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Friendships in Pediatric Brain Tumor Survivors and Non-Central Nervous System Tumor Survivors

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Abstract

Objective   Brain tumors during childhood may disrupt the development and maintenance of friendships due to the impact of disease- and treatment-related factors on functioning. The goal of this study was to determine if children treated for either a brain tumor or a non-central nervous system (CNS) solid tumor could name a friend and to evaluate the social information processes associated with the ability to name a friend. **Method**   Youth (ages 7–14) treated for either a brain tumor ($n = 47$; mean age = 10.51 years) or a non-CNS solid tumor ($n = 34$; mean age = 11.29) completed an assessment within 6 months of the conclusion of treatment that included asking participants to name a friend and completing measures of social information processing (SIP). Rates of self-reported friendship were compared between groups and correlates of being able to name a friend were evaluated. **Results**   Youth treated for a brain tumor (61.7%) were significantly less likely to name a friend compared with youth treated for a non-CNS solid tumor (85.3%). Diagnosis type (brain vs. non-CNS), relapse status, attribution style, and facial affect recognition were significant predictors of being able to name a friend or not in a logistic regression model. **Conclusions**   Youth treated for a brain tumor and those who experienced a disease relapse are at risk for impairments in friendships; difficulties with SIP may increase this risk. Targeted screening and intervention efforts for children diagnosed with brain tumors and those who have relapsed could address difficulties with peers.

Key words: brain tumor; friendships; pediatric cancer; social cognition; social competence.

Introduction

Developing and maintaining friendships is an important and normative task of development (Rubin, Bukowski, & Parker, 2006). Within the developmental literature, friendship is defined as a close, voluntary, and reciprocated relationship between two individuals (Rubin et al., 2006). While most children are able to identify a mutual friendship, approximately 15–20% do not have any mutual friends (Parker & Asher, 1993; Salmivalli & Isaacs, 2005) and remain friendless over time (Parker & Seal, 1996). Such challenges with friendlessness confer significant risk for both concurrent and later negative psychosocial outcomes, including increased internalizing symptoms (Ladd & Troop-Gordon, 2003), risky behaviors (Lansford, Dodge, Fontaine, Bates, & Pettit, 2014), and suicidality (Prinstein & Aikins, 2004).

Self-reported (i.e., not necessarily mutual) friendships also have importance, as feelings about these perceived relationships greatly influence psychological adjustment (Kiesner, Cadinu, Poulin, & Bucci, 2002) and risky behavior (Aloise-Young, Graham, & Hansen, 1994).

Understanding the nature of friendships and peer relationships among youth with brain tumors has increased in importance due to advances in 5-year survival rates (Noone et al., 2018). Diagnosis and treatment of a brain tumor during youth may disrupt the ability to form and maintain friendships due to reduced and altered interactions with peers because of physical and cognitive limitations. Recent psychosocial standards for care in pediatric cancer identified the need to promote social interaction (Christiansen et al., 2015) given the aforementioned barriers to socialization. In addition, pediatric brain tumor survivors (PBTS) who are more connected to friends may have better social competence (Willard, Russell, Long, & Phipps, 2019).

Compared with youth treated for cancer outside the central nervous system (CNS), PBTS are at risk for fewer friendships that persist into young adulthood (Schulte et al., 2018) due to neurodevelopmental late effects. Children with a cancer outside of the CNS undergoing chemotherapy have similar rates of reciprocated friendships during (Noll et al., 1999) and after treatment ends (Reiter-Purtill, Vannatta, Gerhardt, Correll, & Noll, 2003). However, PBTS have significantly fewer friendships and tend to be described as more isolated than their peers (Barrera, Shaw, Speechley, Maunsell, & Pogany, 2005; Desjardins et al., 2019; Salley et al., 2015; Vannatta, Gartstein, Short, & Noll, 1998). In a recent study from the Childhood Cancer Survivor Study, adolescent PBTS were more likely to have 0 friends compared with non-CNS solid tumor survivors and sibling comparison groups (Schulte et al., 2018). However, among PBTS there are little data on the status and predictors of their friendships during the early stages of survivorship. Understanding friendships of PBTS shortly after the conclusion of tumor-directed therapies is needed in order to guide efforts to enhance peer relationships in this at-risk group.

A model of social competence in children with brain disorder (Yeates et al., 2007) has direct applicability to the social difficulties of PBTS (Hocking et al., 2015) and can inform research on survivor friendships. The model suggests that social information processing (SIP) abilities influence how an individual interacts with peers, which in turn influences how peers perceive that individual and whether or not that individual has friends. SIP abilities encompass cognitive-executive functions and the interpretation of other social information, including facial expressions and others' behavior and intentions (Yeates et al., 2007). Evaluating survivor SIP abilities could elucidate potential mechanisms for friendship outcomes and inform interventions.

