Université de Montréal

An Examination of Full and Partial Facial Affect Recognition in Pediatric Brain Tumour Survivors versus Healthy Controls After the Onset of the Covid-19 Pandemic

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Mémoire présenté en vue de l'obtention du grade de maîtrise ès sciences (M.Sc.) en psychologie

Août 2023

Université de Montréal
Unité académique : Département de psychologie, Faculté des arts et des sciences

Ce mémoire intitulé

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Résumé

Introduction. Il est bien établi que les survivants tumeurs cérébrales pédiatriques (STCP) éprouvent des difficultés sociales, et la reconnaissance d'émotions faciales a été étudiée comme un mécanisme sous-jacent. Cependant, l'influence possible de la pandémie sur les capacités de reconnaissance des affects chez les STCP reste inexplorée. La présente étude visait à comparer la reconnaissance des émotions faciales (avec accès au visage complet versus seulement la région des yeux) entre les STCP et des jeunes à développement typique ainsi qu'à examiner son association avec l'adaptation sociale. **Méthode.** Des STCP (n=23) au moins un an après le traitement et des contrôles (n=24) entre 8 et 16 ans ont complété le sous-test de reconnaissance des affects du NEPSY-II (visage complet) et la version enfant du Reading the Mind in the Eyes Test (RMET, seulement le haut du visage). **Résultats.** Les groupes ne différaient pas sur leurs habiletés de reconnaissance d'émotions et ceux-ci n'étaient pas associés à leur adaptation sociale. Comparé aux normes pré-pandémie, notre échantillon avait plus de difficultés dans leur capacité de reconnaissance d'émotions avec visage complet ainsi qu'une meilleure performance avec seulement le haut du visage disponible ($p < .05$). Les participants ont aussi obtenu de meilleurs résultats au RMET qu'au NEPSY-II ($p< .05$). **Conclusion.** En somme, la pandémie semble avoir joué un rôle sur les capacités de reconnaissance des émotions faciales, tant chez les STCP que chez les contrôles, soulignant la nécessité d'études futures sur les effets à long terme de la pandémie sur les compétences sociales des jeunes.

Mots clés : compétence sociale, reconnaissance d'émotions faciales, tumeur cérébrale pédiatrique, survie

Abstract

Introduction. It is well-established that pediatric brain tumour survivors (PBTS) experience social difficulties, and facial emotion recognition has been studied as an underlying mechanism. However, the possible influence of the pandemic on affect recognition abilities in PBTS remains unexplored. The present study aimed to compare facial affect recognition (with full versus partial facial features) between PBTS and healthy controls (HC) and to examine its association with social adjustment. **Method.** PBTS (N=23, ages 8-16) at least one-year post-treatment and HC (N=24, ages 8-16) completed the NEPSY-II Affect Recognition subtest (full face) and the child version of the Reading the Mind in the Eyes Test (RMET, upper face only). **Results.** The groups did not differ in their ability to recognize emotions, and these were not associated with social adjustment. Compared with pre-pandemic norms, our sample had a lower performance in their emotion recognition ability with full face and a better performance with only upper face ($p < .05$). Participants also performed better on the RMET than on the NEPSY-II ($p< .05$). **Conclusion**. In sum, the pandemic appears to have played a role in facial emotion recognition abilities in both PBTS and controls, highlighting the need for future studies on the pandemic long-term effects on young people's social skills.

Keywords: social competence, facial affect recognition, pediatric brain tumour, survivorship

Table of Contents

List of Tables

Article

List of Abbreviations

ASD	Autism Spectrum Disorder
CBCL	Child Behaviour Checklist
COG	Children's Oncology Group
DANVA2	Diagnostic Analysis of Nonverbal Accuracy
FERI	Facial Expression Recognition Instrument
HC	Healthy Controls
IQ	Intellectual Quotient
NEPSY-II	Developmental Neuropsychological Assessment-Second Edition
PBTS	Pediatric Brain Tumour Survivors
RMET	Reading the Mind in the Eye Test
TD	Typically Developing

Acknowledgment

I wish to offer all my gratitude to my parents, my brother, and my close friends. Your constant support in these past two years, your beliefs in my abilities, and your willingness to hear me brainstorm endlessly about my thesis have been monumental in my progress. You are the greatest and I love you *jusqu'à la fin fini*.

A special thank you to my supervisor, Leandra Desjardins, for all that you have taught me. Thank you for your support. Thank you for your feedback. Thank you for your contagious positive energy. Thank you for your trust. Thank you for the multiple learning opportunities. Thank you for creating a supportive lab environment with incredible students. Thank you for sharing your wisdom. Thank you! Your passion and enthusiasm made this master's thesis such a fun experience. I cannot wait for what is to come.

I would also like to thank the Canadian Institutes of Health Research, the Fonds de Recherche du Québec en Santé, and DeSève Foundation for their financial support.

Lastly, an enormous thank you to the families who participated in my research project.

General Introduction

Rationale for the Current Study

Previous studies have established that pediatric brain tumour survivors (PBTS) may experience social challenges, such as more isolation and fewer friendships compared to their peers (e.g., Schulte et al., 2018). Yet, there are still many unknowns about the underlying mechanisms of those challenges, which impedes efforts towards targeted intervention. Facial affect recognition has been investigated as a potential key component towards better understanding PBTS social difficulties (e.g., Bonner et al., 2008). However, conflicting findings indicate further investigation is needed. Moreover, there is currently limited knowledge on the influence of the COVID-19 pandemic on children's social development, especially in PBTS. It is essential to examine how the changed social context of the pandemic, such as the widespread use of masks in social interactions (i.e., loss of some facial cues), may have influenced social competence. Therefore, this master's thesis aimed to 1) investigate the differences in facial affect recognition between PBTS and typically developing (TD) children using two different affect recognition measures (one with full facial features and one with only the eye region available, similar to the facial cues when others wear a mask), 2) examine the association between affect recognition and social adjustment, and 3) explore the association between affect recognition and the amount of self-reported mask exposure children had in their social interactions in the past month.

Pediatric Brain Tumours: Incidence, Treatment, Mortality, and Prevalence of Survivors

Approximately 1000 children are diagnosed with cancer each year in Canada (Government of Canada, 2022). Of these, it is estimated that around 240 children receive a brain tumour diagnosis (Government of Canada, 2022), with brain tumours being the second most

common type of cancer in children (Steliarova-Foucher et al., 2017). Brain tumour classification proposes eight different types: medulloblastoma, supratentorial embryonal tumours, atypical teratoid/rhabdoid tumours, gliomas, ependymomas, craniopharyngioma, choroid plexus tumours, and spinal cord tumours (Udaka & Packer, 2018) source). Each classification has subgroups. For instance, gliomas have four subtypes: high-grade, brain stem, low-grade, and visual pathways gliomas. Low-grade gliomas are the most frequent form of brain tumours in youth (Udaka & Packer, 2018). Tumour treatments are dependent on the tumour classification, its size, its location, its spread, its grade, and individual child characteristics (age, neurological condition, general health) (Canadian Cancer Society, 2023a, Udaka & Packer, 2018). Most frequent treatment avenues include craniosurgery, radiation therapy (photon and proton radiotherapy), chemotherapy, and stem cell transplant (Canadian Cancer Society, 2023a).

Fortunately, progress in cancer treatment has led to a growing population of PBTS (Howlader et al., 2021). Five-year survival rates for pediatric brain tumours currently range from 20% to 95% depending on the type of tumour (Canadian Cancer Society, 2023b, Ward et al., 2014), with a total pediatric brain tumour survival rate of around 72% (Ward et al., 2014). This represents a dramatic increase from the approximately 50% survival rate seen in the 1970s (Ward et al., 2014), leading to an expanding population of PBTS. Although the specific prevalence of PBTS in Canada is currently unavailable, estimates in the United States indicate a prevalence count of approximately 59 000 PBTS (Howlader et al., 2021). The growing PBTS population has led to a greater focus on research on the *quality* of their survivorship. According to the World Health Organization, quality of life, a multifaceted construct, is a significant health outcome that encompasses an individual's overall physical, psychological, and social well-being (World Health Organization, 2023a).

