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Learning from the minds of others: A review of social cognition treatments and their relevance to traumatic brain injury

Cassel, A.^{1,2}, McDonald, S.^{1,2}, Kelly, M.^{1,3} & Togher, L.^{1,4}

¹National Health and Medical Research Council Centre of Research Excellence in Brain Recovery, University of New South Wales, Sydney, Australia

²School of Psychology, University of New South Wales, Sydney, Australia

³School of Psychology, University of Newcastle, Newcastle, Australia

⁴Discipline of Speech Pathology, Faculty of Health Sciences, University of Sydney, Sydney, Australia

Corresponding author:

Dr Anneli Cassel

Moving Ahead Centre of Research Excellence in Brain Recovery

School of Psychology

University of New South Wales

Kensington NSW 2052

Australia

anneli.cassel@unsw.edu.au

Learning from the minds of others: A review of social cognition treatments and their relevance to traumatic brain injury

Social cognition is widely regarded as an essential skill with which to understand the social world. Despite this, the role that social cognition plays in outcome, and whether deficits are remediable after traumatic brain injury (TBI), are not yet well known. The current review examines the construct of social cognition and presents a conceptual biopsychosocial model with which to understand the social cognitive process. This is related to the literature on social cognitive deficits in TBI and we discuss relevant treatment developments to date within this population. We then review social cognition treatment programs researched in other clinical populations in order to advise and inform approaches for those living with TBI. Whilst treatments have focused on emotion perception skills in the TBI literature, programs developed for other clinical populations have had broader targets, focusing on Theory of Mind skills and/or modifying interpretational cognitive biases. Moreover, they have largely proven to be efficacious. Programs that are contextualised, collaborative, and experiential seem optimal in enabling generalisation relevant to individuals' everyday social lives. We argue that there is therefore scope to improve the evidence-based social cognitive treatment options available for those with TBI, taking into account specific adaptations necessary for this population.

Keywords: social cognition treatment; emotion perception; Theory of Mind; empathy; alexithymia; traumatic brain injury

Introduction

Psychosocial changes after moderate to severe traumatic brain injury (TBI) have a profound impact for many: relatives report 60-80% of people with severe TBI experience enduring changes to their behaviour and personality after their injury (Brooks, Campsie, Symington, Beattie, & McKinlay, 1986; Jennett, Snoek, Bond, & Brooks, 1981; McKinlay, Brooks, Bond, Martinage, & Marshall, 1981; Oddy, Coughlan, Tyerman, & Jenkins, 1985; Thomsen, 1975, 1984; Weddell & Leggett, 2006). These changes, such as increased irritability, lability, aggression, childishness, unreasonableness, as well as apathy and loss of spontaneity, impact deleteriously upon interpersonal relationships, remain many years post injury, and are specifically associated with carer burden (Brooks et al., 1986; Brooks & McKinlay, 1983; McKinlay et al., 1981; Thomsen, 1984). As a consequence, reduced participation in society and social isolation are reportedly commonplace for those with TBI, with individuals' circumstances often only worsening with time (Burleigh, Farber, & Gillard, 1998; Cattran, Oddy, Wood, & Moir, 2011; Dawson & Chipman, 1995; Hawthorne, Gruen, & Kaye, 2009; Morton & Wehman, 1995; Tate, Lulham, Broe, Strettlles, & Pfaff, 1989). It has been suggested that these psychosocial changes following TBI may be indicative of an important loss of social perceptiveness and empathy (Lezak, 1978). More recently, these constructs have been understood within the term 'social cognition'; the ability to interpret social and contextual cues in order to understand other people (Lieberman, 2007).

Although the existence of social cognition impairments after TBI has been acknowledged for the past 40 years, research into understanding the mechanisms, or ways to assess these in TBI, has only gained traction in the literature in the past decade or so. Whilst this literature base is growing, remediation of social cognition

has lagged behind. A fairly stark comparison can be made by accessing www.psycbite.com, which indexes all empirically based research into remediation of neuropsychological deficits following TBI (and other neurological conditions). Using keywords to describe different kinds of deficits following TBI it transpires there are many articles describing evaluations of treatments to address behaviour (160), attention (161), language (95) and memory (264). In contrast, a search using keywords: social cognition, emotion perception, empathy and/or Theory of Mind yields a total of just 12 articles, not all of which actually addressed these domains.

This paucity of evidence is not the case in other clinical disorders, such as schizophrenia spectrum disorders (SSD) and autism spectrum disorders (ASD), where research into the remediation of social cognition is far more developed. The aim of the current review, therefore, is to firstly evaluate what is known about social cognition and to consider what is compromised after TBI. Related to this, we also aim to consider what remediation efforts there have been for those with TBI to date and to examine, from a transdiagnostic perspective, what broader techniques and targets might also be relevant for people with TBI.

The construct of social cognition

Social cognition is a construct understood from many different schools of thought: theories range from the perspectives of developmental psychology (Bandura, 2001), psychoanalysis (Fonagy, 1991), to cognitive neuroscience (Adolphs, 2001, 2009). This has perhaps slowed progress of research in this area as inconsistent term use abounds in the literature to describe similar concepts despite social cognition being widely regarded as critical to the understanding of human experiences (Choi-Kain & Gunderson, 2008; Green et al., 2008; Keyzers & Gazzola, 2006). Even so, there is

largely consensus, at least within clinical and cognitive psychology fields, that social cognition refers to the collection of processes that allow us 1) to perceive social cues from the self and others, 2) to interpret and understand both our own and others' emotions, beliefs, and behaviours, and 3) to generate responses to these inferences to guide social behaviour (Adolphs, 2001; Beer, Mitchell, & Ochsner, 2006; Green et al., 2008). It also provides the opportunity to foster relationships via mimicry and shared experiences (Hess, Philippot, & Blairy, 1999).

In general, social cognitive processes have been conceptualised as 1) cognitive, referring to judgements of another's thoughts and beliefs (known as Theory of Mind, [ToM]) and relatedly, perspective taking and cognitive empathy, i.e. putting oneself into someone else's shoes; or 2) affective, referring to emotion perception and emotional empathy (i.e. emotional resonance and responsivity) to feel with another's emotions (McDonald, 2013). Metacognitive abilities such as self-awareness and self-regulation are also an integral ingredient in social cognition. Lowered awareness and ability to identify, describe, and express one's own emotional experiences and bodily sensations associated with emotional arousal is a deficit known as 'alexithymia' (Taylor, Bagby, & Parker, 1997). This skill is thought to be integral in order for an individual to subsequently have the ability to exercise empathy or understand another's position: it is essential that one is aware of their own experiences, and relatedly how this self perspective may be similar or different to how another person thinks or feels (see: Decety & Meyer, 2008; for a review).

The interpretational biases a person holds in relation to how they attribute intent or meaning on their own and others' actions are relatedly thought to play a role in social cognition. Attributional style relates to the causal interpretations one makes in response to events that occur in their life (Moore & Stambrook, 1995). Whether an

individual is inclined to internalise or externalise events, and whether they are inclined to relate them to personal or situational factors, has been shown to influence the whole spectrum of human experience, despite being primarily researched with regard to psychopathy (Craig, Hatton, Craig, & Bentall, 2004; Green et al., 2008; Pearson et al., 2013; Pearson et al., 2014; Zullo, Oettingen, Peterson, & Seligman, 1988).

