is managed by children. The model posits that when a child is faced with a social situation in general, and a social cue in particular, there are six steps that he or she must take to accurately understand and react to the situation: (1) encoding of the cue; (2) representation and interpretation; (3) clarification; (4) response construction; (5) response selection; and (6) behavioral enactment. The first two steps—encoding and interpretation—are particularly important in terms of reactions to nonverbal social cues such as facial expressions. Indeed, during a social interaction, a child must be able to look at a person’s face, quickly encode and process the facial expression and subsequently make assumptions about the emotion and intent the person is feeling during the interaction. Errors at this level of processing can have negative repercussions for the subsequent steps in the model. Errors here, therefore, have the potential to result in a negative social interaction. As noted earlier, for example, a child may see a smile and mistakenly interpret it as one of genuine interest, rather than the intended emotion of polite attention. The ensuing reactions (Steps 3 through 6) to these two interpretations will be very different. Such errors may be one way of understanding the social problems that have been reported in survivors of pediatric BT (see Fuemmeler, Elkin, & Mullins, 2002, for a review). Indeed, studies have shown that children who have difficulty with the first two steps of the SIP model—in particular interpretation of facial expressions—are less accepted by their peers at all ages (Baum & Nowicki, 1998; Custrini & Feldman, 1989; Leppänen & Hietanen, 2001; Nowicki & Carton, 1997; Nowicki & Duke, 1992; Nowicki & Mitchell, 1998).

In order to test the aptitude of survivors of pediatric BT on the first two steps of the SIP model, the current study examined their ability to interpret out-of-context facial expressions. Out-of-context expressions will allow for the isolation of the specific nonverbal skill without the confounding elements of context and situation, which may obscure the assessment. To gain a more complete picture of their deficits, survivors of pediatric BT were compared to an illness comparison group, children with juvenile rheumatoid arthritis (JRA). Children with JRA generally do not exhibit social functioning deficits (Noll et al., 2000; Reiter-Purtill, Gerhardt, Vannatta, Passo, & Noll, 2003), nor do they exhibit cognitive deficits due to their treatment, unlike survivors of BT. Given these factors, our first hypothesis in the current study is that survivors of pediatric BT will show greater impairments on the facial expression recognition task than children with JRA. Furthermore, this difference will remain after controlling for expected differences in cognitive ability between the two groups. This is the first such study to evaluate social skills in survivors with this type of methodology, which may enable greater understanding of the mechanisms underlying social functioning deficits in this group.

Our second hypothesis is with regard to the assessment of potential medical predictors of facial expression recognition in survivors. Survivors of pediatric BT are known to have significant cognitive deficits associated with their disease and treatment (Mulher, Merchant, Gajjar, Reddick, & Kun, 2004). Specifically, survivors struggle with nonverbal abilities, including memory and attention, processing speed, and visual-spatial skills (Buono et al., 1998; Carey, Barakat, Foley, Gyato, & Phillips, 2001). As such, it is hypothesized that those medical factors that are known to be associated with diminished cognitive functioning in survivors—younger age at diagnosis, great number of years since diagnosis, treatment with cranial radiation therapy and shunted hydrocephalus (Reimers et al., 2003)—will be associated with performance on the facial expression recognition task. This hypothesis is further supported by the new field of social cognitive neuroscience, which has linked cognitive and social functioning with neural bases, by demonstrating that the brain regions associated with cognitive functioning overlap
with those related to social functioning (Ochsner, 2004; Yeates et al., 2007).

Finally, as noted earlier, it is well known that children who make errors on the first two steps of the SIP model—encoding and interpretation—and children who have deficits in facial expression recognition are at risk for a range of social problems (Baum & Nowicki, 1998; Custrini & Feldman, 1989; Leppänen & Hietanen, 2001; Nowicki & Carton, 1997; Nowicki & Duke, 1992). As such, our third hypothesis is that performance on the facial expression recognition task will be correlated with markers of social functioning. Specifically, fewer errors on the task will be associated with better social functioning.