Research with other neurodevelopmental groups with known social deficits, such as youth with autism spectrum disorder (ASD) or traumatic brain injury (TBI), suggests that facial affect recognition (Wolf et al., 2008), attributions of others' behavior (Walz, Yeates, Wade, & Mark, 2009), and theory of mind (ToM; i.e., understanding others' thoughts/intentions; Deighton et al., 2019; Dennis et al., 2012) are important SIP processes that influence social relationships. Notably, ToM abilities have been shown to mediate the association between TBI severity and peer relationships (Deighton et al., 2019). While there is some evidence of impaired facial affect recognition abilities in PBTS (Bonner et al., 2008), SIP abilities and their associations to social outcomes in PBTS have been largely unexplored.

The primary objective of this study was to compare the rates of self-reported friendships in children, ages 7–14, treated for either a brain tumor or a non-CNS solid tumor within 6 months of the completion of tumor-directed therapies. A secondary objective of this study was to determine SIP domains associated with survivors identifying a friend or not and whether or not these associations were moderated by diagnostic group. The current study presents baseline data from a longitudinal study to prospectively evaluate social competence in PBTS and non-CNS solid tumors after the completion of therapy. School-age survivors were targeted to better understand social adjustment outcomes of survivors in school and minimize the heterogeneity of daytime placements in younger children. The immediate period after tumor-directed therapy is a critical period when neurodevelopmental sequelae of treatment are emerging and factors affecting later social adjustment outcomes can be identified. It was hypothesized that PBTS would have lower rates of self-reported friendships and that facial affect recognition, attribution responses, and ToM abilities would account for the presence or absence of a self-reported friendship over and above cognitive and demographic factors.

Methods

Participants

Participants were English-speaking youth between ages 7 and 14 at the time of enrollment who had completed any combination of tumor-directed therapy (surgery, chemotherapy, and/or radiation therapy) for either a brain tumor ($n = 47$) or a non-CNS solid tumor ($n = 34$) within the past 6 months. Exclusion criteria included (a) a multi-system genetic condition

that affects cognitive functioning (e.g., Trisomy 21, neurofibromatosis type 1); or (b) cognitive or developmental delay prior to tumor diagnosis. Survivors of a non-CNS solid tumor who received treatments affecting the CNS (e.g., total body irradiation) were also excluded.

One hundred twenty-seven families were approached about the study ($n = 72$ PBTS, 55 non-CNS solid tumor survivors) and 83 (65.3%; $n = 49$ PBTS, 34 non-CNS solid tumor survivors) agreed to participate. Reasons for not participating included lack of interest ($n = 22$), passive refusal ($n = 15$), and being too busy to participate ($n = 7$). Two PBTS participants were unable to complete study procedures after enrolling due to language barriers, resulting in a total sample of 81 (Table I). There were no differences in demographic or medical characteristics between consenting and non-consenting participants.

Procedures
The current data are from the baseline time point of a longitudinal study conducted at a large, urban pediatric medical center. All procedures were approved by our institutional review board and written informed consent (and child assent) was obtained before enrollment. Baseline visits occurred within 6 months after completing tumor-directed treatment ($M = 3.39$ months, $SD = 1.78$ months, range 2 weeks to 6.9 months). Potentially eligible participants were identified through tumor registry records and through cooperation with the medical teams. Study staff contacted all potential participants as they became eligible via letter, phone and in person during clinic visits. Participants completed a brief assessment of aspects of SIP (described below) in a room separate from their parents. Each participant also was asked to "name one of your closest friends" in order to complete aspects of the study not described here. Participants who identified a family member (e.g., cousin) as a friend were asked to identify a friend who was unrelated to them. When a child was unable to identify a friend, this was brought to the attention of their parent who attended the study visit to confirm the child's response—they had no close friends. Self-reported friendships have been used frequently in peer relations research (e.g., Aloise-Young et al., 1994; Kiesner et al., 2002; Laird, Pettit, Dodge, & Bates, 1999). They have demonstrated reliability (Cairns, Leung, Buchanan, & Cairns, 1995; Laird et al., 1999) and evidence of validity with multi-informant approaches (Bowker, 2004; Rodkin & Ahn, 2009). Relevant medical information (e.g., diagnosis, treatments, relapse status, age, age at diagnosis) was obtained through chart review. Parents completed a demographics questionnaire assessing current school attendance (yes/no)

and amount of missed school since diagnosis (<2, 2–5, 5–8, 8–12, >12 months). Participants received a $20 gift card.

Measures
Cognitive Function
Participant IQ was estimated using the two-subtest Wechsler Abbreviated Scale of Intelligence, Second Edition (WASI-II; Wechsler, 2011), which consists of the Vocabulary and Matrix Reasoning. subtests WASI-II IQ estimates from the two-subtest version ($\mu = 100$, $\sigma = 15$) are highly correlated with the full version ($r = .83$; Wechsler, 2011). The WASI-II was given to control for any IQ differences between groups.

Facial Processing
The Diagnostic Analysis of Nonverbal Accuracy – Revised (DANVA-2; Baum & Nowicki, 1998) assesses facial expression recognition accuracy. Participants viewed 24 pictures of child faces and determined the facial expression presented in each picture from one of four options – happy, sad, angry, or fearful. The z score for number of errors served as the measure of facial affect recognition accuracy in analyses. The DANVA-2 has established validity with other measures of facial processing and has been shown to differentiate various clinical groups (Bonner et al., 2008; Nowicki, 2006).

