Sex-Based Differences in Affective and Cognitive Empathy Following Severe Traumatic Brain Injury

Barbra Zupan, Dawn Neumann, Duncan Babbage, Barry Willer

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ABSTRACT

Objective: To examine sex differences in self-ratings for affective and cognitive empathy for males and females with traumatic brain injury (TBI) and compare these to observer ratings.

Method: Self and Observer (e.g. spouse) ratings of affective and cognitive empathy were obtained for 160 participants (116 males) with severe TBI, using the Interpersonal Reactivity Index Empathic Concern (EC) and Perspective Taking (PT) subscales, respectively.

Results: When compared to sex norms, female self-ratings were significantly lower for both subscales, whereas men's self-report ratings were only lower for PT. For EC, more women (44%) were found to be substantially below the normative means ($\geq$ 2 SDs) than men (17%), $p<.001$. When comparing women and men with TBI, self-report and observer ratings indicated both sexes had similar empathy levels (both subscales). Self versus observer ratings showed that women's self-ratings were significantly higher than observer's ratings on PT ($p <.001$); men's self-ratings were significantly higher than observer's ratings on PT ($p<.001$) and EC ($p=.009$).

Conclusions: In contrast to the typically observed superior female empathy, this study suggests this advantage may disappear after a TBI, and possibly result in a disadvantage compared to their uninjured female peers. Theoretical implications of self-awareness and cultural gender expectations for empathy are discussed.

KEY WORDS: empathy, affective empathy, cognitive empathy, sex, traumatic brain injury

PUBLIC SIGNIFICANCE:

1. Empathy allows us to care about, understand, and share another person's emotional experience, so it is important for successful social interactions.
2. Compared to their uninjured female peers, women with TBI were found to have significant difficulty with affective empathy, indicating that in social interactions, they will struggle to share in and appropriately respond to someone else's feelings. This is especially problematic for women because we generally expect them to show more warmth and concern than men.
3. Even though men and women with TBI had similar scores for both affective and cognitive empathy, we concluded that this is a larger problem for women and puts them at a greater social disadvantage because uninjured women generally show much stronger empathy than uninjured men. Thus, our cultural expectations would likely lead us to judge women with TBI more harshly when they don't demonstrate expected empathy.

1. INTRODUCTION

Empathy is an essential component of the development of pro-social behavior and fundamental to successful social interactions because it allows us to care about, understand, and share another person's emotional experience (Hillis, 2014; Neumann et al., 2014, 2012; Rueckert and Naybar, 2008). Empathy is a multifaceted construct that includes at least two distinct, but related components—cognitive and affective empathy (de Sousa et al., 2010; Reniers et al., 2011). Cognitive empathy refers to the ability to take someone else's perspective (Davis, 1980; Pelphrey et al., 2004) while affective empathy refers to the ability to share in and appropriately respond to someone else's feelings (Davis, 1980; Hillis, 2014; Hooker et al., 2010). Both require the capacity to recognize how someone else is feeling through nonverbal and situational cues (McDonald, 2013; Reniers et al., 2011; Williams and Wood, 2010), as well as the ability to contrast someone else's emotional state with one's own personal emotional experiences (McDonald, 2013; Neumann et al., 2014).

Reduced cognitive and affective empathy following severe traumatic brain injury (TBI) have been well documented (de Sousa et al., 2011, 2010; Rushby et al., 2016; Shamay-Tsoory et al., 2004, 2003; Spikman et al., 2012; Williams and Wood, 2010; Wood and Williams, 2008). Reduced empathy contributes to the poor social outcomes reported following TBI and has been identified as the key behavior influencing caregiver distress and life satisfaction (de Sousa et al., 2011; Wells et al., 2005). Thus, reduced empathy may be compromising both the quantity and quality of people's relationships following TBI, particularly since it impacts such a large proportion of this population. It has been reported that 60-70% of people with TBI have low affective empathy (de Sousa

et al., 2010; Williams and Wood, 2010; Wood and Williams, 2008) and approximately 50% have low cognitive empathy (de Sousa et al., 2010).

A related concept to empathy is emotional contagion, which is the tendency to synchronize one's emotional expressions with someone else's and actually feel what someone else is feeling (Coplan, 2010, 2006; Hatfield et al., 2009). De Sousa et al. (2010; 2011) found that reduced affective empathy was accompanied by reduced emotional contagion. Reduced mimicry (automatic and subtle changes in one's muscular activity to match the expressions of others) has also been reported to occur alongside reduced empathy, particularly for negatively-valenced emotions (de Sousa et al., 2010). The emotional convergence that results between the two individuals engaged in social interaction as a result of emotional contagion and mimicry contributes to empathy because the feedback people receive from their own muscles when they adopt the expressions of others leads them to also feel that emotion (Coplan, 2006; Hatfield et al., 2009; MacDonald, 2003; Meltzoff and Decety, 2003).