Method

Procedures

Eligible participants and a parent/guardian were identified by the attending physician (pediatric neuro-oncologist, pediatric rheumatologist, or pediatric neuropsychologist) and approached by a research assistant at a regularly scheduled clinic visit. The study and rationale were explained to the parent/guardian and the patient, after which they completed consent and assent (children 12 years of age and older) procedures using methods approved by the medical center Institutional Review Board. The patient then completed an abbreviated IQ test, a task measuring nonverbal social skills, and a self-report measure of social functioning. The parent/guardian completed three measures of child emotional, behavioral, and social functioning. Demographic and treatment-related information was obtained by chart review. Participation in the study took ~30 min and was completed in its entirety during the clinic visit.

Participants

Survivors of Pediatric BT

All English-speaking survivors of pediatric BT between the ages of 6 and 17 who had been off all treatment and medically stable for at least 1 year, and who had normal or corrected to normal visual and auditory capabilities were eligible for participation. Approximately 75 survivors regularly seen in our off-therapy clinic met initial eligibility criteria. A convenience sample of 55 were approached and 51 (93%) agreed to participate in the study. Reasons given for not participating were lack of time (n = 3) and lack of interest (n = 1).

The final sample of 51 survivors (45.1% male) was 12.4 years of age (SD = 3.13) and 6.1 years (SD = 3.62) from diagnosis (Table I). Diagnoses were varied but the majority of the sample received neurosurgery (92.2%) with significant proportions receiving both chemotherapy and cranial radiation therapy (CRT). Consistent with the make-up of our medical center’s patient population, the majority of the sample was Caucasian. See Table I for all demographic and treatment-related information.

Table I. Participant Demographics by Diagnosis

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>N (%)</th>
<th>M ± SD</th>
<th>N (%)</th>
<th>M ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>23 (45.1)</td>
<td>8 (25.8)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>28 (54.9)</td>
<td>23 (74.2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Race</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Caucasian</td>
<td>43 (84.3)</td>
<td>28 (90.3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>African-American</td>
<td>6 (11.8)</td>
<td>3 (9.8)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other (e.g., Asian, Hispanic)</td>
<td>2 (4.0)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>12.4 ± 3.13</td>
<td>11.6 ± 2.84</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age at diagnosis</td>
<td>6.4 ± 3.68</td>
<td>6.8 ± 4.34</td>
<td></td>
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</tr>
<tr>
<td>Years since diagnosis</td>
<td>6.1 ± 3.62</td>
<td>4.3 ± 3.46</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diagnosis</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brain tumor</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medulloblastoma</td>
<td>12 (23.5)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ependymoma</td>
<td>12 (23.5)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Pilocytic astrocytoma</td>
<td>10 (19.6)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>17 (33.4)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>JRA</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pauciarticular</td>
<td>11 (35.5)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Polyarticular</td>
<td>12 (38.7)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other (e.g., Psoriatic, systemic)</td>
<td>8 (25.8)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Tumor location</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Posterior fossa</td>
<td>26 (51.0)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Third ventricle</td>
<td>17 (33.3)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cerebral hemisphere</td>
<td>8 (15.7)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>VP-Shunt</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Yes</td>
<td>16 (31.4)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>35 (68.6)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Treatment history</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surgery</td>
<td>47 (92.2)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cranial Radiation</td>
<td>34 (66.7)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chemotherapy</td>
<td>34 (66.7)</td>
<td></td>
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</tbody>
</table>

There were no significant differences between groups except for time since diagnosis (t = 2.18, p < 0.05).

Children with JRA

All English-speaking children diagnosed with all forms of JRA, between the ages of 6 and 17 were eligible for participation in the study. Approximately 120 children with JRA were seen in the clinic during our data collection period. A convenience sample of 38 eligible participants were approached and 31 (82%) agreed to participate in the
study. Reasons given for not participating were lack of time ($n = 5$) and lack of interest ($n = 2$).

The final sample of 31 (74.2% female) was 11.6 years of age ($SD = 2.84$) and 4.3 years from diagnosis ($SD = 3.46$). See Table I for all demographic information.