At the sociocultural level, social cognition is posited to tap into implicit social knowledge such as stereotypical knowledge of gender, race etc., as well as implicit cultural and moral principles (Gozzi, Raymont, Solomon, Koenigs, & Grafman, 2009; McDonald, Saad, & James, 2011; Milne & Grafman, 2001). Learned social knowledge of an individual also plays a role, such as their status, familiarity and one's emotional attachment to the person with whom they are interacting. These characteristics, which have also been described within the sociolinguistic framework of systemic functional linguistics (Halliday, 1994), have been shown to influence the nature of language produced between a speaker and listener during interactions of people with TBI (Togher, Hand, & Code, 1997).

Given that social judgements most frequently occur in complex, dynamic, multifaceted situations, it is inevitable that most social cognition tasks tap into non-social generic processes, such as memory, language, cognitive-communication, and executive control (see: McDonald, 2013; for a review). In Figure 1, we have provided a conceptual model of the biopsychosocial factors that are plausibly involved in the social cognitive process, which elaborates on other illustrations in the literature (Gross & Thompson, 2007; Hess et al., 1999; McDonald, 2013; McDonald, Togher, & Code, 2013; Neumann, Zupan, Malec, & Hammond, 2014) to encapsulate the range of processes described above. These are formulated to be reciprocal and reliant on a

network spanning self- and other-awareness of emotional and thought-based processes in order to guide social behavioural responses. Whilst these processes and interrelationships are posited to be conceptual at this stage, we will discuss the social cognitive deficits observed in people with TBI and relate them to this model in the following section.

Figure 1 about here

Although it can be difficult to disentangle social cognitive from other cognitive processes, growing evidence suggests that the interpretation of emotional and mental states is specifically reliant upon interconnected networks involving the amygdala, insular, anterior cingulate gyrus, striatum and prefrontal cortex (Adolphs, 2009; Lieberman, 2007; Phillips, Drevets, Rauch, & Lane, 2003). The frontal and temporal lobes of the brain, especially ventro-medial regions, are particularly vulnerable during TBI as rapid acceleration- deceleration forces cause them to abrade against the middle and anterior fossa of the skull (Bigler, 2007). Thus, it is unsurprising that there is growing interest in understanding the role social cognition plays in social functioning after TBI.

Social cognition after TBI

The incidence of social cognitive deficits following TBI is not well established. In part, this may be due to the number of skills influencing the social cognition process (Figure 1) that are purported to be differentially affected in individuals. Taking emotion perception as an example, 13-39% of people with moderate to severe TBI are estimated to have difficulties recognising emotions from facial expressions (Babbage et al., 2011). However, there are a number of other cues involved in the perception of others' emotions, of which there is growing evidence to suggest that the presence, or

degree, of impairment may vary dependent on the particular cue. For instance, presence of a facial affect perception deficit does not necessarily also indicate the presence of a vocal emotion perception deficit, although in some they can co-occur (Hornak, Rolls, & Wade, 1996; McDonald & Saunders, 2005; Zupan, Babbage, Neumann, & Willer, 2014). Further, there is debate in the literature as to the extent to which 1) the emotion intensity, 2) the emotion valence, and 3) the number of cues available for emotion perception, affect the degree of impairment observed (Rosenberg, Dethier, Kessels, Westbrook, & McDonald, 2015; Rosenberg, McDonald, Dethier, Kessels, & Westbrook, 2014; Rosenberg, McDonald, Rosenberg, & Westbrook, 2016; Zupan & Neumann, 2014).

Emotion perceptive skills have been shown to be associated with ToM (McLellan & McKinlay, 2013; Milders, Ietswaart, Crawford, & Currie, 2008), social behaviour (Knox & Douglas, 2009; Spikman et al., 2013; Watts & Douglas, 2006; Yeates et al., 2016), and self-awareness of social behavioural functioning (Spikman et al., 2013) amongst people with TBI. However, not all have found such an association with either ToM (Henry, Phillips, Crawford, Ietswaart, & Summers, 2006) or social behaviour (Francis, Osborne-Crowley, & McDonald, Under review; Hornak et al., 1996; Milders, Fuchs, & Crawford, 2003; Milders et al., 2008). Relatedly, poorer self-awareness of one's own emotional experiences (alexithymia) also influences one's ability to recognise the emotions of others after a TBI (Neumann, Zupan, et al., 2014). Alexithymia is thought to affect 30-60% of people with moderate to severe TBI (McDonald, Rosenfeld, et al., 2011; Neumann, Zupan, et al., 2014; Williams & Wood, 2010; Wood & Doughty, 2013; Wood, Williams, & Lewis, 2010), affecting more people with TBI than the general population (Koponen et al., 2005; Wood & Williams, 2007). Presence of alexithymia is also thought to affect social behaviour in

those with moderate to severe TBI (Allerdings & Alfano, 2001) and emotional empathy (Williams & Wood, 2010).

One's ability to experience emotional, or affective, empathy is plausibly related to one's own responsivity to emotions. Indeed, there are a number of people with TBI who report reduced emotional experiences in general, such as in response to specific visual emotional stimuli (de Sousa, McDonald, & Rushby, 2012; de Sousa et al., 2010; Saunders, McDonald, & Richardson, 2006; Williams & Wood, 2012) or when assuming a posture associated with a given emotion (Dethier, Blairy, Rosenberg, & McDonald, 2013). Further, there is evidence that people with TBI show impaired physiological responses to facial expressions and other emotional visual material, evidenced by lowered mimicry (de Sousa et al., 2012; de Sousa et al., 2010; Dethier, Blairy, Rosenberg, & McDonald, 2012; Soussignan, Ehrle, Henry, Schaal, & Bakchine, 2005), a reduced automatic startle reflex (Neumann, Hammond, Norton, & Blumenthal, 2011; Sanchez-Navarro, Martinez-Selva, & Román, 2005; Saunders et al., 2006; Williams & Wood, 2012), and diminished arousal (measured through skin conductance) to aversive materials (Angrilli, Palomba, Cantagallo, Maietti, & Stegagno, 1999; de Sousa et al., 2012; de Sousa et al., 2010, 2011; Soussignan et al., 2005). This automatic process whereby one's emotions synchronize with those of others through emotional contagion, is likely to contribute to an individual's experience of affective empathy, and may thus be reduced following a TBI. This is supported by self-reports of adults with severe TBI, of whom 60-70% endorse having problems with empathy, twice as many as compared to demographically matched controls (de Sousa et al., 2012; de Sousa et al., 2010; Williams & Wood, 2010; Wood & Williams, 2008).

As discussed in the section above, empathy is often conceptualised as either cognitive or affective. Cognitive empathy encapsulates one's ability to think about another's thoughts and feelings, and shares many similarities with the construct ToM and related perspective taking, whilst affective empathy relates more to the sharing of emotions and feeling *with* another's feelings. De Sousa et al. (2010) demonstrated relationships between both cognitive and affective components of empathy, and also showed that both these skills were associated with individuals' physiological responsivity to emotional stimuli following severe TBI. Others have also shown these individuals have impairments in, and that there are relationships between, cognitive and affective ToM skills across the breadth of perspective taking abilities (Channon & Crawford, 2010; Channon, Pellieff, & Rule, 2005; Havet-Thomassin, Allain, Etcharry-Bouyx, & Le Gall, 2006; McDonald & Flanagan, 2004; McLellan & McKinlay, 2013; Muller et al., 2010).