Sex differences have been reported for people with and without TBI for other components of social cognition related to empathy, including emotion recognition (Collignon et al., 2010; Rigon et al., 2016; Rosip and Hall, 2004; Schirmer et al., 2005; Zupan et al., 2017) and Theory of Mind (Turkstra, 2008), as well as emotional contagion and mimicry (Dimberg and Lundquist, 1990; Lundquist, 1995; Sonnby-Borgstrom et al., 2008, 2003). Research with non-injured men and women has shown a female advantage for empathy (Baron-Cohen and Wheelwright, 2004; Chopik et al., 2017; Rueckert and Naybar, 2008), particularly for affective empathy (Davis, 1980; Marzoli et al., 2011). Thus, there is reason to believe that there would also be sex differences in levels of

affective and cognitive empathy following TBI. To our knowledge, only Wood and Williams (2008) have examined sex differences in the frequency of low empathy in males versus females following TBI. Using the Balanced Emotional Empathy Scale (BEES; Mehrabian, 2000), a self-report measure of affective empathy, they found that proportionately more males with TBI reported low empathy than females with TBI, supporting the trend reported in non-injured populations. Overall, Wood and Williams' results showed low empathy in both males and females with TBI when compared with controls, with a higher proportion of males showing low empathy overall. However, this study only examined affective empathy. Thus, it remains unclear whether the lower empathy reported for males with TBI is specific to affective empathy, or whether males would also show lower cognitive empathy than females. Moreover, Wood and Williams did not obtain information about how others' perceived empathy levels in the person with TBI. This is a notable gap given the frequency of self-awareness problems following TBI (which may impact self-ratings) and the relevance empathy has to interpersonal relationships.

The primary objective of the current paper is to explore sex differences for affective and cognitive empathy in men and women with severe TBI. Since people with traumatic brain injury under-report emotional difficulties (Barker et al., 2011), particularly people with severe TBI (Spikman et al., 2010), we will additionally examine independent ratings completed by an observer, named by the person with TBI (e.g., family member, friend, caseworker).

The study had the following aims: Specifically, we aim to answer the following questions: 1) To compare post-TBI empathy (affective and cognitive) self-ratings to

normative scores; 2) To examine differences in empathy (affective and cognitive) between men and women with TBI, as perceived by self and an observer; and 3) To compare differences between self and observer empathy (affective and cognitive) ratings. Based on the findings from Wood and Williams (2008) and Williams and Wood (2010), we hypothesized that our participants with TBI would rate themselves substantially lower than the normative sample, and that these differences would be significantly greater for men than for women. We also hypothesized that women would have higher affective and cognitive empathy scores than men. Further, we anticipated that the observers' ratings would be significantly lower than self-ratings. This hypothesis is based on findings from a study on life satisfaction of caregivers: Wells et al. (2005) found that caregivers were more likely to report reduced empathy in their loved one with TBI, than the person him or herself.

2. METHODS

2.1. Participants

Participants for the current study were recruited from [redacted] as part of a larger randomized control trial addressing treatment effects. Ethics approval was received from all participating institutions and all participants provided written consent prior to participation. Participants were recruited from local brain injury support groups and out-patient brain injury rehabilitation centers on the basis of injury type (i.e., TBI and not other forms of neurological injury) and severity.

A total of 160 participants with severe TBI were included in the current study. Injury severity was determined by one of the following: Glasgow Coma Scale of eight or

less; loss of consciousness (LOC) of at least 24 hours; or post-traumatic amnesia (PTA) of seven or more days. Although participants needed to meet severity criteria for only one of these areas to participate in the study, the majority of participants (n=101; 63%) provided information for at least two. Of the 65 participants who provided a GCS score, 56 (86%) of them met the injury severity criterion (Mean 5.17; SD=3.05). Eighty-four participants provided LOC information, all of whom met the 24-hour criterion for severe TBI (Mean 42.35 days; SD=63.64). The majority of participants (n=141) provided information on PTA, 140 of whom were classified as severe.

Participants ranged between 21 and 65 years of age (mean=41.15;SD=12.18) and had an average of 13 years (SD=2.31) of education. Average age of injury was 32.29 years (SD=12.53) and average time post-injury was 8.83 years (SD=8.10). The majority of participants had acquired their injury as a result of a motor vehicle accident involving either a car or motorcycle (65%), followed by falls (14%), then assaults (8%). 5% of the participants were struck by a motor vehicle as pedestrians, 6% sustained their injury as a result of bicycling, boating or ATV incident, and 2% as a result of medical or unknown causes.

To participate in the study, participants had to have sustained their injury after the age of 18 and at least one year prior to study participation. They also had to demonstrate the ability to sufficiently understand basic oral and written English as determined by interaction with the investigator during the scheduling and consent process. In addition, participants also had to show sufficient language comprehension (75%) on either the written or oral version of the Discourse Comprehension Test (Brookshire and Nicholas, 1993). Participants were excluded from study participation in the presence of pre-morbid

developmental or acquired neurological disorders, major psychiatric disorder, current substance dependence and/or uncorrected and impaired vision/hearing.