**Group Differences**

A series of $t$-tests and chi-squared analyses were performed to test for differences in the demographic and medical variables of the two groups. The only difference to reach significance was years since diagnosis, with survivors of pediatric BT further from diagnosis than children with JRA ($t = 2.18$, $p < .05$).

The sample of 81 participants was associated with a power of at least .8 to detect group differences at a .05 level, as calculated using the medium effect-sizes obtained from the only prior published study using this measure with children with chronic illnesses (e.g., sickle cell disease; Boni, Brown, Davis, Hsu, & Hopkins, 2001).

**Measures**

**Diagnostic Analysis of Nonverbal Accuracy—Revised (DANVA2)**

The DANVA2 (Baum & Nowicki, 1998) is a 48-item measure of facial expression recognition. It contains photographs of both adult and child, male and female actors who were either read or asked to read a vignette and then asked to respond with the appropriate high- or low-intensity facial expression. It contains 24 photographs of adult faces and 24 photographs of child faces. Participants are asked to look at each picture and give the correct facial expression from four choices—happy, sad, angry, or fearful. Scoring is done separately for the adult faces and child faces subtests, with scores based on the number of errors the participant makes. The number of errors for each subtest was then converted to age-controlled $z$-scores, using norms available in the DANVA2 Manual (Nowicki, 2006). For the adult faces subtest, reported levels of internal consistency as measured by coefficient $\alpha$ ranged from .64 to .77, while test–retest reliability has been
reported at $r = .84$ (Nowicki & Carton, 1993). For the child faces subtest, internal consistency had a coefficient $\alpha$ of .76, while test–retest reliability was reported at $r = .74$ (Nowicki & Carton, 1993). For the current study, Cronbach’s $\alpha$’s were .70 for the Adult Faces test and .82 for the Child Faces test.

**Child Behavior Checklist (CBCL)**

The CBCL (Achenbach, 1991) is a widely used parent-completed measure of the psychosocial functioning of children aged 4–18. Parents respond to a number of open-ended and forced-choice questions describing their child’s social, academic, behavioral, and emotional functioning across home and school domains. Competence scales are calculated for children’s performance in school, social, and academic domains, and clinical scales are computed for several areas of problem functioning. Parents completed this measure and the internalizing, externalizing, and social problems subscales were used for this study. The Cronbach’s $\alpha$ for the social problems scale was .79.

**Social Skills Rating System (SSRS)**

The SSRS (Gresham & Elliott, 1990) is a 30-item questionnaire completed separately by parents, teachers, and students that assesses social responsibility, prosocial skills, and problem behaviors in children in kindergarten through 12th grade. Versions are available for grades K—6 (3–6 for self-report) and 7–12. The age-appropriate SSRS Parent Report and Self Report scales were used in the current study and Cronbach’s $\alpha$’s ranged from .82 to .93.

**Emory Dyssemia Index (EDI)**

The EDI (Love, Nowicki, & Duke, 1994) is a 42-item questionnaire completed by teachers and parents as a measure of expressive and receptive nonverbal difficulties. “Dyssemias” are broadly defined by the authors as deficits in the accurate and effective use of nonverbal language (Nowicki & Duke, 1994). Items on the scale reflect this definition and are rated for frequency of occurrence on a Likert scale ranging from “never” to “very often.” Scoring consists of a total EDI score as well as scores for the subscales of: gaze and eye contact, space and touch, facial expressions, paralanguage, objectics, social rules and norms, and nonverbal receptivity. Originally validated by teachers of third through fifth grade students, and consistently used clinically with parents, it has a test–retest reliability of .86 for the total score. The Cronbach’s $\alpha$ for the current sample was .97. Parents were asked to complete this measure as an index of nonverbal social behaviors so as to supplement the information obtained from the SSRS.