Attributions of Peer Behavior
The Attributions and Coping Questionnaire – Peers (ACQ; Burgess, Wojslawowicz, Rubin, Rose-Krasnor, & Booth-LaForce, 2006) assessed participant attributions of a same-sex, unfamiliar peer's behavior during five vignettes describing hypothetical social situations that are ambiguous and stressful in nature. Participants are asked to imagine themselves as the protagonist in each vignette and then respond to questions assessing their attributions of the peer's behavior. As an example, one vignette describes having a peer's milk spilled down the protagonist's back at a lunch table at school. After each vignette, participants choose between one of four responses that describe different attributional responses: *prosocial*—assumes good intentions of peer; *external blame*—assumes bad intentions of peer; *internal blame*—assumes that they must have done something to cause the peer's behavior; and *neutral*—assumes peer's behavior was coincidental. Whether or not each attribution type was chosen was coded for each vignette (1 vs. 0) and the total number of responses for each attribution type was summed across the vignettes (range 0–5). For each attribution type, the total number of times that style was used across the vignettes was then converted to a proportion score by dividing the total by 5. A higher proportion

Table I. *Participant Characteristics*

Variables	Brain tumor ($n = 47$), n (%) or $M \pm SD$	Non-CNS ($n = 34$), n (%) or $M \pm SD$
Survivor age in years	10.51 ± 2.2	11.29 ± 2.4
Female survivors**	11 (23.4)	21 (61.8)
Caucasian survivors	35 (79.5)	21 (61.8)
African-American survivors	4 (9.1)	7 (20.6)
Tumor-related characteristics		
Brain tumor types		
Low-grade glioma	19 (40.4)	
Medulloblastoma	6 (12.8)	
Craniopharyngioma	4 (8.5)	
Ependymoma	3 (6.4)	
Germinoma	3 (6.4)	
Other[a]	12 (25.5)	
Brain tumor location*		
Infratentorial	15 (31.9)	
Supratentorial	31 (66.0)	
Non-CNS solid tumor types		
Rhabdomyosarcoma		6 (17.6)
Wilms tumor		5 (14.7)
Soft tissue sarcoma		5 (14.7)
Ewing's sarcoma		4 (11.8)
Other[b]		14 (41.1)
Treatment		
Surgical resection only	15 (31.9)	12 (35.3)
Radiation therapy only	1 (2.1)	1 (2.9)
Surgery and chemotherapy	4 (8.5)	7 (20.6)
Surgery and radiation therapy	3 (6.4)	2 (5.9)
Radiation and chemotherapy	7 (14.9)	2 (5.9)
All three	11 (23.4)	4 (11.8)
Age at diagnosis*	8.59 ± 3.5	10.47 ± 2.9
Positive relapse status*	16 (34.0)	5 (14.7)
Mean IQ	101.39 ± 10.24	102.58 ± 15.35
Caregiver education		
High school degree or less	7 (14.9)	9 (26.5)
Some college/vocational school	14 (29.8)	10 (29.4)
At least college graduate	24 (51.1)	15 (44.1)
Total household income		
<$34,000	3 (4.3)	9 (26.5)
$34,000–$100,000	19 (40.4)	13 (38.2)
>$100,000	21 (44.7)	13 (38.2)
In partnered relationship	38 (84.4)	26 (76.5)

[a]Other tumor types include: dysembryoplastic neuroepithelial tumor ($n = 2$), primitive neuroectodermal tumor ($n = 2$), germ cell tumor ($n = 2$), CNS Ewing's sarcoma ($n = 1$), meningioma ($n = 1$), pineoblastoma ($n = 1$), anaplastic pilocytic astrocytoma ($n = 1$), oligodendroglioma ($n = 1$), and hemangiopericytoma ($n = 1$).

[b]Other tumor types include: ovarian tumor ($n = 3$), osteosarcoma ($n = 2$), mucoepidermoid tumor ($n = 2$), germ cell tumor ($n = 1$), neuroblastoma ($n = 1$), carcinoma ($n = 1$), and unspecified ($n = 3$).

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

score (range 0–1) for each attribution style indicates a greater likelihood of using that particular attribution style. Prior research with the ACQ has demonstrated strong reliability and successfully differentiated youth with different social behavior reputations (e.g., aggressive, shy/withdrawn) and social acceptance (e.g., rejected; Burgess et al., 2006; Dwyer et al., 2010). While both components of the ACQ, Peer and Friend, were administered, only data from the Peer version are presented here.

ToM Tasks

The Jack and Jill task (Dennis et al., 2012) assessed participants' cognitive ToM, or understanding of others' beliefs. This task involves observing cartoon scenes of two characters, Jack and Jill, where Jack moves the location of a ball with Jill either observing or not observing the switch. For each scenario, participants are asked to take Jill's perspective and report whether Jill would know the actual location of the ball. This was repeated 32 times. Consistent with prior

research (Dennis et al., 2012), the accuracy in responses for items where the location of the ball was switched and unwitnessed by Jill was summed (range 0–8) and this switched/unwitnessed score served as an index of ToM.