The degree of this ToM impairment after brain injury may be of at least a moderate to large effect size (0.5-0.7), based on a meta-analysis of adults with acquired brain injury (ABI; of which roughly 50% had TBI) compared to matched control participants (Martín-Rodríguez & León-Carrión, 2010). Self-reported difficulties with perspective taking have been shown to correlate with difficulties in interpersonal interactions following TBI (Saxton, Younan, & Lah, 2013). Further, Meulenbroek and Turkstra (2016) demonstrated that, amongst participants with a TBI, employment outcomes could be predicted by the extent to which social inferences were used in conversation (namely, those with a poorer ability to make social inferences were more likely to have unstable employment). As people with TBI have been found to use fewer mental state terms in conversation than non-brain injured peers (Byom & Turkstra, 2012), this finding suggests those people with TBI

who have such a ToM impairment may go on to experience significant psychosocial sequelae. Such difficulties do not only affect the individual with TBI but also their family: poorer ToM performance has been shown to predict an individual's caregiver's quality of life (Bivona et al., 2015). As mentioned above and posited in Figure 1, other social cognitive skills also interact with ToM ability: emotion perception (McLellan & McKinlay, 2013; Milders et al., 2008), self-awareness (Bivona et al., 2014), and externally-oriented thinking (Neumann, Zupan, et al., 2014). Nonetheless, not all have found such relationships between some, or all, of these processes (Milders et al., 2003; Milders et al., 2008).

It is interesting that Neumann, Zupan, et al. (2014) found that, amongst participants with a moderate to severe TBI, a preference for concrete, externally-oriented thinking, with a reduced tendency to introspect was the strongest factor predicting performance on other social cognitive tasks, i.e. this way of thinking was associated with poorer emotion perception and less self-reported perspective taking. Whilst this study did not separate the valence of emotion, the tendency to externalise has also been found to relate to poorer positive emotion perception (McDonald, Rosenfeld, et al., 2011). This highlights how the tendency of an individual to internalise versus externalise, a thinking style associated with alexithymia but which could also relate to an individual's attributional style, may influence other social cognitive processes. There is some preliminary evidence to suggest that there is an association between having a negative attribution bias (i.e. making externalising-personalising hostile causal inferences to ambiguous events) and irritation and anger after TBI (Neumann, Malec, & Hammond, 2015; Winegardner, Prince, & Keohane, 2015) but, as yet, the relationship between particular interpretational biases and other social cognitive processes is not well known.

In this section, we have begun to explore the evidence for and against the interrelationships of supposed processes involved in social cognition (illustrated in Figure 1). Relationships have been reported between many of these skills, although there is variability in the literature as to whether, and how often, they are observed. Part of this discrepancy may be related to injury characteristics, sample size, and the presence of non-social cognitive deficits in samples. It may also be the case that conflicting findings are related to different outcome measures used in different studies. For example, studies that used a broad-based behaviour measure with which to correlate with emotion perception performance tended to not find a relationship between these domains (e.g. Milders et al., 2003; Milders et al., 2008), whilst those that tapped communication competence did (e.g. Watts & Douglas, 2006; Yeates et al., 2016). This was observed during the development of The Awareness of Social Inference Test (McDonald, Flanagan, & Rollins, 2011), whereby performance on tasks that tapped emotion perception and ToM did not correlate with a broad informant-rated social skills measure but the same performance did predict difficulties in social communication between a person with TBI and a confederate during an in-vivo encounter (McDonald, Flanagan, Martin, & Saunders, 2004). We will briefly consider the importance of using sensitive measurement tools in both the assessment and treatment of social cognitive deficits in the following section.

Assessment of social cognitive abilities

One of the major challenges for the remediation of social cognition is the availability of accurate and sensitive assessment tools, with normative data, with which to assess social cognitive abilities. There are many tools to select from that measure the different aspects of social cognition illustrated in Figure 1, which range from

behavioural, observational, self- or informant-rated questionnaires, to psychophysiological laboratory-based tools. Their psychometric properties and intended purpose can vary greatly, however. It is vital to consider a measure's reliability and validity in order to ascertain the nature of an individual's social cognitive deficit. Of particular importance for remediation, it is also important to consider a measure's sensitivity to change. The most commonly used social cognitive measures, and details of their psychometric properties, have been described elsewhere in the literature for interested readers (Henry, Von Hippel, Molenberghs, Lee, & Sachdev, 2016; McDonald, 2013; McDonald, Honan, Kelly, Byom, & Rushby, 2013).

Importantly, social cognitive deficits do not occur in isolation: there is likely a complex interplay with other neuropsychological and psychosocial factors (Figure 1) also influencing an individual's presentation. For example, the roles that non-social cognitive deficits (such as memory, cognitive flexibility, and disinhibition) play in an individual's presentation are also important to assess. This may inform whether the individual's social cognitive difficulties are a primary presenting concern (not wholly explainable by other factors) or whether they are secondary to an underlying, related, disorder (Henry et al., 2016). This understanding will also subsequently inform what is then targeted in rehabilitation. It is beyond the scope of this review to consider interventions that address underlying mechanisms leading to social cognitive impairment, such as executive dysfunction and low, or distorted, insight of difficulties (but see: Cicerone et al., 2006; Manly & Murphy, 2012; Tate et al., 2014; for reviews). The below sections will now consider the interventions that have been described in the literature that primarily target social cognitive difficulties (i.e. the processes described in the central cycle of Figure 1).

Social cognition remediation efforts in TBI

The few published social cognition rehabilitation studies, to date, in the field of TBI have tended to target emotion perception alone. Some have focused primarily on a particular skill associated with emotion perception, such as facial affect recognition (Guercio, Podolska-Schroeder, & Rehfeldt, 2004; McDonald, Bornhofen, & Hunt, 2009; Neumann, Babbage, Zupan, & Willer, 2014; Radice-Neumann, Zupan, Tomita, & Willer, 2009), emotion prosody recognition (McDonald, Togher, Tate, et al., 2013), and using context to infer emotional experience (Neumann, Babbage, et al., 2014; Radice-Neumann et al., 2009). Others have included all these elements within their treatment program (Bornhofen & McDonald, 2008a, 2008c). When multiple aspects of emotion perception have been targeted, these have been addressed in a graded hierarchy: there has first been work on ‘simple’ cues to affect recognition (e.g. drawing attention to salient facial features, prosody, body language), which are eventually incorporated into training on the perception of complex and dynamic emotions (i.e. judging dynamic audio-visual expressions of emotions through video, therapist modelling, and role play). Some have additionally related emotion perception in others to self-emotional processing through encouraging introspection and imitation (Neumann, Babbage, et al., 2014; Radice-Neumann et al., 2009).

Particular behavioural and cognitive rehabilitative techniques used to teach these skills have included repetition, positive reinforcement (Bornhofen & McDonald, 2008a, 2008c; Guercio et al., 2004; Neumann, Babbage, et al., 2014; Radice-Neumann et al., 2009), errorless learning, self-instructional training (Bornhofen & McDonald, 2008a, 2008c), and use of vanishing cues (Neumann, Babbage, et al., 2014; Radice-Neumann et al., 2009). Although systematic comparisons of the relative efficacy of these techniques is yet to be made, most treatment studies have found

some positive outcomes, with the sole exception of McDonald et al. (2009). This study found that focused attention and mimicry did not improve facial affect recognition performance of participants with brain injuries to the same extent as control participants in a brief one-session intervention. All remaining studies found that treatment improved participants' emotion perception abilities on at least one outcome measure. When facial affect recognition has been targeted in treatment, there have been descriptive accounts of improvement (Guercio et al., 2004), within-subject improvements over time (Radice-Neumann et al., 2009), and between-group treatment effects (Bornhofen & McDonald, 2008a) observed related to this ability. Further, when treatment has focused on affect recognition from dynamic emotional displays, treatment effects have been observed, particularly when participants were given a metacognitive strategy to use (Bornhofen & McDonald, 2008a, 2008c). No study as yet has examined the effect of treatment in relation to self-emotional awareness, although Radice-Neumann et al. (2009) found this skill improved over time within their treatment groups.