Each participant was asked to identify an observer to complete a series of questionnaires, including the IRI. Only the IRI data is reported here. In naming an observer, participants were asked to name someone they see often enough that he/she could accurately respond to questions about the participant's capabilities within everyday situations. Table 1 lists the nature of relationship of observers to participants by sex for observers who completed the questionnaires. The number of males and females within each relationship category is also listed.

----------INSERT TABLE 1 ABOUT HERE----------

2.2. Measures and Procedures

All participants who participated in the current study completed a wide range of tests as part of the larger randomized control study that assessed cognition, language comprehension, olfaction, community integration, interpersonal behavior, emotional inferencing, emotion recognition, and empathy. Only the empathy measure will be discussed here.

2.2.1.The Interpersonal Reactivity Index (IRI)(Davis, 1980)

The Interpersonal Reactivity Index (IRI), a self-report measure, was administered in its entirety, but only the two subscales used to assess affective and cognitive empathy are discussed here. Affective empathy was assessed using the Empathic Concern (EC) scale, which measures a person's capacity to have feelings of warmth, compassion, or concern for others. The Perspective-Taking scale of the IRI measures a person's ability to understand someone else's point of view and was thus used as a measure of cognitive

empathy. Each of these two scales includes a total of seven statements (e.g., Before criticizing somebody, I try to imagine how I would feel if I were in their place) that participants must rate using a 5-point Likert scale ranging from A (does not describe me well) to E (describes me very well). The IRI was initially validated using college-aged students (579 males; 582 females) but has since been used in a range of adult populations (Beven et al., 2004; Lauterbach and Hosser, 2007; Oswald, 2003; Silani et al., 2008; Yarnold et al., 1996). The IRI has been reported to have good psychometric properties (Baldner and McGinley, 2014; Davis, 1983, 1980; De Corte et al., 2007; Fernandez et al., 2011), including stable test-retest reliability and good internal consistency (Davis, 1980; De Corte et al., 2007). This test was chosen for the current study because it has been successfully used in several studies investigating empathy following TBI (de Sousa et al., 2010; Muller et al., 2010; Shamay-Tsoory et al., 2003), and because it differentiates cognitive and affective empathy. Although the IRI has not been validated using observer data, research comparing self and other ratings have shown at least moderate agreement (Cliffordson, 2001; Hodgson and Wertheim, 2007) and the use of observer ratings alongside self-report ratings is considered necessary when evaluating people with TBI (Bivona et al., 2014; Williams and Wood, 2010).

Participants were seated in front of a computer screen. Each statement was displayed on the screen and also read aloud by the examiner. Also displayed on the screen was the 5-point Likert scale ranging from A (does not describe me well) to E (describes me very well). After being read the statement, participants were asked to use the Likert scale to rate how well each statement describes them. The score for each scale ranges from 0 to 28, with higher scores indicating higher levels of empathy.

246 **2.3. Statistical Analyses**

247 To address the first aim of the study, raw scores were used in one-sample *t*-tests to
248 compare the mean score of each subscale for our participants with TBI to the normative
249 mean scores reported for non-injured men and women. In addition, *z*-scores were
250 calculated for the EC and PT subscales of the IRI using sex-adjusted normative scores
251 and then used in chi-square testing to determine the proportion of men and women with
252 TBI who showed impaired affective and cognitive empathy (≥2SD below the normative
253 mean). To address the second aim, a 2 x 2 mixed analysis of variance was conducted for
254 the EC and PT subscales using raw scores, with self-report responses for each subscale as
255 the within subjects variable and sex as the between subjects variable. A second 2 x 2
256 mixed analysis of variance was conducted using observer ratings for the EC and PT
257 subscales as the within-subjects variable and sex of the participant as the between
258 subjects variable. For the third aim, raw scores were used in one-way analyses to
259 compare observer ratings of men versus women with TBI for the EC and PT empathy
260 scales. Paired samples *t*-tests were then conducted to compare observer ratings to self-
261 report ratings for women and for men for each subscale. Only raw scores were used in
262 analyses to address aim three because there is no normative data available for observer
263 ratings for the IRI. All analyses were completed using SPSS statistical software and an
264 alpha level of .05 was used for all comparisons. The Holms-Sequential Bonferroni
265 procedure was applied to control for Type I error (Holm, 1979). This method has been
266 recommended for neuropsychology research where more conservative methods (i.e., the
267 traditional Bonferroni adjustment method) do not account for interrelated variables likely
268 to be present (Eichstaedt et al., 2013). Using this procedure, α=.05, but p-values are

adjusted based on the number of comparisons, in ascending order. For a detailed explanation, see Eichstaedt et al. 2013.

3. RESULTS

In total, 116 males and 44 females were included in the current study. Males and females did not significantly differ in age, level of education, age of injury or time since injury (see Table 2).