**Wechsler Intelligence Scale for Children—3rd edition (WISC-III)**

The Wechsler scales are the most commonly used standardized intelligence tests for children and adults. The WISC-III (Wechsler, 1991) contains 13 subtests for which raw scores are converted to age-based scaled scores, which allows for realistic comparison across a wide age range (such as the one seen in this study). For the current study, a shortened version of the WISC-III comprised of three subtests—Information, Similarities, and Block Design—were used. A formula developed by Sattler (1992) yields an estimated IQ score that is highly correlated ($r = .93$) with the Full-Scale IQ given by administration of the complete test.

**Analytic Plan**

**Preliminary Analyses**

Descriptive statistics were computed for all variables of interest prior to analysis of study hypotheses, and examined to confirm adequate variability and distribution of scores. In addition, a series of preliminary analyses were performed to determine whether there were group differences in cognitive functioning and social functioning as reported on the questionnaire measures. These analyses included a series of independent sample $t$-tests to assess group differences in IQ, and analyses of covariance to assess for group differences in social functioning. To conserve power, multivariate analysis of covariance (MANCOVAs) were used to analyze group differences on measures with multiple outcome variables (e.g., SSRS parent report and CBCL) and ANCOVAs for measures with just one outcome variable (e.g., EDI).

**Hypothesis Testing**

Given that children’s facial recognition ability increases with age in typically developing children, raw score errors on the DANVA2 were converted to age-normed $z$-scores using norms from the DANVA2 manual (Nowicki, 2006). For the first hypothesis, two analyses of variance were performed, with diagnosis (BT vs. JRA) serving as the predictor of errors in adult and child facial expression recognition on the DANVA2. In addition, given the significant difference between the two groups on cognitive ability, a second set of analyses were completed in which estimated IQ served as a covariate to determine whether significant group differences would remain when controlling for IQ.
For the second hypothesis, regarding the association of medical parameters with facial expression recognition skill in survivors of pediatric BT, two hierarchical regression analyses were performed with the survivor group. Block 1 included estimated IQ as a predictor. Block 2 included known medical risk factors of cognitive late effects in survivors—age at diagnosis, years since diagnosis, history of cranial radiation therapy, and shunted hydrocephalus (Reimers et al., 2003)—as predictors. Outcomes were age-controlled z-scores of adult and child errors on the DANVA2. Finally, to assess the third hypothesis, a series of correlations were performed between facial expression recognition skill and markers of social functioning for the entire group of participants. In addition, partial correlations controlling for estimated IQ were also computed for the social functioning outcomes. Given the large number of correlations computed in each set (e.g., 7), we employed Hochberg’s (1988) modified Bonferroni technique to control for family-wise error rate.

Results

Preliminary Analyses

As noted earlier, the groups were comparable with regard to demographic variables; however, there were a number of group differences on study measures. Specifically, estimated IQ scores for the JRA group were significantly higher than those of the BT group (t = –4.14, p < .001). In addition, parents rated survivors of pediatric BT as exhibiting significantly more problem behaviors on the SSRS [F(1, 75) = 4.42, p < .05], more deficits in the use of nonverbal social behaviors as rated by the EDI [F(1, 77) = 5.86, p < .05], and more social problems [F(1, 75) = 25.44, p < .001] and internalizing behaviors on the CBCL [F(1, 75) = 5.20, p < .05]. These differences were present even when controlling for estimated IQ.

In contrast, there were no differences in self-reported social functioning on the SSRS (Table II).

Hypothesis 1: Group Comparisons

As expected, significant group differences were found for both adult and child facial recognition scores [F(1, 79) = 24.6, p < .001; partial $\eta^2 = .24$ for adult faces; F(1, 79) = 11.9, p < .001; partial $\eta^2 = .14$ for child faces]. After controlling for IQ, however, diagnosis was a significant predictor of facial expression recognition skill for adult faces only [F(1, 78) = 11.49, p = .001; partial $\eta^2 = .13$; Table II]. That is, survivors of pediatric BT made significantly more errors interpreting adult facial expressions than children with JRA, after controlling for estimated IQ. In contrast, when controlling for IQ with child facial recognition scores, there was only a trend for differences in errors according to diagnostic group [F(1, 78) = 3.17, p = .08; partial $\eta^2 = .04$]. Again, children with a history of BT made more errors than children with JRA. Of note, the main effect of IQ appeared robust for both child faces [F(1, 78) = 14.38, p < .001] and for adult faces [F(1, 78) = 10.56, p < .001].