These positive trends are remarkable despite differences between studies with regards to the materials and strategies used during training, how the treatment was provided (one-to-one or in a group), their duration (ranging from six to 25 hours), and intensity. There has been some evidence that these treatments can generalise to influence social behaviour through anecdotal staff-reports and informant ratings of reduced aggressive behaviour (Guercio et al., 2004; Radice-Neumann et al., 2009) and increased socially favourable behaviours and communication (Bornhofen & McDonald, 2008a; McDonald et al., 2008; McDonald, Togher, Tate, et al., 2013).

Emotion perception training has been combined with social skills training in one broad-based study, yielding evidence that this combination can improve both

social perception and behavioural targets (McDonald et al., 2008). Indeed, social behaviour has most often been the target of treatment in research aiming to improve social functioning amongst people with brain injury. However, as the focus of this review is on social *cognitive* processes, the published studies that primarily target a social behaviour to train social skills or social communication are reviewed elsewhere (Driscoll, Dal Monte, & Grafman, 2011; Finch, Copley, Cornwell, & Kelly, 2015; Togher et al., 2014).

Nonetheless, treatment programs that target other facets of social cognition, either singly or in combination with emotion perception are scant. To our knowledge, there have been two promising reports to date, one targeting ToM in combination with emotion perception and emotion regulation in TBI, and one targeting a hostile attribution bias in two men with ABI, but these have (as yet) only been reported in conference proceedings (Spikman, 2016; Winegardner et al., 2015). This indicates there is still much we can learn from remediation efforts in other clinical populations.

Remediation of social cognitive deficits in other clinical populations

The paucity of comprehensive approaches to remediate social cognitive deficits within the TBI population is in stark contrast to treatments developed and trialled with other clinical conditions. These have been most extensive in those with ASD and SSD but there have also been treatments described in other neurodevelopmental conditions (such as pervasive developmental disorder – not otherwise specified [PDD-NOS]) and other psychiatric populations (e.g. borderline personality disorder [BPD] and bipolar disorder). Table 1 describes exemplars of treatment programs across the breadth of diagnoses and includes programs that target a single facet of social cognition (targeted interventions), programs that target multiple facets (comprehensive interventions), as

well as programs that additionally incorporate cognitive remediation and/or social skills training (broad-based interventions). We will consider the approaches used in these populations to target the overlapping social cognitive constructs of emotion perception, emotion self-awareness, ToM, empathy, and interpretational biases below, in order to draw out the themes and techniques that could also be applied in treatments for those with TBI.

Table 1 about here

Emotion perception treatment approaches

Much like the studies described in the section above, the most extensively studied treatment target for social cognition, particularly in the psychosis field, has been that of emotion perception (Fiszdon & Reddy, 2012; Kurtz & Richardson, 2012; Statucka & Walder, 2013). Treatment approaches are very similar to those already described above for TBI. For instance, the most commonly treated target has been facial affect recognition, which has been remediated through use of attention shaping and psychoeducation with the support of pictures and videos (e.g. Golan & Baron-Cohen, 2006; Marsh et al., 2010; Penn & Combs, 2000; Russell, Chu, & Phillips, 2006; Wölwer et al., 2005). For brevity, commonly cited treatment programs that targeted emotion perception either as the sole target or as part of a comprehensive program (i.e. they also targeted other facets of social cognition, described more below) are detailed in Table 1. These programs have been extensively reviewed in SSD populations: findings suggest that training of emotion perception abilities have efficacy and can additionally improve wider social function amongst participants (Horan, Kern, Green, & Penn, 2008; Kurtz & Richardson, 2012; Statucka & Walder, 2013). Similarly, these treatments have also been shown to improve affect recognition

in ASD samples (Golan et al., 2010; Golan & Baron-Cohen, 2006; Silver & Oakes, 2001).

Emotion self-awareness treatment approaches

Self-emotional awareness has not routinely been targeted in treatments within the social cognition literature. However, as we posit this skill to be integral for an individual in order for them to also be able to perceive, interpret, and understand another's emotion experiences (Figure 1), we have considered treatments that aim to target deficits in self-emotional processing (an impairment known as alexithymia). Despite alexithymia being frequently observed in those with psychiatric disorders, as well as in the general population, there are few treatments that explicitly target this skill (Cameron, Ogrodniczuk, & Hadjipavlou, 2014). In a review of all psychotherapeutic treatments that have included measures of alexithymia as part of their outcome measurement, Cameron et al. (2014) found that most did not explicitly target alexithymia as part of the treatment itself. Even so, of approaches used in both those treatments that targeted alexithymia and those that did not, psychodynamic, cognitive-behavioural, art, and/or drama therapies, were commonly reported. Of the studies that specifically targeted alexithymic processes, the ability to identify, differentiate, and describe emotions were most often targeted. Participants have been trained to increase their awareness of their own emotional experiences through psychoeducation, role play, reflection, and mimicry (Beresnevaite, 2000; Byrne, Bogue, Egan, & Lonergan, 2014; Kennedy & Franklin, 2002; Levant, 2009; Melin, Thulesius, & Persson, 2010; Tchanturia, Doris, Mountford, & Fleming, 2015). Some have also focused on teaching strategies, such as progressive muscle relaxation, to improve awareness of bodily sensations (Beresnevaite, 2000; Melin et al., 2010;

Storch, Keller, Weber, Spindler, & Milos, 2011). In one study, in a sample of participants with coronary heart disease, all facets thought to be involved in alexithymia were targeted, including fostering participants' imagination through describing dreams and fantasies (Beresnevaite, 2000). There has additionally been a growing interest in using third wave cognitive therapies, such as acceptance and commitment therapy and mindfulness techniques, to target experiential avoidance related to alexithymic tendencies (Byrne et al., 2014; Cassel & Humphreys, 2016). As Cameron et al. (2014) note, the studies that directly targeted alexithymia in treatment tended to find significant improvements in participants' self-emotional processing following treatment, but that it was important for alexithymia to be a specific intervention target for this change to be consistently observed.

Theory of Mind treatment approaches

Early attempts to treat ToM deficits were first developed for people with autism, training participants to pass variants of the Sally-Anne task. In this task, participants watch two dolls hide an object together. Then, while one is out of the room, the other changes the object's hiding place (Baron-Cohen, Leslie, & Frith, 1985). If the participant can recognise that the two dolls have different beliefs about where the object is hidden (with one doll holding a 'false' belief), it is presumed that they have developed the capacity to perspective take, a cognitive ToM skill. People with ASD have been taught to pass this task successfully through: 1) feedback (Swettenham, 1996), 2) thought bubbles to make explicit what the dolls are thinking (Wellman et al., 2002), and 3) visualising the dolls' beliefs as mental pictures or photos (Fisher & Happé, 2005; McGregor, Whiten, & Blackburn, 1998a, 1998b; Swettenham, Baron-Cohen, Gomez, & Walsh, 1996). Invariably, trained success on this task has not

generalised to novel tasks and real-world perspective taking. Only one group attempted to translate this approach to a real-world context, teaching participants to apply the same picture-in-the-head technique they had learned using dolls to real people acting in videos. This effort to increase understanding that real people can hold ‘false’ beliefs had only modest success (McGregor et al., 1998b).