Pediatric Brain Tumours: Physical, Emotional, Cognitive, and Social Long-Term Sequelae

Unfortunately, PBTS may experience disease and treatment late effects, impacting their quality of life (e.g., Macartney et al., 2014). Potential late effects include physical, emotional, cognitive, and social long-term sequelae (Perreault et al., in press). Some *physical late effects* include pain, motor impairments, hearing impairment, cardiovascular disease, fertility issues, changes in physical appearance, and risk of secondary cancer (Erdmann et al., 2021; Perreault et al., in press). PBTS *emotional functioning* can be also impacted. A meta-analysis indicated that PBTS showed higher levels of depressive symptoms, anxious symptoms, and overall distress compared to typically developing peers (Sharkey et al., 2020). Higher rates of suicidal ideation relative to the general population have also been noted (Shah et al., 2015), as well as a higher risk for post-traumatic stress disorder relative to siblings (Stuber et al., 2010). Regarding *cognitive functioning*, PBTS are at risk of experiencing deficits in overall Intellectual Quotient (IQ), with more difficulties often noted in the specific domains of attention, working memory, and processing speed (Stavinoha et al., 2018). Amongst late effects, *social competence* has also emerged as a significant area of impairment for PBTS (e.g., Hocking et al., 2015; Schulte & Barrera, 2010). Social competence is "the ability to achieve personal goals in social interaction while simultaneously maintaining positive relationships with others over time and across situations" (Yeates et al., 2007, p. 536). In one study, caregivers of pediatric medulloblastoma survivors reported social difficulties as the most devastating consequence of their child's diagnosis (Henrich et al., 2014). The current master's thesis will specifically focus on the social competence of PBTS, an area of challenge in PBTS that still requires extended examination. By better understanding their social competence needs, optimal interventions can be created to help build PBTS social skills and thus increase their overall quality of life. Social skills refer to the

abilities necessary for an individual to be successful in social interactions (e.g., Yeates et al., 2007).

Model of Social Competence

A model for understanding social competence in children with a brain disorder was created by Yeates et al. (2007). The model posits that social competence is a construct encompassing three main components influencing one another: social information processing, social interactions, and social adjustment. The first component, *social information processing (SIP*), relates to an individual's social cognitive processes and characteristics, and it is often measured with performance tasks. SIP consists of three sublevels influencing each other: social problem-solving, cognitive-executive, and social-affective functions. SIP is a term that has often been used to describe a six-step process of encoding social cues, interpreting these cues, defining objectives, creating social response options, deciding on a specific response, and enacting that behavior (see Crick & Dodge, 1994 for more information). Crick & Dodge's SIP (1994) corresponds to Yeates et al.'s social problem-solving sublevel component. Yeates et al.'s social problem-solving component (2007) also reflects what others have often described as social cognition, which is "those aspects of higher cognitive function which underlie smooth social interactions by understanding and processing interpersonal cues and planning appropriate responses" (Scourfield et al., 1999, p. 559). In addition to social problem-solving, Yeates et al. (2007) model includes cognitive-executive and social-affective functions in their definition of SIP. Cognitive-executive functions refer to neurocognitive processes like planning, organizing, attention, and working memory while social-affective functions refer to processes like emotion regulation (i.e., considered an aspect of coping when used as a response to a stressful situation) and pragmatic language. The second main component of Yeates et al. (2007) model, *social*

interaction, refers to the behaviours carried out in social situations and can be measured through direct observations. The third component, *social adjustment*, is the perception of the overall quality of a child's social relationships and the extent to which they can achieve desirable and developmentally appropriate social goals such as having friends (Yeates et al., 2007). Social adjustment is often measured by self, parent, or teacher-reported questionnaires (e.g., Hocking et al., 2015).

This model was the framework directly applied for a review of social competence studies in PBTS (Hocking et al., 2015) and has been referenced in multiple PBTS studies since then (e.g., Desjardins et al., 2021; Hocking et al., 2021, Schulte et al., 2018). Yeates et al. (2007) multidimensional model is particularly relevant for PBTS social competence as it considers individual characteristics of the child in addition to brain insults (e.g., type of insult) and environmental (e.g., parenting style, family functioning) risk and resilience factors. More specifically, the inclusion of brain insult in the model is especially pertinent for PBTS as they may undergo multiple brain insults via their tumour (e.g., type, location, grade) or treatment (e.g., radiation, surgery). Other models of social competence have presented similar components (e.g., Beauchamp & Anderson, 2010), but have yet to be directly applied as a framework for understanding PBTS social competence.

Social Competence in PBTS

Thus far, most research on PBTS social competence has examined social adjustment (e.g., Hocking et al., 2015; Schulte et al., 2018). Notably, a large study of pediatric cancer survivors found that around 46% of PBTS are perceived by their caregivers as having social competence deficits and that 30% also had poor relationships with their peers (Schulte et al., 2018). PBTS are often described by caregivers, peers, and teachers as being socially isolated

(e.g., Barrera et al., 2005; Salley et al., 2015; Vannatta et al., 1998). They are also more likely to have no friends compared to children with other types of cancers and their healthy siblings (e.g., Hocking et al., 2021; Schulte et al., 2018), and they are less likely to have their friendship nominations reciprocated relative to their peers with typical developmental trajectories (Desjardins et al., 2019a). Importantly, the social challenges faced by PBTS often extend well into their survivorship and can affect certain adulthood social milestones such as marriage and cohabitation which they achieve at lower rates than healthy controls (Font-Gonzalez et al., 2016). Social competence is important to attend to as it impacts quality of life, and also influences other important domains of functioning, such as one's emotional, academic, and vocational achievement (e.g., French & Conrad, 2001; Gest et al., 2006; Ladd & Troop-Gordon, 2003; Schulte & Barrera, 2010).

Potential risk factors for social competence problems in PBTS have been identified, with the most consistent evidence found for the impact of cranial radiation therapy, a common and often unavoidable treatment (e.g., Schultz et al., 2007; Vannatta et al., 2007). Cranial radiation, particularly when it is received by young children, can lead to neurocognitive impairments (Anderson et al., 2004; Brinkman et al., 2016). Cranial radiation can create microscopic damage to normal white matter, resulting in tissue loss and compromised fiber integrity, which may reduce cognitive processing (e.g., Mabbott et al., 2006). More precisely, one study found the largest difference of white matter integrity in the large fiber tracts (e.g., corpus callosum; Mabbott et al., 2006) after cranial radiotherapy. Another study noted that young children treated with cranial radiation for a medulloblastoma showed a deficiency in the development of normal white matter volume compared to TD children, suggesting that their neurocognitive impairments may be due to impaired maturation of white matter after radiation (Reddick et al., 2005). Most

consistently, PBTS have been noted to show impairments in overall IQ, processing speed, working memory, executive functioning, and attention (e.g., Oyefiade et al., 2021, Stavinoha et al., 2018). These neurocognitive difficulties, often impacted by intensity of cranial radiation treatment, may in turn lead to social difficulties (Diamond, 2013, Hocking et al., 2015). For instance, when PBTS experience difficulties in processing speed and working memory (Stavinoha et al., 2018), it may be more challenging to interact with many people simultaneously or understand complexities that may arise in social interactions.

Other than cranial radiation, younger age at diagnosis, longer time since diagnosis, and lower socioeconomic status are also associated with greater social competence challenges in PBTS (e.g., Hocking et al., 2015; Schulte & Barrera, 2010). While research on risk factors is expanding (e.g., Soto et al., 2023), many variables still require further investigation. For instance, tumor location as a risk factor for difficulties in social competence in PBTS is still not fully understood (e.g., Oyefiade et al., 2021). Some studies found that survivors of infratentorial tumors had lower social functioning compared to survivors of supratentorial tumors (e.g., Patel et al., 2011) while others found the opposite (e.g., Ris & Noll, 1994). More information is also needed between social-affective functions and other components of the social competence model, as there is currently limited knowledge on this association (e.g., Hocking et al., 2015) although several studies have highlighted elevated rates of depression and anxiety in PBTS (e.g., Fuemmeler et al., 2002). There is some indication that there is a bidirectional relationship of anxiety and depression with social adjustment (e.g., Desjardins et al., 2019b), and that coping with cancer and social stressors may influence social adjustment (e.g., Desjardins et al., 2020). Moreover, a greater examination of SIP sublevel components is necessary.

Facial Affect Recognition

Facial affect recognition is an important element of SIP and has emerged in recent years as a key sublevel component towards better understanding social competence in PBTS (Hocking et al., 2015). Facial affect recognition is the ability to accurately perceive, differentiate, and interpret a variety of affects (e.g., happy, sad, angry) conveyed by someone's facial expression. Facial expressions are one of the richest sources of social nonverbal information (Blair, 2003; Erickson & Schulkin, 2003). Therefore, correctly interpreting facial expressions is essential in understanding social situations and how to respond appropriately (Erickson & Schulkin, 2003). If a child struggles to identify emotions in others, it may be challenging for them to react appropriately, which could lead to negative consequences on their social adjustment (Yeates et al., 2007).