Hypothesis 2: Medical Predictors of Facial Recognition Errors in Survivors of BT

In order to examine possible medical predictors of facial expression recognition deficits in survivors of pediatric BT, two hierarchical regression analyses were conducted. While the set of medical parameters did account for a small proportion of the variance in error scores (Table III), no individual predictor reached statistical significance. It should be noted, however, that there was a trend for the impact of history of cranial radiation therapy (β = –0.31, p = .053) and age at diagnosis (β = 0.37, p = .059) for errors on the child faces subtest (Table III). Specifically, children who received radiation therapy and who were younger at diagnosis made more errors on the child facial expression recognition task.

Table III. Hierarchical Regression Analyses Predicting Facial Expression Recognition Skill from Medical Risk Factors

<table>
<thead>
<tr>
<th></th>
<th>Adult error z-scores</th>
<th>Child error z-scores</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Std β* SE t F $\Delta R^2$</td>
<td>Std β* SE t F $\Delta R^2$</td>
</tr>
<tr>
<td>Block 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Estimated IQ</td>
<td>.37 .01 2.71** 0.14</td>
<td>.39 .01 2.86** 0.15</td>
</tr>
<tr>
<td>Block 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age at diagnosis</td>
<td>–0.23 .07 –1.01</td>
<td>–0.37 .08 1.94+</td>
</tr>
<tr>
<td>Years since diagnosis</td>
<td>–0.08 .07 –0.38</td>
<td>.12 .08 0.65</td>
</tr>
<tr>
<td>Cranial radiation therapy</td>
<td>.09 .44 .56</td>
<td>–0.31 .51 –1.99+</td>
</tr>
<tr>
<td>VP-shunt</td>
<td>–1.13 .38 –0.95</td>
<td>–0.22 .44 –1.58</td>
</tr>
</tbody>
</table>

*Regression weights at entry into the model.

* $p < .06$; ** $p < .05$; *** $p < .01$. 

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Table IV. Correlations between Facial Expression Recognition Skill and Measures of Social Functioning (SSRS, EDI, CBCL)

<table>
<thead>
<tr>
<th></th>
<th>Adult error z-score</th>
<th>Child error z-score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Partial correlation</td>
<td>Correlation*</td>
</tr>
<tr>
<td>Social skills rating system</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parent-report</td>
<td>0.32****</td>
<td>0.10</td>
</tr>
<tr>
<td>Problem behaviors</td>
<td>−0.42*</td>
<td>−0.26</td>
</tr>
<tr>
<td>Self-report</td>
<td>0.09</td>
<td>−0.12</td>
</tr>
<tr>
<td>Child behavior checklist</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Social problems</td>
<td>−0.39**</td>
<td>−0.28*</td>
</tr>
<tr>
<td>Internalizing behaviors</td>
<td>−0.33***</td>
<td>−0.21</td>
</tr>
<tr>
<td>Externalizing behaviors</td>
<td>−0.17</td>
<td>−0.09</td>
</tr>
<tr>
<td>Emory dyssemia index</td>
<td>−0.27</td>
<td>−0.09</td>
</tr>
</tbody>
</table>

*Criterion p = .05; **Criterion p = .025; ***Criterion p = .017, ****Criterion p = .005.

*Controlling for estimated IQ.

**Hypothesis 3: Associations between Facial Recognition Scores and Ratings of Social Functioning**

As noted earlier, correlations were computed to examine the association between facial recognition scores and parent and self ratings of participants’ social functioning. Additionally, given the large number of correlations computed, Hochberg’s modified Bonferroni correction was employed in each set of analyses to control for family-wise error rate. Without controlling for estimated IQ, many social functioning variables were significantly correlated with facial recognition scores in the expected direction (i.e., more errors were associated with poorer reported social functioning; Table IV). However, when controlling for IQ, many fewer significant results were found. Specifically, significant correlations were found between social functioning as measured by the CBCL Social Problems subscale and errors made on both child ($r = −0.25$, $p < .05$) and adult faces ($r = −0.28$, $p < .05$), such that greater numbers of errors in facial expression recognition were associated with greater parent-reported social problems. No other partial correlations reached significance (Table IV).