In the SSD field, cognitive ToM skills have been targeted more broadly by focusing on a wider breadth of cues from which to infer mental states in others. Similarly to above, some have used artificial materials to represent social interactions. Often this has taken the form of sketches or comic strips (Bechi et al., 2013; Choi & Kwon, 2006; Mazza et al., 2010). In these, two or more characters are represented in a series of pictures depicting a social interaction, which requires comprehension of the characters’ intentions, desires, and/or beliefs in order to make sense of the interaction. These have been discussed within group treatments to aid mental-state inferencing. Written sentences that highlight the most relevant features pertinent to inferring a character’s intentions have sometimes been included on the assumption that participants’ ToM difficulties may be related to a poorer ability to extract relevant information from context. Even so, the treatment benefit from such a verbalisation technique does not have strong evidence (Sarfati, Passerieux, & Hardy-Baylé, 2000). Many solely targeted first-order ToM skills (i.e. the ability to understand another person’s mental state) but Bechi et al. (2013) built on this foundation to also target second- and third-order perspective taking in their ToM intervention (e.g. deception, double bluffs, and white lies). They also targeted affective ToM abilities using the same technique of comic strip exemplars during treatment. These included faux pas scenarios and the use of irony, based on the rationale that these require appreciation of emotional states in order to understand the situation. This more in-depth training led

to improved performance at completing a picture sequencing task tapping first- and second-order ToM beliefs but this did not translate to broader real-world functioning. The use of social stories has also been used in computer-based learning to aid perspective taking. Such programs have been based on principles of neuroplasticity and cognitive rehabilitation, requiring the participant to work through tasks individually, albeit with support from a therapist (Fernandez-Gonzalo et al., 2015; Nahum et al., 2014).

Greater success has been achieved using more realistic materials to improve perspective taking skills in ASD, SSD, and bipolar disorder, i.e. using video vignettes to portray two or more actors in a social interaction. In these, participants have been instructed to pay particular attention to the mental states of the actors. Learning about this skill has been facilitated through guided discovery within a cognitive-behavioural treatment model, either in group discussions or on a one-to-one basis (Bechi et al., 2012; Combs et al., 2007; Lahera et al., 2013; Marsh et al., 2013; Roberts & Penn, 2009; Tas, Danaci, Cubukcuoglu, & Brüne, 2012; Turner-Brown, Perry, Dichter, Bodfish, & Penn, 2008). Video vignettes have also been used as part of computer-based programs (e.g. Fernandez-Gonzalo et al., 2015). Typically, participants are guided in their interpretations with a therapist, through explicit focus on the concrete aspects of the vignette (e.g. place, time, behaviours, physical features) and Socratic questioning to discuss hypotheses one might make in relation to actors' motivations, intentions, and mental states.

The relative success of many of the programs that used more realistic materials may be in their additional focus on experiential learning. A luminary in the field of rehabilitation, Mark Ylvisaker, argued for the importance of 'apprentice' style learning in which target skills are ideally trained in situ in order to maximise both

relevance and generalisation (Ylvisaker, 2003). Many of the above treatment studies applied a particular treatment program known as Social Cognition and Interaction Training (SCIT; Penn, Roberts, Combs, & Sterne, 2007). This protocol takes an approach that is sympathetic to that advocated by Ylvisaker, including naturalistic experiential learning. This allows participants to learn about appropriate responding to others' mental states in social interactions, often using real-life experiences. Approaches other than SCIT, in SSD, ASD, and PDD-NOS populations, have also utilised skill-based learning as a means to target social cognitive, particularly perspective taking, abilities (Bauminger, 2002, 2007; Begeer et al., 2011; Crooke, Hendrix, & Rachman, 2008; Hadwin, Baron-Cohen, Howlin, & Hill, 1996; Hogarty et al., 2004; Soorya et al., 2015; Steerneman, Jackson, Pelzer, & Muris, 1996). For example, to teach about perspective taking at a physical level, Ozonoff and Miller (1995) asked group participants to lead a blindfolded trainer through a maze, teaching members to take the physical perspective of the blindfolded person. Role plays and experiential games have also been used to convey higher-order ToM skills that involve putting oneself in the position of someone else, e.g. one ToM Treatment program describes how participants role played and then described the third-person mental states of the characters they were acting (Hoddenbach et al., 2012; Steerneman et al., 1996). Many of these programs have been successful at improving primary outcomes (i.e. ToM performance) and some have further demonstrated generalisation of treatment gains to real-world social behaviour (Bauminger, 2002, 2007; Combs et al., 2007; Combs et al., 2009; Crooke et al., 2008; Roberts & Penn, 2009; Soorya et al., 2015; Steerneman et al., 1996).

New developments in technology have opened the potential for virtual reality based treatments using similar techniques to enhance perspective taking and social

skills. Kandaloft, Didehbani, Krawczyk, Allen, and Chapman (2013) used ‘avatars’ that represent the user in a realistic social interaction with a confederate via a computer interface (e.g. in a job interview, at a café), for which they receive coaching and, later, feedback with a therapist to incorporate in subsequent social interactions. Virtual reality has the added benefit of representing real-life social scenarios in a safe and controlled manner, allowing for repeated practice whilst minimising the risk of social anxiety, which may hinder learning of social cognitive skills. Whilst evidence of the effectiveness of this intervention is only beginning to emerge (in this case series, significant improvements post-treatment were noted on social cognitive measures but not for conversational skills), the potential for the use of virtual reality and technology in the treatment of ToM and broader social cognitive deficits is a promising development.

Training of ToM is not limited to cognitive rehabilitative, cognitive-behavioural, or social learning approaches. Perspective taking has long been a therapeutic goal within psychodynamic psychotherapy (Kongerslev, Simonsen, & Bo, 2015), particularly with regards to mentalizing; defined as “the process by which we make sense of each other and ourselves, implicitly and explicitly, in terms of subjective states and mental processes” (Daubney & Bateman, 2015, p. 132). The evidence base for such an approach is most advanced in studies using mentalization-based treatment (MBT) for people with BPD. In a psychodynamic framework, the interpersonal difficulties often experienced by those with BPD have been understood, at its core, to be a result of an incapacity to mentalize as a result of poorly developed attachment relationships (Bateman & Fonagy, 2013). MBT posits to improve a client’s ability to mentalize through fostering a non-judgemental and accepting therapeutic relationship in which the therapist actively models and encourages the

client to perspective take. In this respect, it is not unlike some of the cognitive-behavioural treatments described above that aim to improve perspective taking through guided discovery, modelling, and role play. Empirical studies that have examined the effectiveness of MBT for BPD have shown this approach is beneficial in reducing crises and self-injurious behaviour, that is, those behaviours posited to result from ‘non-mentalizing’ and an inability to consider alternative explanations for behaviour (Bateman & Fonagy, 1999, 2008, 2009; Rossouw & Fonagy, 2012).

Empathy treatment approaches

A number of studies have posited to target aspects of empathy within their treatment packages (e.g. Baron-Cohen, Golan, & Ashwin, 2009; Davis et al., 2014; Golan & Baron-Cohen, 2006). However, the particular empathy targets in these treatments have tended to relate to either emotion perception or ToM (related to cognitive empathy) as we have described them: i.e. they are more related to the cognisant process of thinking about another’s mental or affective state, rather than the affective experience of feeling with another’s emotional state (which we have figuratively presented in Figure 1 as the interrelation between ‘Theory of Mind’ and ‘Affective Empathy’). Whilst both of these cognitive and affective facets of social cognition have been suggested to be involved in empathizing per se (Baron-Cohen & Wheelwright, 2004), no treatment programs to our knowledge have specifically targeted the affective component of empathy.