Participant conative ToM, or their understanding of how individuals influence how others think and feel, was assessed using the Literal Truth, Ironic Criticism, and Empathic Praise Task (Dennis, Purvis, Barnes, Wilkinson, & Winner, 2001). In this task, participants are shown pictures of someone engaging in a task (e.g., cleaning a room, building a block tower). Simultaneously, they are read a narrative describing another individual's character (e.g., "she liked to cheer people up"; "she liked to bug and annoy people") and presented an audio recording of the character saying something to the individual engaged in the task (e.g., "you built a great tower"). The intonation of the speaker's statement varies among neutral (positive or negative truth), ironic, or empathic across the items with each intonation paired with each of the six tasks in a standardized order for a total of 18 items.

Participants then respond to two factual questions (what happened in the picture and what did the speaker say about the event), two questions about the speaker's beliefs (what the speaker thought about the task and the individual engaged in the task), and two questions about the speaker's intentions (what the speaker wanted the individual to think about the task and what the speaker wanted the individual to think about him/herself). Responses for the belief and intent items were scored as correct (2), underspecified (1) or incorrect (0). The original task (Dennis et al., 2001) was modified from 18 to 10 items after piloting the study procedures in four participants by eliminating one True Positive and two True Negative story, leaving two stories in each of these categories, three Ironic stories, and three Empathic stories, leaving three stories in each category. Separate scores for items assessing the speaker's beliefs and the speaker's intentions toward the individual engaged in the task were totaled (range 0–20).

Statistical Analyses

Descriptive statistics summarized participant demographic and medical variables and chi-square and t-tests compared the diagnostic groups on these variables. Chi-square tests compared rates of friendships between the two diagnostic groups. Chi-square and t-tests evaluated associations between whether or not a participant reported a friendship and specified variables, including participant age, age at diagnosis, current school attendance, treatment modality, treatment duration, relapse status, IQ, sex, facial affect recognition accuracy, and ToM abilities. Version 3 of the PROCESS macro for SPSS (Hayes, 2017) was used to evaluate whether or not diagnostic group moderated associations between SIP domains and friendship status. Variables significantly associated with naming a friend or not were entered into a logistic regression model to evaluate their respective associations with friendship status while accounting for each other.

Results

Descriptive and Preliminary Analyses

The PBTS group had more males (76.6% vs. 38.2%, χ^2 [1, $N = 81$] = 12.15, $p < .01$), was younger at the time of diagnosis ($m = 8.59$, $SD = 3.50$ vs. $m = 10.47$, $SD = 2.86$, t (81) $= -2.58$, $p < .05$), and more likely to have experienced a relapse (34.0% vs. 14.7%, χ^2 [1, $N = 81$] = 3.84, $p = .05$) than the non-CNS solid tumor group. In addition, the PBTS group was farther from diagnosis ($m = 26.46$ months, $SD = 32.84$) than the non-CNS solid tumor group ($m = 13.25$ months, $SD = 20.07$ months), t (81) = 2.21, $p < .05$. The groups did not differ in terms of age at the time of study participation, ethnicity, time since completing tumor-directed treatments, missed school, current school attendance, or estimated IQ. There were no differences between the PBTS and non-CNS solid tumor participants on any of the measured indices of SIP (Supplementary Table 1). Youth who experienced a relapse had longer treatment durations ($m = 42.42$ months, $SD = 39.55$ months) than those who did not ($m = 9.21$ months, $SD = 16.29$ months), t (79) $= -3.74$, $p < .01$. Relapse was unrelated to missed school or treatment modalities.

Rates of Friendships and Their Predictors

PBTS (61.7%) were less likely to report having a friend compared with non-CNS solid tumors survivors (85.3%), odds ratio = 3.60, $\chi^2 = (1, N = 81)$ 5.40, $p < .05$. In two-sided t-tests, survivors who reported having a friend had fewer errors in labeling facial expressions on the DANVA, more neutral attribution responses on the ACQ, and more correct responses on the three ToM variables (Table II). Notably, IQ, sex, age, age at diagnosis, time since diagnosis, treatment duration, tumor-directed treatment modalities, and current school attendance were unrelated to whether they provided the name of a friend. However, participants who had experienced a disease relapse prior to study enrollment (47.8%) were more likely to report not having a friend compared with those who had not had a relapse (17.2%), odds ratio = 0.23, $\chi^2 = (1, N = 81)$ 8.02, $p < .01$. There was not a significant interaction between diagnosis group and relapse status in moderation analyses predicting whether or not a friend was named. In analyses evaluating whether diagnostic group moderated associations between SIP domains and whether or not a friend was named while