Although all participants named an observer, only 134 completed the questionnaires, 96 for the male participants and 38 for female participants. Using only observers who completed the questionnaires, the overall range of relationship of observers to participants did not differ between men and women, $X^2(6)=9.75$ $p=.136$. However, the number of support workers versus friends named as observers significantly differed between men and women, $X^2(1)=7.46$ $p=.01$, with women naming few support workers as their observer than men. Overall, participants named more female observers who completed the questionnaires (n=87) than male observers (n=24). This difference was significant for both male [$X^2(5)=22.98$ $p<.001$] and female [$X^2(5)=21.58$ $p=.001$] participants.

----------INSERT TABLE 2 ABOUT HERE----------

For information purposes, table 3 lists the total IRI score and the score for each subscale by men and women. Only the EC and PT subscales were analyzed here. Figure 1 displays the normative mean raw scores for non-injured men and women reported in the IRI for both the EC and PT subscales, as well as self-report and observer ratings for the EC and PT subscales for men and women with TBI in this study.

----------INSERT TABLE 3 ABOUT HERE----------

----------INSERT FIGURE 1 ABOUT HERE----------

3.1. Aims

3.1.1.Comparison of empathy scores for men and women with TBI to normative scores.

Using the available normative data for men and women for the EC and PT subscales of the IRI, one sample *t*-tests were conducted to determine whether self-reported EC and PT of men and women with TBI in the current study significantly differed from the self-reported norms in the IRI (scores are reported in table 4). For EC, average self-report scores for women with TBI were significantly lower than the normative mean for women, $t(42)=4.34$, Holm's adjusted $p<.001$, 95% C [-4.12, -1.50]. Average self-reports for men with TBI did not significantly differ from the normative mean for men, $t(115)=.34$, Holm's adjusted $p=.734$, 95% C [-.76, 1.08]. Average self-reports for PT by women with TBI were significantly lower than normative mean PT scores for women reported in the IRI, $t(43)=4.64$, Holm's adjusted $p<.001$, 95% C [-5.42, -2.14]. Men with TBI also had significantly lower self-reported PT scores than the average normative scores for men, $t(115)=2.73$, Holm's adjusted $p=.014$, 95% C [-2.73, -.43]. See Figure 1.

To further address this question of the study, we used *z*-scores to compare the proportion of men and women with TBI who showed impaired affective and/or cognitive empathy (see table 4). Men and women with TBI were identified as impaired if their self-reported score for the subscale (EC; PT) was two or more standard deviations lower than the normative groups' mean scores for their sex. For EC, a significantly larger proportion of women with TBI were found to be impaired than men with TBI, $X^2(1)=12.30$, $p<.001$.

The proportion of women found to be impaired for PT did not significantly differ from the proportion of men, $X^2(1)=1.14$ $p=.284$.

----------INSERT TABLE 3 ABOUT HERE----------

3.1.2. Differences in empathy between men and women with TBI.

A 2 x 2 mixed design ANOVA was conducted with self-ratings for IRI subscale (EC; PT) as the within-subjects variable and sex as the between-subjects variable. Overall, participants rated their capacity for EC higher than their PT abilities, as indicated by a significant main effect of IRI subscale ratings, $F(1, 157)=78.82$, $p<.001$, $\eta_p^2 = .33$. There was no effect of sex on IRI subscale scores, $F(1, 157)=.573$, $p=.45$, $\eta_p^2 = .00$ and the interaction between these variables was not significant, $F(1, 157)=.389$, $p=.534$, $\eta_p^2 =.002$.

A second 2 x 2 mixed design ANOVA was conducted to compare observer ratings on the IRI subscales for men and woman with TBI. Only the 134 participants (96 males; 38 females) for whom observers completed the IRI questionnaire were included in this analysis. Similar to self-ratings, observers rated EC capacity as higher than PT abilities for participants, $F(1,123) = 134.14$, $p <.001$, $\eta_p^2 =.552$. Although observers did not rate men and women differently, $F(1, 123)=.349$, $p=.556$, $\eta_p^2 =.003$, a significant interaction was found, $F(1, 123) = 4.44$, $p=.037$, $\eta_p^2 =.035$. Examination of observer ratings within each sex showed that for women, observers rated affective empathy (EC) significantly higher than cognitive empathy (PT), $t(34)=7.5$, Holm's adjusted $p<.001$, 95% C [6.520, 11.366]. This also occurred for men—observer ratings were significantly higher for EC than PT, $t(89)=9.23$, Holm's adjusted $p<.001$, 95% C [4.857, 7.521]. See Figure 1.