Facial Affect Recognition in PBTS

There is limited yet growing research examining facial affect recognition in PBTS of various ages and times since diagnosis. Findings indicated that PBTS tend to make more errors in recognizing adult facial expressions compared to children with Juvenile Rheumatoid Arthritis (i.e., an illness comparison group with no known social difficulties; Bonner et al., 2008; Noll et al., 2000). PBTS also performed worse on two measures of affect recognition (adult and child faces) relative to TD children (Willard et al., 2017). It was found that lower scores on affect recognition were related to lower parent-rated social adjustment in PBTS (Bonner et al., 2008) and to higher difficulty in naming a friend (Hocking et al., 2020). Hocking et al. (2021) found that PBTS with lower levels of social adjustment made more mistakes in facial emotion recognition relative to TD children and youth with autism spectrum disorder (ASD), which they suggested indicated that facial affect recognition may play a unique role in social competence of PBTS compared to other children. However, two recent studies reported conflicting findings that

there were no differences in affect recognition between PBTS and both TD youth (Hocking et al., 2021) and children with solid tumours (i.e., a tumour comparison group with no brain insult and usually without SIP difficulties; Albee et al., 2021). Existing studies have used a variety of affect recognition measures (e.g., Bonner et al., 2008; Hocking et al., 2021; Willard et al., 2017), which may explain discrepancies in findings as different visual stimuli are presented (e.g., some with child faces, some with adult faces) and different tasks are used (e.g., recognition versus recall tasks). There are also differences in the studies' samples, such as different age and time since diagnosis ranges, that may also explain some conflicting findings. However, due to the low prevalence of pediatric brain tumour, samples are often relatively small and heterogeneous, limiting the ability to examine the contribution of other factors (e.g., time since diagnosis, tumor type, tumor location) conclusively on affect recognition. Nonetheless, the discrepancies highlight the need for further research on affect recognition in PBTS.

Measures of Affect Recognition in PBTS: DANVA, FERI, Let's Face It, NEPSY

As mentioned, discrepancies in findings regarding affect recognition in PBTS may be explained by differences in measures used in previous studies. Measures that have been used include the Diagnostic Analysis of Nonverbal Accuracy (DANVA2; Bonner et al., 2008; Hocking et al., 2020; Willard et al., 2017), Facial Expression Recognition Instrument (FERI; Willard et al., 2017), Expression across Identity subtest of Let's Face It Skills Battery (Hocking et al., 2021), and the Affect Recognition subtest of the Developmental Neuropsychological Assessment-Second Edition (NEPSY-II; Kok et al., 2020; Willard et al., 2021).

DANVA2

The DANVA2, a computer-based measure, can be used with individuals aged from 3 to 99 (Nowicki & Duke, 2008). It consists of pictures of child and adult faces. For each picture,

children are tasked to choose which emotions best represent the facial expression of the picture. Choices include happy, sad, angry, or fearful. Scoring is based on the total number of errors and is done separately for child and adult faces. This measure offers normative data based on studies with large samples who have previously used the measure with individuals of varying ages. Notably, these studies often include individuals with specific psychopathologies (e.g., anxiety, autism spectrum disorder, conduct disorder) as opposed to typically developing youth (Nowicki & Duke, 2008).

FERI

The FERI is a computer-based measure that can be used with children from 8 to 16 years old (Hubal et al., 2008). It consists of pictures of adult faces with high and low-intensity facial expressions, with one-third of the pictures matching the participant's gender and ethnicity, another third matched with ethnicity but of the opposite gender, and the last third with mismatched gender and ethnicity. The images shown were created with computer modeling aimed at generating lifelike human faces. In the first part of the test, children have to determine which emotions the faces display between happy, sad, angry, fearful, surprise, and disgust. In the second part, children are tasked to move a slide bar that changes the facial expression of the lifelike human face to the requested emotion. Scores on this task are based on the total number of correct answers. Limitations include the lack of normative data and standardized scores, as well as the absence of child faces as visual stimuli (Hubal et al., 2008).

Let's Face It skills battery, Expression Across Identity Subtest

Let's Face It can be administered to children aged 6 to 18 (Wolf et al., 2008). In this computer-based task, children are shown adult faces expressing basic emotions (happy, angry, sad, disgust, frighten). For each trial, children are presented with a face for one second and are

then shown three other faces. They must select which of the three faces depicts the same emotion as the initial face presented. Scores indicate the total number of trials that were correctly answered. This task has a large normative dataset from 128 TD children for comparison, although there are no standardized scores available (Wolf et al., 2008). Similarly to the FERI, this task also does not have a child face component.

NEPSY Affect Recognition Subtest

This paper-based subtest can be used with children from 3 to 16 years old (Korkman et al., 2007), and it has been translated to French. Children are presented with static pictures of children's (boys and girls) faces. This subtest consists of three tasks: one where participants are shown a child's face expressing an emotion and tasked with selecting from four other pictures which one depicts the same affect as the first, one where participants are shown four faces and they have to choose which two express the same emotion, and lastly, one where participants are shown a face for five seconds and then have to select two out of six pictures that represents the same affect. The total score of this subtest represents the number of good answers. The NEPSY-II subtest has normative data from a large French-speaking TD sample (n=185) and has a standardized total score as well as available percentile scores for the recognition of specific emotions (happy, sad, neutral, fear, angry, and disgust). It offers the advantage of being easily utilized in clinical settings as it is embedded within an established and widely used neuropsychological assessment battery and the visual stimuli are culturally diverse (Korkman et al., 2007).

COVID-19 Pandemic: Masks and Social Isolation on Affect Recognition

When examining social competence and its underlying mechanisms (e.g., facial affect recognition), considering the social context is important. In March 2020 (World Health

Organization, 2020), a worldwide pandemic was declared due to the COVID-19 virus. Globally, there have been over 750 million confirmed cases and almost 7 million deaths attributed to COVID-19 (World Health Organization, 2023b). The contagious nature of the virus led to the enaction of a variety of measures aimed at curbing the spread of the virus, and these often had a significant impact on our social interactions by changing the social landscape. For children and adolescents, the measures included virtual schooling, limited extracurricular activities, reduced number of people to interact in-person, social distancing, lockdowns as well as mask-wearing during in-person social interactions. The impact of the pandemic on the social isolation and social development of children and adolescents is currently being studied. For instance, a recent systematic review indicated increased levels of loneliness (i.e., an element of social adjustment) in adolescents since the onset of the pandemic compared to pre-pandemic, with high levels of loneliness being associated with lower well-being, more anxiety and depression symptoms as well as sleep problems (Farrell et al., 2023). Another study noted that adolescents who reported more perceived negative changes due to COVID-19 had higher levels of loneliness, stress, and symptoms of depression (Espinoza & Hernandez, 2022). A qualitative study (Ballonoff Suleiman et al., 2022) noted that the majority of adolescent participants expressed that the pandemic and social isolation tested and changed their friendships. Many mentioned how social isolation challenged the creation and maintenance of friendships (Ballonoff Suleiman et al., 2022). As of yet, no studies to our knowledge have reported on the social competence of PBTS as impacted by the pandemic. Further, little is known about the role of the pandemic on specific social skills such as affect recognition. With the widespread use of masks, facial cues available during social interactions often included only the visible upper portion of the face (i.e., masks obstructing the lower part of the face). Individuals thus had fewer facial visual social cues to interpret other's

emotions during social interactions, and this has possibly influenced facial affect recognition as a social skill. It is possible that the amount of mask exposure may have reduced or increased one's affect recognition abilities.

Affect Recognition with Partial Facial Features: Reading the Mind in the Eye Test

To take into account the possible role of mask exposure on social competence, examining partial affect recognition (i.e., affect recognition when only the eye region is visible) appears essential. To assess this, some studies have adapted full-face measures by adding surgical masks to visual stimuli (e.g., Chester et al., 2023). Chester et al. (2023) found that TD children aged 7 to 12 had worse partial affect recognition (i.e., faces wearing masks) compared to full affect recognition (i.e., full facial cues), especially in children whose families had more social disruptions during the pandemic. Chester et al. (2023) modified an existing facial affect recognition measure, however; there are very few available and validated measures specifically designed to measure affect recognition with partial facial cues. One empirically validated measure that can be used to achieve this is the Reading the Mind in the Eye Test (RMET). This measure was initially created to assess theory of mind (i.e., inferring mental states to others based on context). However, the RMET has the quality of a facial affect recognition task in that it requires individuals to infer facial emotions based only on static images, without contextual information, of the eye and upper face region (Baron-Cohen et al., 2001). In fact, Oakley et al. (2016) argued that instead of measuring theory of mind, RMET is more likely a measure of affect recognition. Previous research has used the RMET for emotion recognition (e.g., Guastella et al., 2010, Kulke et al., 2022). A recent study found that TD adolescents during the pandemic performed better on the RMET, as a measure of emotion recognition, compared to a sample tested before the pandemic (Kulke et al., 2022). This finding indicates a potential pandemic

effect in TD youth, but no similar studies have been conducted with PBTS, a population particularly at risk for social competence difficulties. RMET has been used previously with children with a brain injury (Tonks et al., 2007), indicating that it may be administered to PBTS to investigate their partial affect recognition abilities in the context of the pandemic. Tonks et al. (2007) found that children with a brain injury aged 9 to 17 performed worse on the RMET (i.e., lower partial affect recognition skills) compared to TD children.

Current Study

Building off of previous research in affect recognition in PBTS and expanding knowledge to consider the context of the pandemic, the current study aimed to investigate facial affect recognition between PBTS and healthy controls using two different affect recognition measures (one with access to full facial features [NEPSY-II] and one with only partial facial features [RMET]). We expected PBTS to obtain lower scores on both affect recognition measures compared to healthy controls. A secondary aim was to examine the association between affect recognition on both tests and social adjustment (i.e., difficulties in peer relationships and age-inappropriate social behaviours as measured by the Social Problems subscale of the Child Behaviour Checklist [CBCL]). We expected that worse affect recognition would be correlated to poorer social adjustment, as measured by the CBCL subscale. Finally, this study intended to explore the association between affect recognition abilities and the amount of self-reported mask-wearing youth were exposed to during their social interactions in the past month.