Table II. *Variables Associated With Ability to Name a Friend*

Variable	Identified a friend (*n* = 58)	Did not identify a friend (*n* = 23)	Test statistic	Effect size
Sex (% female)	43.1% (*n* = 25)	30.4% (*n* = 7)	$\chi^2(1,\ N = 81) = 1.11$	Phi = .11
Age	11.00 ± 2.1	10.43 ± 2.6	$t(79) = -1.02$	Hedges' g = .25
Age at diagnosis	9.99 ± 2.8	8.21 ± 4.0	$t(79) = -1.95$	Hedges' g = .56
Time since diagnosis (months)	18.49 ± 26.5	28.08 ± 32.9	$t(79) = 1.37$	Hedges' g = .34
Relapse status (% positive)	17.2% (*n* = 10)	47.8% (*n* = 11)	$\chi^2(1,\ N = 81) = 8.02**$	Phi = −.32
IQ	103.16 ± 11.34 (*n* = 57)	98.59 ± 15.05 (*n* = 22)	$t(77) = -1.46$	Hedges' g = .37
DANVA Child Faces Errors Z scores	0.04 ± 0.93 (*n* = 55)	0.79 ± 1.57 (*n* = 22)	$t(75) = 2.10*$	Hedges' g = .65
ACQ Neutral Attribution proportion	0.41 ± 0.23	0.28 ± 0.19 (*n* = 21)	$t(77) = -2.31*$	Hedges' g = .59
Jack and Jill – Switched/ Unwitnessed Accuracy	6.64 ± 2.6 (*n* = 55)	3.85 ± 3.6 (*n* = 20)	$t(73) = -3.15**$	Hedges' g = .96
Irony and Empathy Actor Beliefs	14.95 ± 3.4 (*n* = 57)	12.57 ± 4.8 (*n* = 21)	$t(76) = -2.08*$	Hedges' g = .62
Irony and Empathy Actor Intentions	15.18 ± 4.4 (*n* = 57)	12.19 ± 5.2 (*n* = 21)	$t(76) = -2.54*$	Hedges' g = .65

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

controlling for relapse status, only the interaction between diagnosis and Irony and Empathy Actor Intentions (conative ToM) was significant (1, $N = 78$) 7.87, $p < .01$. Non-CNS solid tumor survivors had similar rates of identified friendship as PBTS at the lowest levels of conative ToM and higher rates of identified friendship at higher levels of conative ToM (Supplementary Figure 1).

Logistic regression evaluated the associations between the ability to name a friend and variables that had significant associations with friendship status in the univariate and moderation analyses (Table III). The overall model was significant, χ^2 (8, $N = 70$) = 34.44 $p < .001$, Nagelkerke's $R^2 = .57$, with relapse status, diagnosis, and facial processing as significant predictors of the ability to name a friend, p's < .05. There also was a trend association between more neutral attribution responses on the ACQ and the ability to name a friend, $p = .06$.

Discussion

Given improved survival rates and the known importance of having a friend on later psychological health, it is vital to understand and address social outcomes in youth with cancer. This study evaluated rates of the ability to name a friend in youth who recently completed tumor-directed therapy for either a brain tumor or a non-CNS solid tumor. PBTS were significantly less likely to name a friend compared with youth treated for a tumor outside the CNS. Self-reported ability to name a friend also was related to relapse status and SIP indices, such as facial affect recognition, while unrelated to other demographic and medical

factors. These findings offer directions for future research and clinical efforts.

More than 38% of the PBTS could not provide the name of a friend. This is a concerning rate that contrasts to the lower rate reported by youth with non-CNS solid tumors, who experience similar treatment-related difficulties (i.e., missed school) that might disrupt friendship development and maintenance. Furthermore, disease relapse increased the likelihood of not naming a friend, potentially due to the significantly longer treatment period for those with a relapse and likely longer period of time removed from typical social life. Other potentially relevant factors across childhood cancer, including missed school, demographic (e.g., sex), and developmental factors (e.g., age/age at diagnosis), were unrelated to friendship status. These findings suggest that youth with brain tumors and those with a history of relapse should be screened regularly for social challenges. Furthermore, asking concrete questions (e.g., "Can you name one friend?"), may be an efficient way to screen for social difficulties and facilitate the allocation of support services.

The ability to name a friend was related to several SIP variables in univariate models while unrelated to estimated IQ suggesting that social cognition may be more relevant to friendship status than overall cognitive ability. The only other published study evaluating SIP in youth with cancer found impairments in facial processing in PBTS compared to youth with juvenile rheumatoid arthritis that were modestly associated with parent-reported social acceptance (Bonner et al., 2008). The current study extends this work by evaluating other SIP domains (Yeates et al., 2007), including attribution style and ToM, in youth with brain or

Table III. *Logistic Regression Model of Ability to Name a Friend*

	B	S.E.	Wald	Exp(B)
Diagnosis (Brain vs. non-CNS)	−2.31	1.14	4.10	0.10*
Relapse Status (Yes vs. No)	2.22	0.99	4.96	9.22*
DANVA Child Faces Errors Z score	−1.36	0.59	5.41	0.26*
Jack and Jill – Switched/Unwitnessed Accuracy	−0.03	0.16	0.03	0.97
ACQ Neutral Attribution proportion	4.02	2.13	3.54	55.52[a]**
Irony and Empathy Actor Beliefs	−0.07	0.12	0.30	0.94
Irony and Empathy Actor Intentions	−0.15	0.28	0.27	0.86
Interaction: Diagnosis × Irony and Empathy Actor Intentions	0.35	0.21	2.65	0.86
Constant	3.41	4.45	0.59	30.20

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

non-CNS tumors and linking these domains to whether a child could name a friend. Interestingly, among youth with non-CNS solid tumors, only those at the lowest levels of conative ToM had a low likely likelihood of identifying a friend. Conversely, only PBTS at the highest levels of conative ToM had a high likelihood of identifying a friend. Other moderation effects between SIP ability and diagnosis group were not supported.