Interpretational bias treatment approaches

Emotion perception and ToM interventions, across clinical groups, have shared many commonalities of techniques and approaches. Treatments that target the biases people have when they interpret and attribute causes to others’ behaviour are far more

variable, reflecting the different kinds of biases that characterise different clinical populations with social cognitive deficits (Brosnan, Chapman, & Ashwin, 2014). All targeted interventions for interpretational biases have been specifically designed for people with SSD. These often target the prevalent ‘jumping to conclusions’ bias associated with psychosis (Moritz & Woodward, 2007b; Ross, Freeman, Dunn, & Garety, 2011). Other biases that have been targeted, commonly within the widely researched Metacognitive Training (MCT) program (or variants of), include attributional distortions, bias against disconfirmatory evidence, over-confidence in memory errors, and depressive cognitive patterns (Aghotor, Pfueller, Moritz, Weisbrod, & Roesch-Ely, 2010; Moritz, Veckenstedt, Randjbar, Vitzthum, & Woodward, 2011; Moritz & Woodward, 2007a; Rocha & Queirós, 2013). Cognitive restructuring has been used to address these biases, focused on generating multiple alternatives, increasing perspective taking (like above), and increasing belief flexibility in order to reappraise and create a more balanced explanation of these beliefs. To aid participants in this task, in the SCIT program, Penn et al. (2007) created ‘characters’ that signify different attributional biases (e.g. Blaming Bill and My-fault Mary) to help those who may have difficulties with cognitive flexibility and generativity (Roberts, Kleinlein, & Stevens, 2012). Other cognitive reappraisal techniques, such as considering the pros and cons of different hypotheses and considering the evidence for and against various beliefs have also been used. Within the targeted MCT program, treatment outcomes have been encouraging in ameliorating these cognitive biases, particularly ‘jumping to conclusions’ (Moritz et al., 2014), but the impact of this on functioning has been less examined.

Only one study, to our knowledge, has explicitly considered interpretational bias within a social cognitive treatment for people with ASD. This study used

materials adapted from SCIT to be more relevant for adults living with autism (Turner-Brown et al., 2008). The program took a shift away from a ‘jumping to conclusions’ focus to one that focused more on distinguishing between social and non-social stimuli. Again, whilst these authors showed improved emotion perception and ToM skills in the treated group (as SCIT is a comprehensive treatment program), this did not transfer to their wider social functioning.

There is additionally a broader literature of treatments aimed at people who present with anger and aggression. Whilst a number of interventions described in this literature commonly focus on managing anger from a behavioural perspective, some also focus on the attributions and information processing styles commonly associated with anger, such as the hostile attribution bias. Again, the goals and techniques used in these studies are similar to those described above: increasing participants’ ability to social problem-solve, to reappraise cognitions, to undertake social perspective taking, and to generate consequences for different courses of actions (Guerra, Henry, Huesmann, & Tolan, 2007; Guerra & Slaby, 1990; Linkh & Sonnek, 2003; Sukhodolsky, Golub, Stone, & Orban, 2005; Sukhodolsky et al., 2009). These techniques have been found to reduce participants’ tendency to normalise aggressive beliefs or assign hostile attributions to ambiguous situations and, relatedly, reduce incidents of anger or aggression (Sukhodolsky, Smith, McCauley, Ibrahim, & Piasecka, 2016).

Family involvement

From a systemic perspective, there have been a number of studies in the literature that have additionally incorporated family involvement. More often, parents have been engaged in the treatment programs developed for children or adolescents with ASD

(Bauminger, 2002, 2007; Begeer et al., 2011; Soorya et al., 2015) and children with conduct disorder (Datyner, Kimonis, Hunt, & Armstrong, 2016). Parent involvement in these studies has comprised active involvement in the child's treatment sessions (e.g. by providing parents' summaries, active involvement in sessions, and involvement in homework assignments) as well as dedicated parent psychoeducation and treatment sessions. Family members have also been involved in one trial using SCIT to treat social cognitive deficits in SSD (Tas et al., 2012). Again, this took the form of dedicated psychoeducation sessions with a focus on social learning principles, such as reinforcement, and cognitive-behavioural principles, such as the reciprocity between thoughts, emotions, and behaviours. Although Tas et al. (2012) did not set out to examine the additive effect of family involvement in comparison to traditional SCIT, they did observe significant social functioning improvements in the treatment group, with large effect sizes, which was also reflected in enhanced Quality of Life following treatment.

Summary of treatment approaches

In summary, the field of social cognition remediation is only starting to emerge in TBI but is considerably more advanced in other clinical disorders, notably ASD and SSD. To date, social cognitive treatments for people with TBI have focused on emotion perception (particularly facial affect recognition, but some also on other cues to emotion recognition) and remediating such deficits through use of pictures, photos, videos, games, and/or role play. Although there are very few empirical treatment studies published, outcomes are promising. However, there is presently a lack of treatments that target other, or multiple, aspects of social cognition (such as those illustrated in Figure 1) in this population. More remediation efforts have been

developed and evaluated for use with other clinical population (Table 1 provides some exemplars of these). Treatment evidence across other populations also varies in its relevance to everyday life: ranging from artificial laboratory interventions to those that prioritise naturalistic interactions and transfer to real-life functioning. Most have found significant (or at least trend-level) improvements on outcomes assessed. Even so, it would appear that more naturalistic, experiential remediation approaches have the most potential to generalise to real world settings.

The case for developing social cognition treatments in TBI

It is clear there are many facets to, and interrelationships within, the social cognitive construct that influence social behaviour. We posit in Figure 1 how these processes may relate to each other: whilst this model is presently conceptual in nature, for many, deficits emerge related to these social cognitive processes following a TBI. Additionally, there is a growing evidence base detailing the interrelationships between these facets. Advancing this evidence base further to better our understanding of the mechanisms and relationships involved in social cognition will undoubtedly benefit this field. To date, treatments for people with TBI have tended to focus solely on emotion perception skills. Within the TBI literature, there has been the expressed need to broaden efforts so that multiple social cognitive skills are targeted to maximise treatment outcome (Neumann, Babbage, et al., 2014). This then lends the question: to what extent can the research in other clinical populations, notably ASD and SSD, be useful in formulating treatment of social cognition for people with TBI?

In considering this, the first issue to address is the theoretical underpinnings that would guide such remediation in a brain injury setting. There is an abundance of evidence for the potential for neuronal reorganisation and recovery following brain

injury (Bütefisch, 2004; Chen, Cohen, & Hallett, 2002; Hallett, 2001; Keyvani & Schallert, 2002). One theoretical model for rehabilitation is based around the notion that repetitive activation of target processes is required to harness this plasticity. Such repetition should cause repeated synchronous neural firing and subsequently increase the strength and density of synaptic connections (Robertson & Murre, 1999). Certainly, functional recovery and associated cortical changes have been seen in many motor, sensory and cognitive processes as a result of careful, targeted and graduated practice (see: Bornhofen and McDonald, 2008b; for review). To restore cognitive processes, Robertson and Murre (1999) argued for the need of both bottom-up (provision of perceptual cues) and top-down (attentional control strategies, e.g. rehearsal, self-instruction) rehabilitative strategies, coupled with repetition of precise targets to maximise the potential for neuronal recovery. Bornhofen and McDonald (2009) developed their Reading a Smile emotion perception treatment (Table 1) based on these principles with promising preliminary outcomes in TBI (Bornhofen & McDonald, 2008a, 2008c). The focused approach of most other treatments in TBI, and in other clinical disorders, is also consistent with this remediation model (e.g. Combs et al., 2008; Nahum et al., 2014; Russell et al., 2006).