**Discussion**

The current study assessed the facial expression recognition ability and social functioning of survivors of pediatric BT as compared to children with JRA. As hypothesized, survivors made significantly more errors when interpreting out-of-context facial expressions than children with JRA. For adult faces, diagnosis remained a significant predictor after controlling for variability between groups on estimated IQ. Consistent with known risk factors of cognitive deficits in the survivor population, there was a trend for history of radiation therapy and younger age at diagnosis to predict poorer performance in the recognition of emotion in child faces. Additionally, survivors of pediatric BT also evidenced significant deficits on parent- and child-completed measures of social functioning as compared to children with JRA and parent-reported social problems were associated with increased errors in perceiving both adult and child faces. Facial expression recognition represents a combination of the first two steps (i.e., encoding and interpretation) of Crick and Dodge’s (1994) SIP model. The actual behavior that results from this information represents the sixth and final step of this model (i.e., behavioral enactment). Although this preliminary study did not attempt to evaluate and operationalize all of the steps of this model, we do provide some evidence of the impact of errors at steps 1 and 2 on the final stage, behavioral enactment. Specifically, social functioning and facial recognition skills were strongly correlated. After controlling for estimated IQ, however, these associations were less robust. However, a significant association between parent-reported social problems and errors in facial expression recognition did remain.

Surprisingly, we did not find additional associations between questionnaire ratings and facial expression recognition, independent of estimated IQ. It is possible that such questionnaire-based measures do not adequately capture the nature and range of social outcomes in this patient population. Indeed, the parent- and child-completed measures used in this study were originally developed to be sensitive and specific to aspects of social functioning related to psychiatric illness (e.g., aggression, social anxiety). As such, they tend to focus on maladaptive behavioral outcomes (e.g., getting teased, threatening, or bullying others). Review of the extant literature reveals that survivors of childhood cancer tend to look relatively “average” on these standardized scales (Patenaud & Kupst, 2005), and that survivors and their parents tend to overestimate quality of life (of which social functioning is an index) on such measures (O’Leary, Diller, & Recklitis, 2007). Given the significant deficits revealed by the DANVA2 in this study, it is necessary to look to other methods to adequately understand social impairments in this population.

Furthermore, there likely are other critical factors that were not assessed in this study that account for the difference in facial expression recognition skill between survivors of BT and children with JRA. One such factor is...
attentional processes. Significant impairments in attention have been implicated in the cognitive deficits often seen in this population (Mulhern, Merchant et al., 2004; Mulhern & Palmer, 2003). As such, recent studies have investigated the impact of stimulant medications on attentional processes in survivors (see Daly & Brown, 2007, for a review). The largest trial to date found that methylphenidate (i.e., Ritalin) not only affected attentional processes, but was also correlated with improvements in parent- and teacher-reported social functioning (Mulhern, Khan et al., 2004). Other reports also have found an association between attention dysfunction and social problems in survivors (Patel, Lai-Yates, Anderson, & Katz, 2007). Investigations also have explored the facial expression recognition ability of children with attention-deficit hyperactivity disorder (ADHD). Not only do many of these children have difficulties with peer interaction (see Hoza, 2007, for a review), they also show impairments in emotion recognition for faces (Cadesky, Mota, & Schachar, 2000; Pelc, Korneich, Foisy, & Dan, 2006). Such findings underscore the likelihood that the nature and range of social functioning impairments in survivors of pediatric BT are related, at least in part, to the global processes that affect their everyday cognitive functioning (e.g., attention, working memory, and processing speed).