3.1.3.Comparison of Observer ratings with Self-report ratings

As can be observed in Figure 1, we found that observers rated perspective-taking skills of women with TBI significantly lower than women rated themselves, $t(34)=4.11$, Holm's corrected $p<.001$, 95% C [3.164, 9.350]. Observer and self-report ratings did not significantly differ for women on the EC scale, $t(36)=.724$, Holm's corrected $p=.474$, 95% C [-1.851, 3.905]. For men, observer ratings were significantly lower than self-reported ratings for both EC, $t(91)=2.67$, Holm's corrected $p=.018$, 95% C [.607, 4.132] and PT, $t(93)=4.63$, Holm's corrected $p<.001$, 95% C [2.489, 6.234, subscales.

4. DISCUSSION

The primary aim of the current study was to examine sex differences in affective and cognitive empathy following TBI. The first aim was to compare self-reported affective and cognitive empathy for men and women with TBI to available self-report normative data. We hypothesized that both men and women with TBI would show significantly lower empathy than expected from the normative data and that this difference would be greater for men. Our hypothesis was only partially supported. Women with TBI rated themselves significantly lower than the normative means for women for both affective and cognitive empathy, while men with TBI only rated themselves lower for cognitive empathy. Contrary to our hypothesis, significantly more women with TBI were found to have impaired affective empathy than men. These results suggest that reduced empathy may be a greater problem for women following TBI than men, particularly for affective empathy. Our results for affective empathy differ from those of Wood and Williams (2008) who found men with TBI to be more impaired than women. The conflicting result may reflect differences in the measures used. We

measured both cognitive and affective empathy, in contrast to Wood and Williams who only measured affective empathy. Directly comparing affective empathy measures, we used the EC scale of the IRI, which concentrates mainly on one's compassion and concern for another person, whereas Wood and Williams (2008) used the Balanced Emotional Empathy Scale (BEES), a scale which has a stronger emphasis on the ability to experience the emotions of others. These differences in focus may account for our incompatible findings. Another possibility is a cultural difference ([redacted] versus [redacted]), which is something that should be explored in future studies.

The second aim of the current study was to compare self-reported affective and cognitive empathy for women and men with TBI. Given the normative data available for the IRI and previous studies with non-injured adults, largely showing females to be superior to men in both types of empathy, we had hypothesized that women with TBI would score significantly higher than men on both subtests. Instead, we found no significant difference in responses between men and women for the EC or PT subtests. Notably, this same result was also found for observer ratings, providing further evidence to suggest that men and women do not differ in their empathy after TBI. It is possible that uninjured females more fully engage regions of the brain that make them more empathic (Rueckert and Naybar, 2008; Schulte-Ruther et al., 2008), but that these regions become disrupted after the TBI, causing them to lose this advantage. Another possibility may involve cultural beliefs and expectations. Stereotypical beliefs that women should show more warmth and concern than men, and that women are more likely to consider others' viewpoints may have led to more critical self and observer ratings for females

than for males (Despins et al., 2015), thereby equalizing the overall rating scores. Interestingly, self-report measures of empathy have been reported to result in higher empathy scores for women because women are motivated to rate themselves in line with the sex-based cultural expectations that exist for social behavior for women (Christov-Moore et al., 2014; Despins et al., 2015; Gleichgerrcht and Decety, 2013; Klein and Hodges, 2001), yet the women with TBI in our current study rated themselves more severely. Perhaps the women in the current study did not consider cultural expectations when responding to the IRI and thus were rating themselves without this motivating factor. Alternatively, they may have been more critical in their self-ratings because of previous negative interactions they experienced as a result of their low empathy, thus triggering more critical self-ratings.

Another possible explanation for our unexpected findings could be poor self-awareness. Since people with TBI are known to have poor insight into their own difficulties, particularly those related to social cognition, we compared self-report and observer ratings as our third aim. Men rated themselves significantly higher than observers rated them for both EC and PT, suggesting an overall lack of awareness and insight into their difficulties with empathy. However, for women, findings were somewhat mixed on their agreement. Ratings by observers and women with TBI were discrepant for Perspective Taking, but similar for Empathic Concern. It is uncertain as to whether this, in part, supports the possibility that women have some insight into their difficulties with affective empathy, or whether both self-ratings and observer ratings were motivated by stereotypical beliefs and expectations regarding how warm or caring women should be (Prentice and Carranza, 2002), or some combination of the two. If

culturally, women are expected to show warmth and concern and they do not, they may receive harsher feedback during social interactions than males (Haag et al., 2016). In other words, women with TBI may receive responses within their social environments (Wood and Eagly, 2000) that help heighten their awareness of their difficulties. Women with TBI have been previously reported to more accurately rate themselves than men in areas of social communication (Despins et al., 2015). They also experience better social outcomes than men (Farace and Alves, 2000), which further suggests increased awareness around pro-social behavior. Future studies exploring empathy using self-rating scales should additionally include a measure of awareness and potentially a more objective measure of empathy, such as tasks that involve responding to vignettes or hypothetical scenarios or a perspective-taking test. Exploring the relationship between awareness and self-reported empathy may provide further insight into how this behavior is impacted for men versus women following TBI.