Submitted Article

An Examination of Full and Partial Facial Affect Recognition in Pediatric Brain Tumour Survivors versus Healthy Controls After the Onset of the Covid-19 Pandemic

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Abstract

Objectives. Pediatric brain tumour survivors (PBTS) are at risk for challenges in social competence, but greater knowledge is needed regarding the mechanisms underlying these challenges. Following the onset of the Covid-19 pandemic, this study compared affect recognition (with full and partial facial cues) between PBTS and healthy controls (HC) and its association with social adjustment as well as mask exposure in social interactions. **Methods.** Twenty-three PBTS, at least one-year post-treatment, and 24 HC between 8-16 years old participated. Youth virtually completed the NEPSY-II Affect Recognition subtest (full facial features), the Reading the Mind in the Eyes Test – Child version (partial facial features), and a brief questionnaire regarding mask exposure in social interactions. Parents completed online the Child Behaviour Checklist and a short demographic form. **Results.** There were no significant differences between groups on both full and partial facial affect recognition skills, and these skills were not found to be associated with social adjustment or total amount of mask exposure. Within the combined sample, participants performed better on the partial facial cues compared to the full facial affect recognition measure ($p < .05$). Incidental findings indicated that the combined sample performed worse on full facial affect recognition and better on partial facial affect recognition compared to pre-pandemic normative data and reference samples ($p < .05$). **Conclusions.** The pandemic appears to have an influence affect recognition abilities in both PBTS and HC, underscoring the importance of further research into its lasting impact on the social competence of youth.

Keywords: social competence, facial affect recognition, pediatric brain tumour, survivorship

Introduction

Brain tumours are the second most common type of cancer in children (Steliarova-Foucher et al., 2017). Fortunately, progress in medical treatment has led to an increased survival rate, currently around 72% which represents a dramatic increase from the approximately 50% survival rate in the 1970s (Ward et al., 2014). Thus, the expanding PBTS population has led to a greater focus in research on the quality of this survivorship. Unfortunately, PBTS survivorship may be impacted by a broad range of disease and treatment late effects (Perreault, in press), with social competence emerging as a significant area of impairment for PBTS (e.g., Hocking et al., 2015; Schulte & Barrera, 2010).

Notably, caregivers of PBTS have reported social difficulties as the most devastating consequence of their child's diagnosis (Henrich et al., 2014). PBTS are often described by caregivers, peers, and teachers as socially isolated (e.g., Salley et al., 2014; Vannatta et al., 1998). They are also more likely to have no friends compared to children with other types of cancers and their healthy siblings (e.g., Barrera et al., 2005; Hocking et al., 2020). Friendlessness is important to attend to as it is a risk factor for internalizing symptoms (Ladd & Troop-Gordon, 2003) and has also been found to impact academic and vocational functioning (e.g., Gest et al., 2006; Schulte & Barrera, 2010). Risk factors for greater deficits in social competence in PBTS include cranial radiation therapy, younger age at diagnosis, and longer time since diagnosis (e.g., Hocking et al., 2015; Schulte et Barrera, 2010).

Yeates et al. (2007) social competence model, initially developed for children with brain disorders, has been directly applied as a framework to better understanding PBTS social competence (Hocking et al., 2015) and has been used in many PBTS studies (e.g., Hocking et al., 2021; Schulte et al., 2018). The model posits that social competence is a construct encompassing

three main components: social information processing (SIP; i.e., interpretation of social cues), social interactions (i.e., behaviours carried out in social situations), and social adjustment (i.e., perception of age-appropriate social competence) (Yeates et al., 2007). Similar constructs have also been posited in other models of social competence (e.g., Beauchamp & Anderson, 2010). It is well-established that PBTS often experience difficulties in social adjustment (e.g., Hocking et al., 2015; Schulte et Barrera, 2010). However, there is still limited knowledge on the underlying mechanisms of these deficits in PBTS, which impedes efforts toward targeted remediation of difficulties. SIP may be an especially relevant component to attend to as it is considered a foundational component of the model, subsequently influencing social interaction and social adjustment (Yeates et al., 2007).

One element of SIP, facial affect recognition, has emerged in recent years as a key component towards better understanding social competence in PBTS (Hocking et al., 2015). Facial affect recognition is the ability to properly recognize, discriminate, and interpret different affects (e.g., happy, sad, angry) demonstrated by someone's facial expression. Correctly interpreting facial expressions, one of the richest sources of social nonverbal information (Blair, 2003; Erickson & Schulkin, 2003), is essential for people to understand the social situations they are in and how to respond appropriately (Erickson & Schulkin, 2003). Indeed, if a child cannot correctly identify emotions in others, it may be challenging to have the appropriate social reaction, which could have negative consequences on one's social adjustment (Yeates et al., 2007).

There is a limited but growing number of studies examining facial affect recognition in PBTS of different ages and time since diagnosis and using a variety of affect recognition tasks (e.g., Bonner et al., 2008; Hocking et al., 2021). PBTS have been found to make more errors in

recognizing adult facial expressions compared to children with Juvenile Rheumatoid Arthritis (i.e., an illness comparison group with no known social difficulties; Bonner et al., 2008; Noll et al., 2000) and obtain lower scores on affect recognition measures relative to typically developing (TD) children (Willard, 2017). Worse affect recognition is correlated with lower PBTS social adjustment as rated by parents (Bonner et al., 2008) and with greater difficulty in naming a friend (Hocking et al., 2020). Hocking et al. (2021) noted that PBTS with worse levels of social adjustment made more errors in identifying facial affect compared to both TD children and youth with autism spectrum disorder (ASD), concluding that facial affect recognition might be uniquely important to PBTS' social competence compared to other children. On the other hand, two recent studies found that PBTS did not differ on affect recognition skills compared to TD youth (Hocking et al., 2021) and children with non-central nervous system solid tumours (i.e., a tumour comparison group with no brain insult and usually without SIP difficulties; Albee et al., 2021). Discrepancies in findings may be explained by the variability of measures used across studies, but they also highlight the need for further study of affect recognition in PBTS.

Moreover, studies have yet to consider the influence of the current COVID-19 pandemic and widespread mask use on affect recognition skills in PBTS. With mask-wearing, only the upper portion of facial social cues (i.e., eyes, eyebrows, and forehead) is visible to infer emotions during social interactions. Thus, mask-wearing (less exposure to facial cues) may negatively influence affect recognition. Very few existing measures are available to address this inquiry, with one empirically validated and available measure being the Reading the Mind in the Eye Test (RMET). Although frequently used as a measure of theory of mind (inferring mental states to others), the RMET demonstrates the quality of a facial affect recognition task as the child needs to determine others' emotions based solely on static images, without context, of the eye

and upper face region (Baron-Cohen et al., 2001; Oakley et al., 2016). RMET has been used previously as a measure of emotion recognition (e.g., Guastella et al., 2010) and utilized in a study with children with brain injury (Tonks et al., 2007), suggesting it could be administered to PBTS for affect recognition purposes.

Overall, there is evidence that affect recognition is a relevant construct to understanding social competence in PBTS (e.g., Bonner et al., 2008; Hocking et al., 2021). However, there are still many unknowns about 1) affect recognition in PBTS compared to TD youth, 2) how it may relate to social adjustment, and 3) affect recognition in PBTS in the context of the COVID-19 pandemic. Therefore, the primary aim of the study was to investigate the differences in affect recognition between PBTS and healthy controls (HC) using two different measures (Developmental Neuropsychological Assessment – Second Edition (NEPSY-II) for affect recognition with full facial features available and the RMET for partial facial features available). We hypothesized that PBTS would obtain lower scores on affect recognition measures with both full and partial facial cues compared to HC. The secondary aim was to examine the associations between affect recognition measures and social adjustment. We hypothesized that lower affect recognition would be associated with worse social adjustment. The final exploratory aim was to investigate the association between affect recognition skills (full and partial) and self-reported exposure to masks during social interactions.