Notably, facial affect recognition accuracy was the only SIP variable significantly related to the ability to name a friend in the logistic regression model with a trend for attribution style. Additional research is needed to understand how variability in facial processing relates to social adjustment outcomes in survivors to establish if it is a risk factor or a viable intervention target (Bolte et al., 2006). Computerized interventions involving repeated matching trials to improve recognition of facial features (Faja et al., 2012) and facial expressions in ASD have demonstrated the viability of facial processing training in youth with known social impairments. The trend finding for attribution style and the ability to name a friend is consistent with studies in typically developing youth and youth with TBI (Walz et al., 2009). Given that attributional style can be addressed with cognitive-behavioral interventions, further investigation of this cognitive process and its role in friendship and social acceptance outcomes in pediatric cancer is warranted.

Variables assessing different aspects of ToM were not significantly related to the ability to name a friend in the overall logistic regression. This contrasts with the model of social competence (Yeates et al., 2007) and with existing research in pediatric TBI showing impairments in ToM compared to youth with an orthopedic injury (Dennis et al., 2012, 2013; Walz, Yeates, Taylor, Stancin, & Wade, 2010) and with recent evidence that ToM mediates the association between injury severity and peer-reported social adjustment in pediatric TBI (Deighton et al., 2019). The cross-sectional nature of the present study may explain some of the contrasting findings compared

with these TBI studies. Further studies should evaluate the development of ToM over time and its role in the social adjustment of youth with cancer.

This study offers a cross-sectional view of the ability of youth treated for cancer to name a friend at an early stage of survivorship. Longitudinal studies are needed to determine the patterns of friendship status and social problems from the point of diagnosis onward in order to guide screening and intervention efforts. In this study, there were no significant differences in SIP abilities between groups, likely due to the data being collected at an early point in survivorship. Additional research with long-term survivors is needed to evaluate whether differences in SIP abilities develop over time between PBTS and non-CNS tumor survivors and to determine the various contributions of SIP domains and physical late effects on friendship and other social outcomes. It is possible that youth with non-CNS cancers may develop problems with friendships later in survivorship (Reiter-Purtill et al., 2003) or that difficulties for PBTS could worsen with worsening SIP abilities secondary to late effects. Prior research has either focused on youth undergoing cancer therapy (Noll et al., 1999) or on PBTS farther removed from diagnosis and treatment (Salley et al., 2015; Vannatta, Zeller, Noll, & Koontz, 1998). The high number of PBTS who could not name a friend in this sample is striking given that this group likely has not yet developed significant late effects, which tend to emerge years after the conclusion of tumor-directed therapies and could negatively impact friendship status further. The strengths of this study include comparing rates of friendship among a diverse sample of youth with and without CNS disease to underscore the role of tumors in the brain, controlling for IQ and relevant demographic and medical factors, and employing an innovative SIP measurement approach. In addition to the cross-sectional nature of this study described above, other limitations to consider include a small sample of non-CNS tumor survivors, a largely male sample of PBTS, conducting the research at a single site and relying on a self-report measure of

friendship status rather than collecting this information from peers. However, our approach allowed for the presence of a friend outside a child's primary classroom, unlike the approach typically used in sociometric research (e.g., Noll et al., 1999; Salley et al., 2015; Vannatta, Gartstein, et al., 1998), which may be important given that relationships both within and outside of the classroom are important to social development (Kiesner, Poulin, & Nicotra, 2003).

In summary, PBTS were less able to name one friend compared with those treated for a non-CNS tumor, and the ability to name a friend was related to domains of SIP while unrelated to medical and demographic factors. Findings suggest that all survivors should be screened regularly for difficulties with social functioning (e.g., Can you give me the name of one friend?) and that they might benefit from interventions that attempt to increase their acceptance and inclusion in social circles (Devine et al., 2016) or enhance their processing of social information communicated by the faces of others (Bolte et al., 2006).

Supplementary Data

Supplementary data can be found at: https://academic.oup.com/jpepsy.

Funding

References

Aloise-Young, P. A., Graham, J. W., & Hansen, W. B. (1994). Peer influence on smoking initiation during early adolescence: A comparison of group members and group outsiders. Journal of Applied Psychology, 79, 281–287.

Barrera, M., Shaw, A. K., Speechley, K. N., Maunsell, E., & Pogany, L. (2005). Educational and social late effects of childhood cancer and related clinical, personal, and familial characteristics. Cancer, 104, 1751–1760.

Baum, K. M., & Nowicki, S. (1998). Perception of emotion: Measuring decoding accuracy of adult prosodic cues varying in intensity. Journal of Nonverbal Behavior, 22, 89–108.