5. STUDY LIMITATIONS

To evaluate affective and cognitive empathy in people with TBI, we chose to use the Interpersonal Reactivity Index (IRI), a scale previously used with a range of adult populations, including adults with TBI. While this scale has been reported to have good psychometric properties, it is a self-report measure. Responses to self-report measures by people with TBI are susceptible to a lack of self-awareness, and in fact, comparison of self-report and observer data in the current study did indicate a discrepancy. Self-report measures for empathy may also result in responses motivated by cultural stereotypes and expectations, by both the individual him/herself and observers asked to rate them. Without objective measures of empathy, it is difficult to draw concrete conclusions about

sex differences in affective and cognitive empathy following TBI. Future studies should incorporate tests that use vignettes or short video clips alongside any self-report measures, or utilize performance-based perspective-taking tasks.

Future studies of this nature should also include a test of self-awareness and/or emotional awareness. A questionnaire that asks participants to rate traits and/or characteristics in terms of how masculine/feminine or how socially desirable each trait/characteristic would be for a man or woman would also be useful. Including a questionnaire of this type would allow us to determine the degree to which people's cultural expectations were driving empathy ratings.

Given previous research that has reported a correlation between affective empathy, emotional contagion, and facial mimicry (Hatfield et al., 2009), adding an emotional contagion scale (e.g., Doherty, 1997) and a dynamic emotion recognition task alongside empathy measures would be beneficial. Myoelectric activity (EMG) measures of muscles in the face conducted during a task of this nature would be important in qualifying the self-report responses and or supporting data from an empathy based task (e.g., vignettes). Using an emotion recognition task would allow us to further confirm results of self-report measures since previous research has found a positive relationship between affective empathy and the ability to recognize emotion in faces (Blair, 2005). Using an emotion recognition task that is dynamic in nature would allow us to explore this relationship in a more ecologically valid manner, further informing our understanding of sex differences following TBI. Moreover, including EMG measures alongside tests of empathy, emotional contagion, and emotion recognition may provide insight into whether men and women with TBI differ in their ability to generate and

454 regulate their emotional responses towards others and whether any difference that might
455 occur depends on the valence of the emotion conveyed. Given that brain imaging studies
456 have shown differences in the neuronal structures activated in response to emotional
457 stimuli for men versus women (Campanella et al., 2004; Killgore et al., 2001; Krach et
458 al., 2009; Lee et al., 2002; Li et al., 2008; Schirmer and Kotz, 2003; Wildgruber et al.,
459 2002), information such as this would contribute to our knowledge of the neural systems
460 that drive empathy, dynamic emotion recognition and emotional contagion.

461 Participants in the current study were asked to identify an observer to complete a
462 series of questionnaires about their social-cognitive behavior. Not all observers named
463 participated in the study and not all who did, identified their own sex on the
464 questionnaires. In addition, the relationship the observers had with participants varied
465 widely and the length of that relationship was not specified. Observers were not asked to
466 compare the individual's current capacity for empathy with their capacity prior to injury,
467 but these types of comparisons may have been occurring regardless, particularly since the
468 majority of observers for both men and women were family members. Varied
469 relationships may also have impacted ratings simply due to the frequency and situations
470 in which the observers interact with the individual they were asked to rate. For instance,
471 it is plausible that ratings by a parent for an adult child living with him/her would include
472 considerations of a wider range of social interactions and situations, than ratings by a
473 support worker. While it would have been ideal to have consistency in the type of
474 relationship the observers had with the person with TBI, it does not seem a practical or
475 likely prospect. However, future research could ask observers more specific questions
476 about the length and nature of their relationship with the participant. In the current study,

there was not an overall difference between men and women in the type of observer named. This finding was likely due to the similar proportion of men and women who named either a parent or spouse/partner as their observer, the two largest categories of observers. When these categories were removed from the analysis, men were more likely than women to name a support worker as their observer, and women were more likely than men to name a friend. Given that women with TBI are reported to have better social outcomes than men, this pattern should not be surprising. However, the overall numbers of observers named who were not family was small so it would be imprudent to draw conclusions on this data. Future research may consider asking participants to name two observers which may extend the overall number of observers who participate, but also broaden the categories of types of observers. This would allow for a more in-depth analysis of how empathy (or other social-cognitive behaviours) are impacting an individual's relationships.

The purpose of the current study was to compare cognitive and affective empathy within a large group of people with severe TBI. Nonetheless, the lack of a matched control group might still be viewed as a limitation. Although the IRI includes normative data for men versus women, the data was primarily collected using college aged adults. Future studies of sex differences in empathy should include a healthy control group closely matched for age, sex, and education of the participants with TBI. Although the imbalance between the number of males and females included in the current study is representative of rate of incidence of head injuries in men versus women (Colantonio et al., 2010; Faul et al., 2010; Nalder et al., 2016), including a larger, or at least more closely matched number of females in future studies, would also be beneficial.