Method

Participants

In this non-randomized cross-sectional study, participants were either PBTS or HC. One French-speaking primary caregiver for each child was also invited to participate. Within our sample, 89.4% were mothers participating. Inclusion criteria for PBTS included being 8 to 16

years old, at least 1-year post-treatment, and French-speaking. French is an inclusion criterion as it is the official language of Quebec, Canada (where the study took place), and 77.5% of the population predominately speaks French at home (Government of Quebec, 2022; Statistics Canada, 2022). Exclusion criteria included actively receiving treatment for relapse or palliative care, having an existing diagnosis of ASD, having first-degree relatives with ASD (i.e., higher likelihood of autism traits), and a diagnosis of Tuberous Sclerosis Complex or Neurofibromatosis type 1 as there is an increased likelihood of also having ASD (Garg et al., 2013; Jeste et al., 2008). Exclusion criteria were selected given that significant affect recognition difficulties are well-established in the ASD population (e.g., Tanaka et al., 2021). Due to the low base rate of pediatric brain tumours, children with any brain tumour diagnosis and all types of received treatment were eligible to participate. A convenience sample of 23 PBTS with a mean age of 12.92 (SD=2.46), age at diagnosis ranging from 1 to 10 years old (M=5.36, SD=2.70), and time since brain tumour diagnosis ranging from 1 to 14 years (M=7.14, SD=3.12) participated. Amongst PBTS, 60.9% were male and 91.3% were White. Diagnoses principally included medulloblastoma (34.8%), pilocytic astrocytoma (21.7%), and craniopharyngioma (17.4%). Primary medical treatment approaches included a combination of chemotherapy, radiation, and surgery (30.4%), surgery only (26.1%), and a combination of radiation and surgery (17.4%). Additional sample characteristics are summarized in Table 1.

Inclusion criteria for HC included being aged 8 to 16 years old and French-speaking. Exclusion criteria included having a medical history of any type of cancer, having an existing diagnosis of ASD, or having first-degree relatives with ASD (see reasons above). A convenience sample of 24 HC with a mean age of 11.50 (SD=2.36) and a sex distribution of 50% female

participated. HC reported race predominantly included White (50%), Black (12.5%), and Middle Eastern (20.8%). Further participant descriptive statistics are summarized in Table 1.

Procedure

After receiving approval from our institution's Research Ethics Board, recruitment took place from May 2022 to May 2023. PBTS were recruited either through provincial and national cancer organizations (Leucan and Brain Tumour Foundation of Canada) email listservs or through a local pediatric neuro-oncology clinical patient database. Eligible families from the database were contacted by phone or met in-person at the clinic to discuss the study. Seventy-two families of PBTS were contacted, 30 families consented to participate, and 23 completed the study. Twenty families could not be reached (e.g., never responded to contact or no response to follow-up contacts). Twenty-two families declined to participate in the overall larger longitudinal study in which this study is included. Reasons for declining to participate included not having time (40.9%), not being interested in participating in research studies at this time (31.8%), and children not being interested in the research subject (27.3%).

HC were recruited through advertisements shared online via the hospital's website and social media platforms, email lists (e.g., staff listservs), Facebook groups (e.g., French parent groups), and community organizations (e.g., university sports centers, libraries). Interested families were invited to contact the research assistant for more information. Families of 39 children responded to study advertisements, and 24 HC completed the study. Reasons for families not completing the study included: not eligible after answering screening questions (20%), no responses to contact follow-ups about completing the study (46.7%), no longer interested in participating (20%), or no longer having the time (13.3%).

After receiving detailed information about the study, interested and eligible families were asked to provide written assent/consent for their participation. Due to pandemic constraints and for accessibility purposes, all study measures were administered remotely. Families were scheduled for virtual study appointments (via Zoom) with a research assistant trained in the administration of all measures. For the NEPSY-II, telepractice guidance was used (Pearson, 2022). For the RMET, images were shown through screen-sharing. To optimize virtual assessments, participants were recommended to be in a quiet space, alone, and without preventable distractions (e.g., no phones). Families were also asked about their internet access and the size of their screen (e.g., recommended to use a computer screen or a tablet, but not a phone). Study measures were all available in French. Primary caregivers were asked to complete a short questionnaire (see all caregiver measures below) through the secure online platform LimeSurvey. Data collected for this study is not publicly available for privacy reasons, as participants did not consent to have their information publicly shared.

Materials

Child measures

A Developmental Neuropsychological Assessment-Second Edition (NEPSY-II). The NEPSY-II is a widely used, standardized measure of neuropsychological functioning with well-established validity and reliability (Brooks et al., 2009; Korkman et al., 2007). For the current study, only the subtest of Affect Recognition was administered, which consists of four different tasks assessing children's ability to recognize affect (happy, sad, anger, fear, disgust, and neutral) from pictures of children's full faces (Korkman et al., 2007). This subtest has been used in two recent studies with children with brain tumours (newly diagnosed patients Kok et al., 2020; preschoolers patients Willard et al., 2021), suggesting it could be administered to child and

adolescent PBTS. Raw scores obtained were converted into aged-based standard scores (M=10, SD=10), with higher scores reflect better ability to recognize affect. Normative data is based on a sample of 185 French-speaking children (Korkman et al., 2007).

Reading the Mind in the Eye Test, Child Version (RMET). RMET is a well-established measure that we used as a proximal measure for affect recognition with partial facial expression availability. It was recently translated in Canadian French (Desjardins et al., 2021). In the RMET, children are instructed to look at black-and-white static pictures of the eye region of various adult faces and select a word out of four proposed that best matches the emotion portrayed in the picture. It consists of 28 images (Baron-Cohen et al., 2001), and the final raw score is based on the number of items the participant answered correctly. Standardized scores for the child RMET are not currently available, but data from three studies with TD children (ages 6 to 17; Rosso & Riolfo, 2020; Ruenda et al., 2015; Vogindroukas et al., 2014) indicate a weighted average of 17.78 (SD=1.07).

COVID-19 Questionnaire on Social Interactions and Masks Exposure. This short survey was created for the purpose of this study to assess the frequency with which children interacted with both adults and children who wore masks in the past month. As an example, questions for peers were: “How many days a week do you interact (play, talk, do an activity), in person, with peers and friends?” and “When you interact with peers and friends, in person, how often do they wear masks?”. The same questions were asked for interactions with adults. Possible answers were on a five-point Likert scale. The composite score of total exposure to masks in social interaction reflects the number of days per week the child interacted with others (adults and peers) in the last month and the frequency in which others (adults and peers) wore masks during these interactions.

Caregiver Measures

Child Behaviour Checklist (CBCL). CBCL is a standardized parent-completed questionnaire consisting of various scales commonly used to detect emotional and behavioural problems in children and adolescents aged from 4 to 18 years old (Achenbach & Rescorla, 2001). The CBCL has well-established validity and reliability, and it has been used in multiple studies with PBTS (e.g., Barrera et al., 2005). The Social Problems subscale reflects difficulties in social adjustment (Hocking et al., 2015; Schulte & Barrera, 2010), and was used in this study. The Social Problems subscale consists of 11 items assessing difficulties in peer relationships and age-inappropriate social behaviours. Higher scores indicate more social difficulties as determined by the primary caregiver.

Socio-Demographic Form and Medical Information. Parents completed a demographic questionnaire, and the medical charts of PBTS were reviewed. Information on age, sex, race, time since diagnosis, and type of treatment (e.g., radiation, chemotherapy, surgery) of children was obtained. Information on parents' marital status, educational background, and main occupation was also obtained to describe the sample.

Data Analysis

Descriptive statistics (e.g., n, sample percentage, means, standard deviation, range) summarizing group characteristics were generated for demographic information (child age, sex, race; caregiver marital status, educational background, and main occupation) and medical information for PBTS group (tumour type, time since diagnosis, treatment received). Descriptive statistics were also conducted for key study variables.

For preliminary analyses, an independent samples T-test and a Chi-square analysis were performed to examine potential group differences (PBTS versus HC) in child's age and sex.

Additionally, independent samples T-tests were used to examine potential differences in affect recognition based on sex in the overall sample and radiation treatment (yes versus no) in PBTS. Pearson correlations were used to evaluate associations between affect recognition and age in the overall sample and time since diagnosis in the PBTS.

For our primary aim, two independent samples T-tests of affect recognition between groups (PBTS versus HC) were conducted: one for each test type (full face with NEPSY-II and partial with RMET). To further evaluate the difference between full and partial affect recognition (combined sample), a paired-samples T-test was conducted. To allow for comparison between the two measures (exploring whether participants performed similarly on full or partial affect recognition), z-scores were generated for each affect recognition measure raw scores. Although we initially planned on using pre-pandemic normative data to create these z-scores, an incidental finding that our sample performed differently relative to normative data indicated this was no longer advisable (see Results Aim 1). Z-scores were therefore created based on the current HC data. For our secondary aim, two Pearson correlations were performed to examine the associations between affect recognition and social adjustment, one with the NEPSY-II and the other for RMET. Lastly, for our exploratory aim, Pearson correlations were conducted to explore the associations of total mask exposure in social interactions with full and partial affect recognition. Cohen's d is used to report effect sizes.

Results

Preliminary Analyses

Descriptive Statistics: Affect Recognition, Social Problems, and Mask Exposure

Mean PBTS NEPSY-II Affect Recognition score was within the below-average range (7.57 ± 3.63) while mean HC score was within the average range (8.92 ± 3.34; Korkman et al.,

2007). On the RMET, PBTS had an average score of 19.39 ± 4.08 while HC had an average of 20.96 ± 2.63. Mean scores for both groups were within the normal range on the CBCL Social Problems subscale (t-score of 65 and below; Achenbach & Rescorla, 2001), although averages were approximately half (HC: 54.33 ± 5.43) to a full (PBTS: 58.87 ± 7.64) standard deviation above the normative mean. For mask exposure, PBTS and HC predominantly reported never or rarely being exposed to people wearing masks (PBTS: 69.0% for adult masking and 78.3% for peers masking; HC: 66.6% for adult masking and 75.0% for peers masking; see Table 2 for details).