Hogarty and Flesher (1999a, 1999b) advocated a similar approach, discussing the importance of perceptual cueing, grading the difficulty of tasks, and use of coaching within a holistic model, to enhance metacognitive strategy use in Cognitive Enhancement Therapy (Table 1) for people with schizophrenia. These principles have been widely used in many of the training approaches described above: for example, when targeting ToM, many programs described beginning by training simple perspective taking (e.g. holding physically different views to someone else), then building on these skills by increasing complexity over time (e.g. to culminate in

understanding of third-order embedded mental states). Further, participants are provided with multiple opportunities to practice these skills with reviews, feedback, and provision of strategies to use. From a psychotherapeutic perspective, it is likely that CBT approaches also have a great potential to offer. The social cognitive process can be understood as a multidimensional construct, with reciprocity between an individual's thoughts, feelings, and behaviour in any given social context (see Figure 1, and Bauminger, 2002; Couture, Penn, & Roberts, 2006; Spikman, 2016). Many of the treatments we described have been designed on these principles (Table 1) and CBT has been shown to have utility after brain injury for a range of mental health difficulties, in an adapted form (Hsieh et al., 2012; Khan-Bourne & Brown, 2003; Waldron, Casserly, & O'Sullivan, 2013).

Secondly, there are other confluences between people with TBI and other clinical populations that are relevant to remediation. Many individuals with SSD, ASD, and other disorders, have been found to have similar cognitive deficits to those with TBI: they can display a range of neurocognitive difficulties, including problems with processing speed, attention, working memory, verbal and visual learning, and executive functioning (Bâ, Zanello, Varnier, Koellner, & Merlo, 2008; Calhoun, 2006; Eack et al., 2013; Green, 2006; Green, Kern, Braff, & Mintz, 2000; Keefe et al., 2006; Lepage, Bodnar, & Bowie, 2014; Russo et al., 2007). Thus, there is good reason to believe that social cognitive techniques used to treat other clinical disorders may also be applied to the TBI context, albeit with the need to consider individual needs and the unique adaptations necessary for this population. Treatment provision in this population would need to reflect the severity of an individual's brain injury and particular needs identified through a thorough assessment and formulation to inform

whether restitution or compensatory approaches are most appropriate (Robertson & Murre, 1999; Wilson, 2005).

While deficits in emotion perception and ToM appear to be relatively similar across populations, the realm of interpretational biases appears to be one where special accommodations need to be made for the TBI context. For instance, the ‘jumping to conclusions’ bias appears less relevant to the TBI population than it does for those with psychosis, even in those who develop psychosis after TBI (Batty et al., 2016). Of greater relevance may be the need to target a ‘negative attributional bias’, as preliminary evidence suggests that people with TBI are more likely to assign intentional, hostile, and blaming attributions to others in social situations (Neumann et al., 2015). Considering irritability, anger, and aggression are common sequelae of TBI (Arciniegas & Wortzel, 2014; Baguley, Cooper, & Felmingham, 2006; Stéfan et al., 2016), this bias may be a particularly appropriate target in social cognitive treatments for this population. Little other research exists that investigates common attributional styles amongst people with TBI and their relation to social cognition. Still, recognising the role of interpretational biases in treatment likely still has therapeutic relevance for people with TBI, considering their role in social avoidance post-injury (Riley, Brennan, & Powell, 2004; Riley, Dennis, & Powell, 2010), and more broadly within cognitive-behavioural theory as an often implicit way of processing information, regardless of how such biases manifest (Beck & Dozois, 2011; Clark & Beck, 2010; Lang & Craske, 1997).

Further, one of the major attributes that we speculate as integral to social cognition in Figure 1, and has been recognised by others in the literature, is the necessity to have a well-developed understanding of the self and how self-knowledge differs from other-knowledge (Adolphs, 2009; Daubney & Bateman, 2015; Hess et

al., 1999). Relatedly, insight into one's own emotional experiences and responses likely interacts with the ability to then be able to recognise and understand others' emotional experiences. Training that explicitly addresses difficulties with such awareness and understanding has been lacking from treatment approaches in the current evidence base. However, this facet will require consideration in any treatment programs for people with TBI given that poor self-awareness is so commonly observed following injury (Prigatano, 2005) and can negatively impact rehabilitative outcome (Ownsworth & Clare, 2006). Whilst a number of treatments already exist that target low, or distorted, self-awareness for people with TBI (Fleming & Ownsworth, 2006; Tate et al., 2014), none have yet examined the impact of low self-awareness or presence of alexithymia in the context of social cognition remediation.

Finally, the broader social cognition literature is useful for highlighting the importance of the type of learning methods used to rehabilitate social cognitive deficits. Many of the programs developed in other populations have been limited by their lack of relevance to everyday life and their reliance on artificial materials that do not capture the essence, and nuances, of human social interactions. This lack of contextualisation may result in the individual losing motivation with the training approach whilst simultaneously minimising opportunities to transfer learned skills to everyday life. Indeed, few of the laboratory studies that used a secondary outcome measure of social functioning found generalisation effects. Within TBI rehabilitation, it has long been highlighted how important it is for rehabilitation to be contextualised and for it to be person-centred, collaborative, and factor for the diversity of human experience (Wilson, 1997, 2002; Ylvisaker & Feeney, 2000; Ylvisaker, Hanks, & Johnson-Greene, 2002). For this to be achieved in social cognition treatment, there needs to be consideration of: 1) an individual's unique goals in relation to their social

functioning, 2) psychoeducation about the impact of different aspects of social cognition (and such deficits) on emotions, beliefs, and behaviour, 3) discussion about real-life examples of when difficulties or misinterpretations have occurred in social interactions (including normalisation of these occurrences, increasing understanding of what was missed or misinterpreted, and building skills to reduce the probability of misunderstandings in the future), and 4) experiential learning and feedback of constructs discussed. Experiential learning could take the form of role plays, imitation, and mimicry, with repetition and practice emphasised (particularly outside of therapy sessions, ideally facilitated by a significant other). Such a contextualised approach may then lend itself more easily for any treatment gains to generalise into an individual's real-world everyday social interactions, and maintain these gains into the long term. This is an important goal for any rehabilitation effort in this population, considering the profound impact psychosocial difficulties can result in functionally after a TBI.

Conclusions

In conclusion, there is much we can learn about social cognition remediation from the wider clinical literature that also holds relevance for people with TBI. Within our model of social cognition (Figure 1), there is an interplay between the perceptions, interpretations, and inferences we make in relation to our own and others' cognitive and emotional experiences of the social world. This system relies on metacognitive awareness, including an awareness of the self versus other and awareness of one's own emotional experiences, as well as a myriad of biopsychosocial factors that can influence the information we perceive and filter, the social cognitive process itself, and the way we respond to social stimulation.

There is a clear need to develop and improve the rehabilitative efforts in the TBI population to target not only emotion perception but also other social cognitive skills, such as perspective taking, emotional self-awareness, and empathising, that are reportedly impaired in many. The ability to recognise interpretational biases and how these interact with emotion perception to influence thoughts and emotions about a particular social situation, are also important constructs to consider in order to formulate and treat difficulties in this area. The current under-recognition of the role of social cognition in rehabilitation outcomes, and the paucity of treatment programs for those with TBI is a disservice to the many who continue to have difficulties understanding the social world after their brain injury.

We have argued in this review for the need to develop broader social cognitive treatments for those with TBI, given treatment advances and efficacious findings in other clinical populations. Further, we have provided a compelling rationale why this evidence base can also largely apply to those with TBI, albeit with a number of considerations and modifications. Given the importance of social cognition for human social experience, this area offers great potential for future research, and importantly, the potential to advance evidence-based psychosocial treatments for those with a TBI to enable them to better navigate the social world.