6. CONCLUSIONS

This is the first study to investigate sex differences for both affective and cognitive empathy following TBI. In contrast to the typically observed superior female empathy, this study suggests this advantage may disappear after a TBI, and possibly result in a disadvantage for women compared to their uninjured female peers. Results showed no sex differences in how men and women rate themselves for Empathic Concern (EC) or Perspective Taking (PT) following TBI, or in how observers rate them. While this suggests that their capacity for empathy is similar to each other following TBI, normative data for women indicates that women should have higher levels of both affective and cognitive empathy than men. In other words, similar raw scores suggest that women are in fact having more relative difficulty than men. Using normative data as a baseline, women with TBI in the current study were found to be significantly more impaired than men with TBI for affective empathy, but not cognitive empathy. This study highlights that empathy deficits are prevalent in women following TBI (>40%) despite the fact there is an underlying assumption that being female makes them less vulnerable to social-cognitive deficits following TBI(Despins et al., 2015; Farace and Alves, 2000; Rigon et al., 2016; Turkstra, 2008). While this may be true for some areas of social cognition (i.e., emotion recognition), it does not appear to be true for affective or cognitive empathy.

Self-report and observer ratings both suggested that cultural expectations were influencing responses—that women should show more warmth and concern than men. Future studies investigating sex differences in empathy following TBI need to include self-awareness and task-based empathy measures so we can better understand sex-based

differences in this area of social cognition. Such understanding would assist clinicians when they are identifying goals for intervention and may lead to treatments specifically tailored for women or men with TBI because it would provide us insight into whether or not women have greater self-awareness of their deficits in affective empathy. If greater awareness is present, our approach to treatment would differ for affective versus cognitive empathy and also for women versus men. For instance, while women who have awareness of their affective empathy deficits may benefit from group treatment approaches, perspective taking may be better approached in individualized treatment sessions that utilize self-prediction, self-evaluation, verbal, and video-taped feedback in more naturalistic environments with a focus on increasing self-awareness (Goverover et al., 2007; Ownsworth et al., 2006, 2000; Toglia and Kirk, 2000). In addition, women's seeming awareness of their deficits with affective empathy may also lead them to respond more readily to treatment targeting this construct.

This is one of a few studies to evaluate sex-based differences in empathy following traumatic brain injury, and the first to explore cognitive empathy in addition to affective empathy. Although further research is needed to fully understand how individual differences influence affective and cognitive empathy following TBI, the results contribute to the mounting literature in sex differences and indicate that sex is an important factor to consider, for both researchers and clinicians, when evaluating and treating areas of social cognition after TBI.

CONFLICT OF INTEREST

None.

ETHICAL STANDARDS

The authors assert that all procedures contributing to this work comply with the ethical standards of the relevant national and institutional committees on human experimentation and with the Helinski Declaration of 1975, as revised in 2008.

553 **REFERENCES**

554 Baldner, C., McGinley, J.., 2014. Correlational and exploratory factor analyses (EFA) of
555 commonly used empathy questionnaires: New insights. Motiv. Emot. 38, 727–744.
556 Barker, L., Mornton, N., Morrison, T., McGuire, B., 2011. Inter-rater reliability of the
557 Dysexecutive Questionnaire (DEX): Comparative data from non-clinician
558 respondents - All raters are not equal. Brain Inj. 25, 997–1004.
559 doi:10.3109/02699052.2011.597046
560 Baron-Cohen, S., Wheelwright, S., 2004. The Empathy Quotient: An investigation of
561 adults with Asperger Syndrome or high functioning Autism and normal sex
562 differences. J. Autism Dev. Disord. 34, 163–175.
563 Beven, J.., O'Brien-Malone, A., Hall, G., 2004. Using the interpersonal reactivity index
564 to assess empathy in violent offenders. J. Forensic Psychol. 1, 33–41.
565 Bivona, U., Riccio, A., Ciurli, P., Carlesimo, G.A., Delle Donne, V., Pizzonia, E.,
566 Caltagirone, C., Formisano, R., Costa, A., 2014. Low self-awareness of individuals
567 with severe traumatic brain injury can lead to reduced ability to take another
568 person's perspective. J. Head Trauma Rehabil. 29, 157–171.
569 doi:10.1097/HTR.0b013e3182864f0b
570 Blair, R.J.R., 2005. Responding to the emotions of others: Dissociating forms of empathy
571 through the study of typical and psychiatric populations. Conscious. Cogn. 14, 698–
572 718. doi:10.1016/j.concog.2005.06.004
573 Brookshire, R., Nicholas, L., 1993. Discourse comprehension test. Communication Skills
574 Builder, Tucson, AZ.
575 Campanella, S., Rossignol, M., Mejias, S., Joassin, F., Maurage, P., Debatisse, D.,