Bolte, S., Hubl, D., Feineis-Matthews, S., Prvulovic, D., Dierks, T., & Poustka, F. (2006). Facial affect recognition training in autism: can we animate the fusiform gyrus? Behavioral Neuroscience, 120, 211–216.

Bonner, M. J., Hardy, K. K., Willard, V. W., Anthony, K. K., Hood, M., & Gururangan, S. (2008). Social functioning and facial expression recognition in survivors of pediatric brain tumors. Journal of Pediatric Psychology, 33, 1142–1152.

Bowker, A. (2004). Predicting friendship stability during early adolescence. Journal of Early Adolescence, 24, 85–112.

Burgess, K. B., Wojslawowicz, J. C., Rubin, K. H., Rose-Krasnor, L., & Booth-LaForce, C. (2006). Social information processing and coping strategies of shy/withdrawn and aggressive children: Does friendship matter? Child Development, 77, 371–383.

Cairns, R. B., Leung, M.-C., Buchanan, L., & Cairns, B. D. (1995). Friendships and social networks in childhood and adolescence: Fluidity, reliability, and interrelations. Child Development, 66, 1330–1345.

Christiansen, H. L., Bingen, K., Hoag, J. A., Karst, J. S., Velazquez-Martin, B., & Barakat, L. P. (2015). Providing children and adolescents opportunities for social interaction as a standard of care in pediatric oncology. Pediatric Blood & Cancer, 62, S674–S677.

Deighton, S., Durish, C. L., Taylor, H. G., Rubin, K., Dennis, M., Bigler, E. D., ... Yeates, K. O. (2019). Theory of mind and parental nurturance as predictors of peer relationships after childhood traumatic brain injury: A test of moderated mediation. Journal of International Neuropsychological Society, 25, 931–940.

Dennis, M., Purvis, K., Barnes, M. A., Wilkinson, M., & Winner, E. (2001). Understanding of literal truth, ironic criticism, and deceptive praise following childhood head injury. Brain and Language, 78, 1–16.

Dennis, M., Simic, N., Agostino, A., Taylor, H. G., Bigler, E. D., Rubin, K., ... Yeates, K. O. (2013). Irony and empathy in children with traumatic brain injury. Journal of the International Neuropsychological Society, 19, 338–348.

Dennis, M., Simic, N., Gerry Taylor, H., Bigler, E. D., Rubin, K., Vannatta, K., ... Yeates, K. O. (2012). Theory of mind in children with traumatic brain injury. Journal of the International Neuropsychological Society, 18, 908–916.

Desjardins, L., Barrera, M., Chung, J., Cataudella, D., Janzen, L., Bartels, U., ... Fairclough, D. (2019). Are we friends? Best friend nominations in pediatric brain tumor survivors and associated factors. Supportive Care in Cancer, 27, 4237–4244. doi:10.1007/s00520-019-04706-3

Devine, K. A., Bukowski, W. M., Sahler, O. J. Z., Ohman-Strickland, P., Smith, T. H., Lown, E. A., ... Noll, R. B. (2016). Social competence in childhood brain tumor survivors: Feasibility and preliminary outcomes of a peer-mediated intervention. Journal of Developmental and Behavioral Pediatrics, 37, 475–482.

Dwyer, K. M., Fredstrom, B. K., Rubin, K. H., Booth-LaForce, C., Rose-Krasnor, L., & Burgess, K. B. (2010). Attachment, social information processing, and friendship quality of early adolescent girls and boys. Journal of Social and Personal Relationships, 27, 91–116.

Faja, S., Webb, S. J., Jones, E., Merkle, K., Kamara, D., Bavaro, J., ... Dawson, G. (2012). The effects of face expertise training on the behavioral performance and brain activity of adults with high functioning autism spectrum disorders. Journal of Autism and Developmental Disorders, 42, 278–293.

Hayes, A. F. (2017). Introduction to mediation, moderation, and conditional process analysis: A regression-based approach (2nd edn). New York, NY: Guilford Press.

Hocking, M. C., McCurdy, M., Turner, E., Kazak, A. E., Noll, R. B., & Barakat, L. P. (2015). Social competence in pediatric brain tumor survivors: Application of a model from social neuroscience and developmental psychology. *Pediatric Blood & Cancer*, 62, 375–384.

Kiesner, J., Cadinu, M., Poulin, F., & Bucci, M. (2002). Group identification in early adolescence: Its relation with peer adjustment and its moderator effect on peer influence. *Child Development*, 73, 196–208.

Kiesner, J., Poulin, F., & Nicotra, E. (2003). Peer relations across contexts: Individual-network homophily and network inclusion in and after school. *Child Development*, 74, 1328–1343.

Ladd, G. W., & Troop-Gordon, W. (2003). The role of chronic peer difficulties in the development of children's psychological adjustment problems. *Child Development*, 74, 1344–1367.

Laird, R. D., Pettit, G. S., Dodge, K. A., & Bates, J. E. (1999). Best friendships, group relationships, and antisocial behavior in early adolescence. *Journal of Early Adolescence*, 19, 413–437.