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Table 1. Description of social cognition treatment program exemplars

Treatment	Target(s)	First Evaluated By	No of Articles	Population(s)	Description
Training of Affect Recognition (TAR)	EP	Frommann, Streit, and Wölwer (2003)	7	SSD	Length: 12 sessions, 45 min, 2 per week Format: group pairs, one facilitator (psychotherapist) Content: computer- and desk-based tasks to (1) identify and discriminate facial signs of six basic emotions; (2) reintegrate into holistic processing, including non-verbal cues and processing of different affect intensities; (3) integrate mimicked expressions into social, behavioural, and situational context.
Micro-Expression Training Tool (METT)	EP	Russell, Chu, and Phillips (2006)	4	SSD	Length: 1 session, 40-60 min Format: individual, with facilitation Content: computer-based program that (1) shows four pairs of commonly confused facial emotions in slow-motion video sequence (anger/disgust, contempt/happy, fear/surprise, fear/sadness); important distinctions explained verbally while participant instructed to attend to visual display and verbal commentary. Following, (2) participant practices labelling still micro facial expressions (shown for 1/25 sec), with feedback; then (3) watches review video, similar to (1) but with different faces.
Mind-Reading: Interactive Guide to Emotions (MRIGE)	EP	Golan and Baron-Cohen (2006)	2	ASD, SSD	Length: 10-15 weeks, 2 hours per week Format: individual, independent use (can be facilitated/supplemented with group sessions) Content: computer-based database of emotions, organised systematically based on emotion groups and developmental levels. Users access (1) an emotion library: emotions are defined, demonstrated in silent films of faces and voice recordings, written sentences of situational examples; (2) a learning centre: emotion lessons and quizzes; and (3) the game zone.
Reading a Smile: An Emotion Perception Treatment Program	EP	Bornhofen and McDonald (2008)	3	TBI	Length: 14-16 sessions, 90 min, 2 per week Format: group pairs, one facilitator (therapist) Content: tasks and games (vignettes, audio recordings, videos, role play, therapist modelling, homework), hierarchically structured to (1) interpret conventional emotional contexts (social knowledge); (2) judge static visual emotion cues; (3) judge dynamic emotion cues (via single and multiple modalities); (4) use emotion cues to evaluate social behaviour and interactions; and (5) make social inferences based on emotion and situational cues.
Mentalization-Based Treatment (MBT)	ToM	Bateman and Fonagy (1999)	11	BPD, self-harm, other PD	Length: 18 months, 1 per week Format: individual psychotherapy, supplemented with group sessions Content: sessions focus on the process of mentalizing within a close attachment relationship, encourage client to perspective take through active therapeutic stance: demonstrating empathy; exploring, clarifying, and (sometimes) challenging perspectives; identifying affect; and mentalizing the therapeutic relationship.
Emotion and Theory of Mind Imitation Training (ETIT)	EP, ToM	Mazza et al. (2010)	2	SSD	Length: 8 sessions, 50-min, 2 per week (over 12 weeks) Format: closed group, four facilitators (psychologist, psychiatrist, two rehabilitation therapists) Content: C-B approach (psychoeducation, cognitive restructuring, role-play, reinforcement, homework) to (1) use eye gaze to predict another's intention; (2) observe and imitate facial emotion expressions; (3); infer a character's mental state and emotion shown in a sequence of sketches; and (4) attribute intentions to others based on the congruity/incongruity of comic-strip story endings.

Metacognitive Training (MCT)	ToM, IB	Moritz & Woodward (2007)	21	SSD, BPD	Length: 8 sessions, 45-60 min, 2 per week (recommend complete twice) Format: open group (3-10 participants), one facilitator (MH therapist); adapted for 1:1 format Content: C-B approach (psychoeducation, guided discovery, tasks, homework): (1) normalization; (2) facilitating insight into cognitive biases and their role in delusions; and (3) introducing doubts in belief conviction.
Social Cognition and Interaction Training (SCIT)	EP, ToM, IB	Penn et al. (2005)	16	SSD, ASD, BD	Length: 20-24 sessions, 45-60 min, 1 per week Format: closed group (5-8 participants), two facilitators (MH therapist) Content: C-B approach (psychoeducation, group discussions, role play, therapist modelling, homework) to (1) develop emotion perception skills (through use of photos, videos); (2) learn to 'figure out situations' (focus on attributional biases and ToM); and (3) test out using skills in relation to everyday experiences.
Theory of Mind Treatment	EP, ToM + SS	Steerneman et al. (1996)	4	Children with SBD, PDD-NOS, ASD	Length: 16-21 sessions, 60 min, 1 per week (has been modified to 8 sessions) Format: closed group (4-8 participants), 1-2 facilitators (MH therapists) Content: skills-based approach with focus on (1) conversational and friend-making skills; (2) emotion recognition (happy, anger, fear, sadness); and (3) first- and second-order ToM. Progressively more difficult activities, e.g. describing different physical perspectives in room, videotaped role play with feedback, puppets acting out a story with group discussions inferring characters' mental states and metacognition. Monthly parent sessions of psychoeducation and suggested activities to promote ToM. Also involved in homework setting and completion.
Virtual Reality Social Cognition Training (VR-SCT)	EP, ToM + SS	Kandalaft et al. (2013)	1*	ASD	Length: 10 sessions, 60 min, 2 per week Format: individual (represented in VR as an 'avatar'), two facilitators (clinicians: a "confederate" and a "coach, also 'avatars') Content: VR environment (e.g. office, restaurant, shops, apartment, coffee house, school, park). User logs into VR environment as avatar, engages with confederate in social situation (e.g. conversation with friend, meeting strangers, job interview), guidance from coach. User given psychoeducation and feedback on performance to incorporate in subsequent social interactions.
SocialVille	EP, ToM + Cog	Nahum et al. (2014)	1*	SSD	Length: 24 hours total: 60-120 min per day, 2-5 per week, 6-12 weeks Format: individual, independent use Content: drill-based computer tasks based on neuroplasticity learning principles. 19-23 exercises in online "city" (locations to visit), graduated in difficulty and complexity (e.g. decrease stimulus presentation time, increase foils, use subtler cues). Each trial trains processing speed, working memory, and attention in tasks of facial affect recognition, emotional prosody, and social stories. User given feedback and rewards after each trial.
Cognitive Enhancement Therapy (CET)	ToM, IB + Cog + SS	Hogarty et al. (2004)	12	SSD, ASD	Length: 24 months, 60-90 min, 2 per week Format: group pairs, larger group after 4-6 months (3-4 pairs), one facilitator (MH therapist) Content: cog rehab (attention, memory, problem solving) for ~6 months. 56-week program of CET: continued cog rehab and group C-B tasks graduated in difficulty (psychoeducation, group activity e.g. videotaped role play, pros and cons of real-life social dilemmas, review and feedback, homework) to (1) shift from concrete to gistful thinking; (2) perspective take; (3) appraise affect and social contexts; and (4) initiate and maintain conversations.

* Preliminary case series with limited efficacy findings

Index: ASD = autism spectrum disorder, BD = bipolar disorder, BPD = borderline personality disorder, C-B = cognitive-behavioural, Cog = cognition, EP = emotion perception, IB = interpretational biases, MH = mental health, PD = personality disorder, PDD-NOS = pervasive developmental disorder – not otherwise specified, SBD = social behavioural difficulties, SS = social skills, SSD = schizophrenia spectrum disorder, TBI = traumatic brain injury, ToM = Theory of Mind.

Figure 1. A conceptual biopsychosocial model of processes involved in social cognition