One notable finding of the current study is the lack of differences between groups in contrast to the within-group variability found in the performance of survivors on the Child Faces subtest of the DANVA2. Indeed, while there were no significant differences between survivors and children with JRA on this portion of the task, certain medical variables (history of cranial radiation therapy and age at diagnosis) did predict performance, albeit not significantly, for survivors of pediatric BT. This is particularly important given that children spend a significant portion of their time with peers; it is where they learn, practice, and perfect new social skills. It may be acceptable that survivors cannot interpret adult facial expressions; adults will likely be forgiving of social missteps made by survivors. In contrast, the peer group adheres to very strict rules by which all participants are expected to abide. A child who cannot follow these rules, for whatever reason, is more likely to be rejected or neglected by the peer group (see Asher & McDonald, in press, for a review). This potential consequence of facial expression recognition deficits also points to the necessity of obtaining peer ratings of survivors’ social functioning; a task that has not, as of yet, been consistently accomplished. Indeed, at this time, only one peer ratings study has been completed with survivors of pediatric BT (Vannatta, Gartstein, Short, & Noll, 1998). However, this study assessed 28 children in 28 schools, and as such, it is not a method that would be feasible or practical to use on a consistent basis.

The current study has several limitations. First, while the DANVA2 has been used successfully in both the medical and the healthy child literature (Boni et al., 2001; McClure & Nowicki, 2001), it is not a standardized measure. Because photographs of actors are used, it is not possible to ensure uniform intensity of emotional expression. Indeed, the child faces in particular appeared to be more intense in their depiction of emotions and this could account for the lack of differences between survivors and children with JRA. Therefore, while the DANVA2 is an important tool, the development of a measure that uses realistic, digital facial expressions that can be both standardized and manipulated to reflect subtle differences in intensity will be critical to the further understanding of facial expression recognition deficits in this population.

A second limitation is the lack of a comparison group consisting of children without a chronic illness. However, because we wanted to be sure that any effects could not be directly attributable to the effect of having a chronic illness we felt that a medical comparison group was an important first step.

Future work in facial expression recognition and social functioning with survivors will need to include comparison groups without illness who are matched for age, sex, and race. Additionally, given the limitations of static photographic images, new tools need to be developed to more reliably assess facial expression recognition. This will enable researchers to further explore potential underlying mechanisms to explain the social outcomes of survivors of pediatric BT, including important relations between cognitive and social processes, both at the structural and functional levels. Specifically, in children, a primary aim is to integrate understanding of children’s social development with that of brain structure and function (Yeates et al., 2007). In this case, social cognitive neuroscience has been particularly useful for the study of facial expression recognition. Through the use of imaging techniques such as functional magnetic resonance imaging (fMRI), several areas of the brain, most prominently the amygdala and the frontal lobes, have been implicated for their associations with the processing of emotional facial expressions (Shaw et al., 2005). These techniques have most often been applied to typically developing children, adolescents and adults, to adults who have lesions in particular places (most often the amygdala), and to nonhuman primates. However, this approach has not yet been applied to survivors of pediatric BT.
While many studies have sought to determine the neuro-anatomical corollaries of severe cognitive deficits in survivors (e.g., damage to white matter; Reddick et al., 2003), similar studies have not been carried out to examine survivors’ social deficits. Given that there is so little known about these connections in survivors, specific hypotheses cannot yet be made about the location of damage associated with these deficits in facial expression recognition and ultimately social functioning, as well. However, there is a strong theoretical and research-based rationale for the influence of either the amygdala or the frontal lobes, on the basis of numerous studies completed with other populations (see Adolphs, 1999 for a review), and for the impact of white matter from studies completed with survivors (Reddick et al., 2003). Future studies will seek to determine the exact relationship between deficits in social functioning and neuro-anatomical structures in survivors.

The current study represents an important first step in identifying both theoretical and empirical relationships between social functioning and facial expression recognition skills in the growing population of survivors of pediatric BT. Indeed, the understanding and processing of facial expression recognition has not been studied before in survivors but is an important area of social information processing that may relate to relevant social outcomes and known cognitive deficits in this population, above and beyond the influence of IQ. Moreover, as tools with greater specificity for measuring social outcomes are developed, intervention targets can be identified and implemented so as to improve social functioning and quality of life in this unique and growing group of survivors.

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