Examination of Potential Group Differences and Associations with Socio-Demographic and Medical Variables

PBTS and HC groups did not significantly differ in terms of sex ($\chi^2(1)=5.6$, $p=.45$) or age ($t(45)= -2.01$, $p=.05$, $d= -.59$, 95% CI [-2.83, 0]). Within the combined sample (PBTS and HC), there were no significant sex differences for the NEPSY-II subtest ($t(45)= -1.32$, $p=.19$, $d= -.39$, 95% CI [-3.40, 0.71]) nor for the RMET ($t(45)= -.67$, $p=.51$, $d= -.20$, 95% CI [-2.75, 1.37]). There was no association of age with the NEPSY-II ($r= -.07$, $p=.64$) nor with the RMET ($r=.21$, $p=.16$). Within PBTS, there was no significant difference of radiation (yes/no) on the NEPSY-II ($t(21)= -.18$, $p=.86$, $d= -.08$, 95% CI [-3.67, 3.09]) or on the RMET ($t(21)=1.41$, $p=.17$, $d=.62$, 95% CI [-1.16, 6.10]). Within PBTS, time since diagnosis was not significantly associated with either full or partial affect recognition (NEPSY-II: $r= -.17$, $p= -.17$; RMET: $r=.08$, $p=.08$).

Aim 1: Comparison of Full and Partial Facial Affect Recognition

PBTS versus HC: NEPSY-II and RMET

Contrary to the hypothesis, there were no significant group differences between PBTS and HC in terms of either full ($t(45)=1.33$, $p=.19$, $d=.39$, 95% CI [-0.69, 3.40]) or partial facial

affect recognition (t(37.36)=1.56, p=.13, d=.46, 95% CI [-0.47, 3.60]). The combined sample was therefore used in subsequent analyses.

Incidental Finding: Pre-Pandemic Reference Norms versus Study Pandemic Sample

Although the generation of z-scores for the NEPSY-II and RMET was initially planned with reference and normative data established prior to the pandemic, one sample T-tests indicated significant differences between current study data and previously established data for these measures. Our current pandemic sample obtained significantly lower scores on the NEPSY-II (M=8.26, SD=3.51) relative to pre-pandemic normative data (M=10, SD=3), t(46)=-3.41, p=.001, d= -.50, 95% CI [-2.78, -0.71]. Our pandemic sample performed better on the RMET (M=20.19, SD=3.47) relative to a large comparison sample of children obtained prior to the pandemic (weighted M=17.78, SD=1.7; Rosso & Riolfo, 2020; Ruenda et al., 2015; Vogindroukas et al., 2014), t(46)=4.77, p<.001, d=.70, 95% CI [1.39, 3.43].

Combined Sample: NEPSY-II versus RMET

After generating z-scores for full and partial affect recognition based on the current HC group, a paired samples T-test indicated there was a significant difference in the overall sample between scores on the NEPSY-II subtest and the RMET, t(46)=15.18, p<.001, d=.94, 95% CI [1.95, 3.72]. Participants performed better on the partial affect recognition RMET task (M=-0.29, SD=1.32) relative to the full facial affect recognition NEPSY-II task (M= -3.02, SD=0.64).

Aim 2: Examining the Association Between Affect Recognition and Social Adjustment

Contrary to hypothesis, Pearson correlations indicated that there was no significant association between affect recognition and social adjustment, for RMET (r= -.21, p=.15) and NEPSY-II subtest (r = -.12, p=.43).

Aim 3: Exploring the Role of Mask Exposure on Affect Recognition

Within the combined sample, Pearson correlations indicated that there was no significant association between affect recognition and total exposure to masks in social interactions, for full (r = .22, p=.14) and partial (r= .17, p=.27) facial affect recognition. When separating mask exposure by target (adult and peers), Pearson correlations also indicated no significant association of full and partial affect recognition with exposure to adult mask-wearing (NEPSY-II: r=.23, p=.12; RMET: r=.25, p=.09) or peers mask-wearing (NEPSY-II: r=.16, p=.29; RMET: r=.04, p=.77).

Discussion

Considering the importance of social competence (e.g., Gest et al., 2006; Schulte & Barrera, 2010) and the well-established social difficulties experienced by PBTS (e.g., Hocking et al., 2015; Schulte & Barrera, 2010), it is essential to better understand potential underlying processes of these impairments in this clinically vulnerable population. In addition, the global pandemic has added a pressing need to attend to its impact on the social development of children and adolescents.

Contrary to our hypothesis, PBTS performed similarly on measures of full and partial facial affect recognition relative to HC. A hypothesis for this result is that the COVID-19 pandemic might have had an equalizing effect on both PBTS and HC opportunities to practice affect recognition skills. Indeed, with the pandemic health recommendations (e.g., social distancing, lockdowns, mask-wearing, reduced number of people one can interact with), both PBTS and HC experienced a new social context with fewer interactions and similar opportunities to develop their social skills. In addition, while this finding is contrary to our hypothesis and to some previous studies (Bonner et al., 2008; Willard et al., 2017), it is consistent with two studies that found no differences in full affect recognition between PBTS and typically developing

children (with adult faces; Hocking et al., 2021) and with children with non-central nervous system solid tumours (with child faces; Albee et al., 2021).

The combined current sample appeared to perform differently compared to pre-pandemic normative data and reference samples. Our current sample seemed to have greater difficulty recognizing affect with full facial features compared to normative data. The pandemic context (e.g., limited social interactions, mask-wearing) might have negatively influenced the development of full-face affect recognition in youth during a period of typical improvement in learning this specific skill (e.g., Montiosso et al., 2010). Conversely, our sample seemed to have better partial affect recognition relative to reference samples pre-pandemic, which is consistent with a study (Kulke et al., 2022) that found that adolescents tested during the COVID-19 pandemic obtained higher scores on the adult RMET compared to a sample tested before the pandemic. This finding may be explained by practice effects. Indeed, the development of affect recognition skills has been found to be influenced by stimuli presented to children (e.g., Pollark et al., 2009), and with the pandemic, the current sample interacted with others wearing masks more frequently than pre-pandemic samples. They thus had more opportunities to practice recognizing emotions solely based on eye-region facial cues. The difference between virtual and in-person administration between pre-pandemic data and our sample may also explain these results, although a study found that children aged 4-5 performed similarly on the NEPSY-II Affect Recognition subtest online compared to face-to-face (Nelson et al., 2021). It is also possible that the difference between our sample and pre-pandemic data may be due to the considerable differences between the samples (i.e., norms and reference samples were not collected in the same population [only TD children, while half our sample are PBTS] nor in the same manner [virtual versus in-person]).

Within our sample, participants appeared to perform better on partial compared to full affect recognition, which further supports the potential practice effects. At the outset of the pandemic, others have found that children were better at recognizing emotions from whole faces compared to masked faces (e.g., Ruba & Pollak, 2020). Our study was conducted towards the conclusion of the pandemic, following at least two years of various public health measures often mandating or encouraging mask use and social isolation, and therefore there is a higher likelihood of practice effects due to more time passed with similar visual stimuli.

Although we hypothesize practice effects may explain some of our results, no associations were found of full and partial affect recognition with total mask exposure in social interactions. Another study similarly found that exposure to people wearing masks was not related to affect recognition from upper-facial cues (Kulke et al., 2022). The amount of mask exposure in the past month, as assessed by our measure, may not be ideal for measuring this association. Rather, the long-term exposure to masks during the *years* of the pandemic might better explain potential affect recognition changes. Further, our data was collected in 2022-2023, when many mask mandates were no longer in effect, potentially limiting the weight of one-month mask exposure. Notably, both HC and PBTS predominantly reported rarely or never interacting with others who wore masks at the time the study took place.

Inconsistent with previous PBTS research (Bonnert et al., 2008; Hocking et al., 2021; Willard et al., 2017), participants' abilities on affect recognition were not associated with their social adjustment. With the altered social context of the pandemic, children had to adjust the way they socialize, communicate, and the way they create and maintain relationships (e.g., Ballonoff Suleiman et al., 2022; Larivière-Bastien et al., 2022). Therefore, they may have needed to rely more heavily on other specific social skills such as better coping skills, social problem-solving,

imagination to create social settings, and better online communication skills (e.g., social media use, instant messaging). Studies have found that online friend communication is a protective factor against loneliness and stress in adolescents (Espinoza & Hernandez, 2022) and that it is positively associated with the quality of existing friendships (Valkenburg & Peter, 2007). Hence, it is possible online communication is currently more necessary for social adjustment than affect recognition. Additionally, we wonder whether a combination of social information processing skills may better influence social adjustment. Future research should thus consider examining many aspects of Yeates et al. (2007)'s social competence model concurrently.