Lansford, J. E., Dodge, K. A., Fontaine, R. G., Bates, J. E., & Pettit, G. S. (2014). Peer rejection, affiliation with deviant peers, delinquency, and risky sexual behavior. *Journal of Youth and Adolescence*, 43, 1742–1751.

Noll, R. B., Gartstein, M. A., Vannatta, K., Correll, J., Bukowski, W. M., & Davies, W. H. (1999). Social, emotional, and behavioral functioning of children with cancer. *Pediatrics*, 103, 71–78.

Noone, A. M., Howlader, N., Krapcho, M., Miller, D., Brest, A., Yu, M., . . . Cronin, K. A. (Eds.). (2018). *SEER Cancer Statistics Review, 1975–2015*. Bethesda, MD: National Cancer Institute.

Nowicki, S. (2006). *Manual for the receptive tests of the Diagnostic Analysis of Nonverbal Accuracy 2 (DANVA-2)*.

Parker, J. G., & Asher, S. R. (1993). Friendship and friendship quality in middle childhood: Links with peer group acceptance and feelings of loneliness and social dissatisfaction. *Developmental Psychology*, 29, 611–621.

Parker, J. G., & Seal, J. (1996). Forming, losing, renewing, and replenishing friendships: Applying temporal parameters to the assessment of children's friendship experiences. *Child Development*, 67, 2248–2268.

Prinstein, M. J., & Aikins, J. W. (2004). Cognitive mediators of the longitudinal association between peer rejection and adolescent depressive symptoms. *Journal of Abnormal Child Psychology*, 32, 147–158.

Reiter-Purtill, J., Vannatta, K., Gerhardt, C. A., Correll, J., & Noll, R. B. (2003). A controlled longitudinal study of the social functioning of children who completed treatment for cancer. *Journal of Pediatric Hematology/Oncology*, 25, 467–473.

Rodkin, P. C., & Ahn, H.-J. (2009). Social networks derived from affiliations and friendships, multi-informant and self-reports: Stability, concordance, placement of aggressive and unpopular children, and centrality. *Social Development*, 18, 556–576.

Rubin, K. H., Bukowski, W. M., & Parker, J. (2006). Peer interactions, relationships, and groups. In N. Eisenberg (Ed.), *Handbook of child psychology: Social, emotional, and personality development* (6th edn, pp. 571–645). New York, NY: Wiley.

Salley, C. G., Hewitt, L. L., Patenaude, A. F., Vasey, M. W., Yeates, K. O., Gerhardt, C. A., & Vannatta, K. (2015). Temperament and social behavior in pediaric brain tumor survivors and comparison peers. *Journal of Pediatric Psychology*, 40, 297–308. doi:10.1093/jpepsy/jsuo83

Salmivalli, C., & Isaacs, J. (2005). Prospective relations among victimization, rejection, friendlessness, and children's self- and peer perceptions. *Child Development*, 76, 1161–1171.

Schulte, F., Brinkman, T. M., Li, C., Fay-McClymont, T., Srivastava, D. K., Ness, K. K., . . . Krull, K. R. (2018). Social adjustment in adolescent survivors of pediatric central nervous system tumors: A report from the Childhood Cancer Survivor Study. *Cancer*, 124, 3596–3608. doi:10.1002/cncr31593

Vannatta, K., Gartstein, M. A., Short, A., & Noll, R. B. (1998). A controlled study of peer relationships of children surviving brain tumors: Teacher, peer, and self ratings. *Journal of Pediatric Psychology*, 23, 279–287.

Vannatta, K., Zeller, M., Noll, R. B., & Koontz, K. (1998). Social functioning of children surviving bone marrow transplantation. *Journal of Pediatric Psychology*, 23, 169–178.

Walz, N. C., Yeates, K. O., Taylor, H. G., Stancin, T., & Wade, S. L. (2010). Theory of mind skills 1 year after traumatic brain injury in 6- to 8-year-old children. *Journal of Neuropsychology*, 4, 181–195.

Walz, N. C., Yeates, K. O., Wade, S. L., & Mark, E. (2009). Social information processing skills in adolescents with traumatic brain injury: Relationships with social competence and behavior problems. *Journal of Pediatric Rehabilitation Medicine: An Interdisciplinary Approach*, 2, 285–295.

Wechsler, D. (2011). *Wechsler Abbreviated Scale of Intelligence—Second Edition (WASI-II)*. San Antonio, TX: Pearson.

Willard, V. W., Russell, K. M., Long, A., & Phipps, S. (2019). The impact of connectedness on social functioning in youth with brain tumors. *Pediatric Blood & Cancer*, e27607.

Wolf, J. M., Tanaka, J. W., Klaiman, C., Cockburn, J., Herlihy, L., Brown, C., . . . Schultz, R. T. (2008). Specific impairment of face-processing abilities in children with autism spectrum disorder using the Let's Face It! skills battery. *Autism Research*, 1, 329–340.

Yeates, K. O., Bigler, E. D., Dennis, M., Gerhardt, C. A., Rubin, K. H., Stancin, T., . . . Vannatta, K. (2007). Social outcomes in childhood brain disorder: A heuristic integration of social neuroscience and developmental psychology. *Psychological Bulletin*, 133, 535–556.