The present study offers several strengths. First, this study has a comparison group comprised of TD children, allowing us to evaluate PBTS skills relative to their peers. Second, this study innovatively examined the potential influence of the COVID-19 pandemic on affect recognition, by both using a measure of eye-region affect recognition (similar to facial stimuli with masks) and by considering mask exposure as a variable. Third, all measures were remotely administered. Virtual assessments allowed the recruitment of more rural PBTS, easier accessibility, and more flexibility for families. Fourth, the use of the NEPSY-II subtest offers many advantages such as its diverse visual stimuli, standardized scores, and its easy clinical use as it is embedded within an established and widely-used neuropsychological assessment battery (Korkman et al., 2007).

Limitations of our study also need to be considered. First, although measures were carefully chosen to answer study questions, several weaknesses to this measurement approach may still be noted. For instance, the RMET is only a proxy for affect recognition with partial facial cues and does not have standardized scores. Both our affect recognition measures are considerably different (e.g., different tasks, one with child faces and the other with adult faces),

limiting the comparison between full and partial affect recognition. Second, the COVID-19 Questionnaire on Social Interactions and Masks Exposure is an exploratory measure created for the purpose of this study, and other validated questionnaires on the impact of the pandemic should be considered for future research (e.g., Enlow et al., 2021). Third, this study used virtual assessments which offer advantages but also certain limitations such as less control of the assessment environment. Although it is possible results were influenced by the virtual nature of the assessment, others have found that youth perform similarly on the NEPSY-II Affect Recognition subtest online compared to face-to-face (Nelson et al., 2021). Fourth, the heterogeneity of our sample and our small sample size remains a limitation for analyses and for more robust conclusions about PBTS experiences. It is also possible that children who had greater social challenges did not want to participate in the study. However, there were at least some social adjustment challenges present, as our participants were still half to a full standard deviation above the mean on the Social Problems scale. Although our institution is the largest pediatric brain tumour center in Quebec, obtaining large PBTS sample sizes is often challenging due to the low base rate of brain tumours, mortality rate, and typically single-site nature of novel exploratory studies. Future studies with larger sample sizes are necessary, and we are hopeful regarding the efforts of researchers to collaborate and partake in multi-site studies to address this issue (e.g., Brown et al., 2023).

The current study represents a step towards a better understanding of PBTS facial affect recognition, within the context of the pandemic. It informs an array of future directions for investigation. First, longitudinally determining the impact of the pandemic on the social development of TD children and PBTS is necessary. As hypothesized, certain social skills may now be more important as youth needed to adapt to their changing social environment.

Therefore, creating new norms for measuring social competence post-pandemic may be needed. For instance, social competence measures could incorporate the various ways in which youth have increasingly learned to interact virtually or via social media platforms. The role of digital literacy on social adjustment appears largely unexplored in PBTS to date. Finally, to support engagement in research, future studies should include ongoing partnerships with patients, PBTS, and TD allies. Collaboration can provide insights into current lived experiences and needs, real-world social challenges and facilitators, and perceived priorities for intervention development.

Funding

This project was supported by funding from Leucan, a provincial pediatric cancer organization in Quebec, Canada. The first author (Laurianne Buron) was supported by a Master's Training Scholarship from the Fonds de recherche du Québec – Santé and by a Canada Graduate Scholarship – Master's program from the Canadian Institutes of Health Research.

Conflicts of interest: None declared

Author Contributions

Laurianne Buron (Data curation [lead], Formal analysis, Investigation [lead], Project administration [lead], Writing – original draft [lead], Writing – review & editing [lead]), Sébastien Perreault (Investigation, Project administration, Writing – review & editing), Serge Sultan (Writing – review & editing), Marco Bonanno (Writing- review & editing), Hallie Coltin (Writing – review & editing), Caroline Laverdière (Writing – review & editing), Émélie Rondeau (Project administration), and Leandra Desjardins (Conceptualization [lead], Formal analysis, Funding acquisition [lead], Methodology [lead], Supervision [lead], Writing – review & editing).

Table 1

Sample demographic information

	Pediatric Brain Tumour Survivors (n=23)		Healthy Controls (n=24)	
	n (%)	M ± SD (Range)	n (%)	M± SD (Range)
Race				
White	21 (91.3)		13 (54.2)	
Latino/Hispanic	1 (4.3)			
Black			2 (8.3)	
Middle Eastern			4 (16.7)	
North African	1 (4.3)		3 (12.5)	
Multiracial			2 (8.3)	
Parent/Caregiver marital status				
Common-law	7 (30.4)		9 (37.5)	
Married	10 (43.5)		15 (62.5)	
Divorced or separated	5 (21.7)			
Widowed	1 (4.3)			
Parent/Caregiver completed education				
High School Diploma	5 (21.7)			
Diploma of Vocational Studies	1 (4.3)			
College diploma	4 (17.4)		3 (12.5)	
Bachelor's degree	11 (47.8)		10 (41.7)	
Master's degree	2 (8.7)		11 (45.8)	
Parent/Caregiver's main occupation				
Full-time work	18 (78.3)		16 (66.7)	
Part-time work	3 (13.0)		2 (8.3)	
Unemployed/Looking for work	1 (4.3)		2 (8.3)	
Student	1 (4.3)		3 (12.5)	
Self-employed			1 (4.2)	
Tumour type				
Medulloblastoma	8 (34.8)			
Ependymoma	4 (17.4)			
Craniopharyngioma	4 (17.4)			
Pilocytic astrocytoma	5 (21.7)			

Other (e.g., primary diffuse leptomeningeal gliomatosis, choroid plexus papilloma)	2 (8.7)
Tumour Treatment	
Chemotherapy only	2 (8.7)
Radiation only	1 (4.3)
Surgery only	6 (26.1)
Chemotherapy and radiation	1 (4.3)
Chemotherapy and surgery	2 (8.7)
Radiotherapy and surgery	4 (17.4)
Chemotherapy, radiation, and surgery	7 (30.4)

Table 2

Distribution of mask exposure in social interactions in PBTS and HC

		Never % (n)	Rarely % (n)	Sometimes % (n)	Often % (n)	Always % (n)
In-person interactions with adults per week	PBTS	13.0 (3)	17.4 (4)	34.8 (8)	17.4 (4)	17.4 (4)
	HC	4.2 (1)	16.7 (4)	4.2 (1)	33.3 (8)	41.7 (10)
Frequency of adults mask-wearing	PBTS	39.1 (9)	30.4 (7)	17.4 (4)	13.0 (3)	0 (0)
	HC	20.8 (5)	45.8 (11)	16.7 (4)	12.5 (3)	4.2 (1)
In-person interactions with peers per week	PBTS	4.3 (1)	21.7 (5)	17.4 (4)	30.4 (7)	26.1 (6)
	HC	0 (0)	25.0 (6)	4.2 (1)	29.2 (7)	41.7 (10)
Frequency of peers mask wearing	PBTS	60.9 (14)	17.4 (4)	8.7 (2)	4.3 (1)	8.7 (2)
	HC	41.7 (10)	33.3 (8)	12.5 (3)	12.5 (3)	0 (0)

Note. For in-person interactions: Never = Never, Rarely = One or two times, Sometimes = Three or four times, Often = Five or six times, Always = Everyday

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General Discussion

Review of Study Aims and Results

This study is a crucial step in exploring the complexity of social competence among PBTS and HC during the pandemic by examining facial affect recognition. The primary aim of this study was to compare facial affect recognition skills in PBTS versus HC on two different measures: one with full and one with partial facial features. The secondary aim was to investigate the association between full and partial facial affect recognition and social adjustment. The tertiary aim was to explore the association between affect recognition (full and partial) and total exposure to masks in social interactions.

Results of the current study suggest that PBTS and HC experiences similar levels of both full and partial affect recognition, possibly highlighting how the pandemic may have been an equalizer of social interactions between both groups. While examining the results, incidental findings showed our sample differed in their affect recognition skills compared to pre-pandemic normative data and reference samples. Our sample appeared to perform significantly better on the RMET (partial affect recognition) and significantly worse on the NEPSY-II subtest (full affect recognition) compared to children and adolescents tested prior to the pandemic. Within our sample, there is also an indication participants performed better on partial affect recognition than on affect recognition with whole-face visible. Although we found no association between affect recognition and total exposure to masks in interactions, it is possible our sample better scores on partial affect recognition may still be explained by long-term practice effects of interacting with people wearing masks during the pandemic, since our mask exposure measure only considered the past month experiences (during our one-year recruitment period, mask mandates had started concluding) as opposed to the entire length of the pandemic. Lastly, results indicated no association between affect recognition and social adjustment.

Facial affect recognition abilities remain an important component of social competence and appear especially relevant to investigate in the social context of the pandemic, where children and adolescents had reduced access to social interactions and facial cues (i.e., with mask-wearing and social restrictions). Our study offers a preliminary understanding of this skill in PBTS, a vulnerable population to social competence difficulties, as well as HC during the unique context of the pandemic. While this study is a crucial first step, there are several opportunities for future research in relation to our findings. The following is a discussion of key areas we believe warrant further empirical attention.

Influence of the Pandemic on Social Interactions

The pandemic has had a unique influence on social interactions, particularly among children and adolescents. With health recommendations put in place to limit the spread of the virus, youth experienced important changes to their social environment. Measures that may have changed their social experiences included: reduced face-to-face peer interactions, limited extracurricular activities, virtual schooling, frequent mask-wearing, and social distancing. Therefore, the significant two-year period of social restrictions may have hindered the development and maintenance of social skills, as important opportunities for practicing them were reduced. As of yet, no studies to our knowledge have reported on the social competence of PBTS as influenced by the pandemic. At the present time, we do not yet know the long-term effects of the pandemic on the social development of children and adolescents. Future longitudinal studies are needed to understand the impact on social competence of TD youth and those who may be more at risk of social competence challenges (e.g., PBTS). For example, it is possible the pandemic exacerbated previously existing social competence challenges. Alternatively, the pandemic could have also acted as an equalizer in social interaction opportunities, thereby bridging the gap between HC and those who previously faced social challenges such as PBTS.

Changing Landscape of Youth Social Interactions & Measurement of Social Competence

Due to the changes in social interactions during the pandemic, such as reduced in-person interactions, children and adolescents had to adapt how they socialize, communicate as well as how they create and maintain relationships (e.g., Ballonoff Suleiman et al., 2022; Larivière-Bastien et al., 2022). They may have relied more heavily on very specific skills, such as coping strategies, social problem-solving, creativity in developing and maintaining connections, and increased online communication skills (e.g., social media use and instant messaging). Indeed, for many, interactions via online communities and social media became an important way to communicate with others. In a qualitative study, many participants mentioned that they found and used creative ways to interact online with their peers (e.g., joint online activities, online games; Larivière-Bastien et al., 2022). Although children and adolescents still preferred in-person interactions (Larivière-Bastien et al., 2022), many children had to develop skills in online communication. Adolescents who interacted more frequently with their peers online had lower levels of loneliness (Ellis et al., 2020; Espinoza & Hernandez, 2021). With the increase in social interactions through online platforms, current measures evaluating social competence skills may not fully capture the complexities of this expanding digital realm. The current study used the CBCL to examine social adjustment, as it has been often used with PBTS and allowed us to build on previous research, but it is possible it does not capture the present social reality of youths and other measures (e.g., PEERS-Q; Hearps et al., 2021) may be better suited to this end. Further, to consider the unique nature of virtual communication, creating new measures that encompass digital social skills, digital literacy, social media use, and social adjustment in the landscape of the pandemic may also be necessary to assess social competence more comprehensively in the current context. In addition, it is crucial to explore both in-person and virtual methods of assessments of social competence skills. Virtual assessments gained increased attention during the pandemic due to social interaction restrictions. Virtual

assessment, as utilized in this study, offers numerous advantages such as increased accessibility and inclusivity for participants from rural areas. However, it also presents certain limitations (e.g., increased risk for technological difficulties, less control over the assessment environment including the potential for more distractions). Thus, investigating and comparing the best approaches to assess social competence skills becomes essential to provide the most comprehensive and accurate information on children and adolescents' current challenges and strengths.

Challenges in Recruitment of PBTS

An ongoing challenge of novel single-site social competence studies of PBTS is that of sample sizes. Recruiting PBTS for research studies presents various challenges. Important challenges are the low base rate of pediatric brain tumours and the high mortality rate, which limit the number of eligible participants (Canadian Cancer Society, 2023b; Government of Canada, 2022; Ward et al., 2014). Further, there is a limited number of pediatric oncology treatment centers across Canada, often requiring families to travel far for treatment, limiting opportunities for in-person social competence assessments of youth located in rural areas. Virtual assessments may help increase access to assessments but may not be feasible for all families (e.g., those who may not have a computer screen or sufficient internet bandwidth). Moreover, due to the sensitive nature of PBTS experiences, some families may be hesitant to participate in research studies that are related to the challenges of their diagnosis and treatment. Indeed, some families contacted for this study declined to participate as they did not want to be reminded of their cancer experience or potential sequelae of disease and treatment. Additionally, PBTS have been noted to have high levels of anxiety and depression symptoms (Sharkey et al., 2020), which may impede them from engaging in research projects. However, larger studies on PBTS outcomes are essential to determine the best intervention avenues to assist in the improvement of their quality of life. Therefore, finding solutions to these recruitment difficulties is of most importance. The establishment of

multi-site studies (e.g., Brown et al., 2023), consortiums, and groups such as the Children's Oncology Group (COG) are steps towards studies with larger PBTS samples, which will allow for stronger, broader, and more generalizable findings. Furthermore, there needs to be more emphasis on taking the initiative towards creating patients partnerships. Indeed, this was a weakness of our study and one that we are committed to remediate in future work. By involving PBTS and their families in research design, we can ensure their perspectives and needs are fully considered, and collaboration would further support engagement in research and the impact of outcomes.

Social Competence Interventions for PBTS

Our ultimate goal is to inform the development of optimal social competence interventions for PBTS. In the past, various social skills interventions have been developed specifically for PBTS. A recent review conducted by Willard (2018) examined nine interventions studies that variably targeted 19 different social skills, they noted that these interventions had only modest success in improving children's overall social competence. A limitation to the development of more effective social skills interventions is that no consensus exists on which specific social competence skills should be targeted to optimally help PBTS improve socially (Willard, 2018). Namely, it is well documented that PBTS have deficits in social competence broadly (e.g., Hocking et al., 2015; Schulte & Barrera, 2010), but there is limited knowledge on the specific challenges in social interaction behaviours and social information processing skills experienced by PBTS (Hocking et al., 2015), which thus limits the ability to design optimal targeted social skills interventions. The results of our study suggest the pandemic may have influenced the affect recognition skills of both PBTS and HC, with a seemingly beneficial influence on partial affect recognition while having a possible detrimental influence on full-face affect recognition. Therefore, affect recognition appears as an important area of interest for future studies, but the lack of

influence on overall social adjustment as measured by the CBCL Social Problems scale limits the ability to call for direct targeting of these social skills via intervention at this time.

Several opportunities exist for future PBTS social competence interventions development. Existing models of social competence offer guidance on potential key intervention targets and areas in need for further research (Yeates et al., 2007; Beauchamp & Anderson, 2010). For example, recent work addressing a gap in direct, structured, and objective assessment of social interaction behaviours in PBTS has allowed the identification of specific social behaviours that may be targeted via interventions in PBTS (Desjardins et al., 2021). The models further highlight the importance of future research examining multiple components of the model specifically and their interplay. It is likely a multifaceted intervention, based on the skills that PBTS experience the most challenges with, and targeting multiple components of social competence, would provide better outcomes. In addition, the examination of social virtual communicative skills in PBTS remains unexplored and appears to be a necessary target of investigation based on their gained importance in the past two years. Further, the pandemic has brought unique challenges, and exploring if certain skills are more difficult for PBTS as a result of this social landscape change could inform the creation of targeted interventions based on youth's needs post-pandemic. Moreover, previous interventions have often focused on a skills deficit approach with an emphasis on the remediation of these behaviours in PBTS (Willard, 2018). Yet, it is possible more peer-mediated interventions focused on acceptance, understanding, and social support may offer more optimal outcomes. A single peer-mediated intervention developed for PBTS offered some preliminary positive outcomes and requires further investigation (Devine et al., 2016). Finally, examining whether similar social competence challenges extend to other groups, such as neurodiverse youths or HC, may open collaborative avenues for social competence intervention development across youth.

Conclusion

In conclusion, this master's thesis offers preliminary insights into facial affect recognition in PBTS, an important element of SIP, after the onset of the pandemic. Research examining potential underlying mechanisms of social competence challenges in PBTS holds significant importance, as it contributes to the identification of specific targets for optimal interventions for PBTS. Considering the context of the COVID-19 pandemic is a novel aspect of our project that is also necessary as the changed social landscape may have played a role in the development of specific social competence skills. Results of the current study indicated no differences between PBTS and HC and no association between affect recognition and social adjustment, limiting our ability to conclude on facial affect recognition as a potential target for intervention at this time. Yet, findings suggest that there may have been a change in facial affect recognition abilities following the pandemic, as our sample performed differently than pre-pandemic norms. This highlights the need for future research on the longitudinal impact of the pandemic on the social development of children and adolescents overall, but also in PBTS who may be more at risk for difficulties. Future studies should also explore multiple components of social competence simultaneously (including facial affect recognition) to elucidate their collective influence on overall social adjustment, as facial affect recognition did not appear to solely influence social adjustment in the current study. Our planned next step is to longitudinally examine the role of different social information processing skills (e.g., affect recognition, theory of mind) on social behaviours in PBTS (i.e., another component of Yeates et al., (2007) social competence model) after the onset of the pandemic to understand their current specific social challenges more comprehensively.

References – General Introduction & General Discussion

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