576 Bruyer, R., Crommelinck, M., Guérit, J.M., 2004. Human gender differences in an
577 emotional visual oddball task : an event-related potentials study. Neurosci. Lett. 367,
578 14–18. doi:10.1016/j.neulet.2004.05.097
579 Chopik, W.J., O'Brien, E., Konrath, S.H., 2017. No Title. J. Cross. Cult. Psychol. 48, 23–
580 38. doi:10.1177/0022022116673910
581 Christov-Moore, L., Simpson, E.., Coude, G., Grigaityte, K., Iacoboni, M., Ferrari, P..,
582 2014. Empathy: Gender effects in brain and behavior. Neurosci. Biobehav. Rev. 46,
583 604–627. doi:http://dx.doi.org/10.1016/j.neubiorev.2014.09.001
584 Cliffordson, C., 2001. Parents' judgments and students' self-judgments of empathy: The
585 structure of empathy and agreement of judgments based on the Interpersonal
586 Reactivity Index (IRI). Eur. J. Psychol. Assess. 17, 36–47.
587 Colantonio, A., Mar, W., Escobar, M., Yoshida, K., Velikonja, D., Rizoli, S., Cusimano,
588 M., Cullen, N., 2010. Women's health outcomes after traumatic brain injury. J.
589 Women's Heal. 19, 1–8. doi:10.1089=jwh.2009.1740
590 Collignon, O., Girard, S., Gosselin, F., Saint-Amour, D., Lepore, F., Lassonde, M., 2010.
591 Women process multisensory emotion expressions more efficiently than men.
592 Neuropsychologia 48, 220–5. doi:10.1016/j.neuropsychologia.2009.09.007
593 Coplan, A., 2010. Empathic Engagement with Narrative Fictions. J. Aesthet. Art Crit. 62,
594 141–152.
595 Coplan, A., 2006. Catching Characters' Emotions: Emotional Contagion Responses to
596 Narrative Fiction Film. Film Stud. 26–38.
597 Davis, M., 1983. Measuring individual differences in empathy: Evidence for a
598 multidimensional approach. J. Pers. Soc. Psychol. 44, 113–126.

599 Davis, M., 1980. A Multidimensional Approach to Individual Differences in Empathy.
600 JSAS Cat. Sel. Doc. Psychol. 10, 85.
601 De Corte, K., Buysse, A., Verhofstadt, L.L., Roeyers, H., Ponnet, K., Davis, M.H., 2007.
602 Measuring empathic tendencies: Reliabiility and validity of the Dutch version of the
603 Interpersonal Reactivity Index. Pscyhologica Belgica 47, 235–260.
604 doi:http://doi.org/10.5334/pb-47-4-235
605 de Sousa, A., McDonald, S., Rushby, J., Li, S., Dimoska, A., James, C., 2011.
606 Understanding deficits in empathy after traumatic brain injury: The role of affective
607 responsivity. Cortex. 47, 526–35. doi:10.1016/j.cortex.2010.02.004
608 de Sousa, A., McDonald, S., Rushby, J., Li, S., Dimoska, A., James, C., 2010. Why don't
609 you feel how I feel? Insight into the absence of empathy after severe traumatic brain
610 injury. Neuropsychologia 48, 3585–95. doi:10.1016/j.neuropsychologia.2010.08.008
611 Despins, E.., Turkstra, L.., Struchen, M.., Clark, A.., 2015. Sex-based differences in
612 perceived pragmatic communication ability of adults with traumatic brain injury.
613 Arch. Phys. Med. Rehabil. 97, S26–S32. doi:10.1016/j.apmr.2014.06.023
614 Dimberg, U., Lundquist, L.O., 1990. Gender differences in facial reactions to facial
615 expressions. Biol. Psychol. 30, 151–9.
616 Doherty, R.., 1997. The emotional contagion scale: A measure of individual differences.
617 J. Nonverbal Behav. 21, 131–154.
618 Eichstaedt, K.E., Kovatch, K., Maroof, D.A., 2013. A less conservative approach method
619 to adjust for familywise error rate in neuropsychological research-The Holm's
620 sequential Bonferroni procedure. NeuroRehabilitation 32, 693–696.
621 doi:10.3233/NRE-130893

622 Farace, E., Alves, W.., 2000. Do women fare worse? A metaanalysis of gender
623 differences in outcome after traumatic brain injury. Neurosurg. Focus 8, e6.
624 Faul, M., Xu, L., Wald, M., 2010. Traumatic brain injury in the United States:
625 Emergency department visits, hospitalizations and deaths 2002-2006. Atlanta.
626 Fernandez, A.., Dufey, M., Kramp, U., 2011. Testing the psychometric properties of the
627 Interpersonal Reactivity Indix (IRI) in Chile. Eur. J. Psychol. Assess. 27, 179–185.
628 Gleichgerrcht, E., Decety, J., 2013. Empathy in clinical practice: How individual
629 dispositions, gender, and experience moderate empathic concern, burnout, and
630 emotional distress in physicians. PLoS One 8, e61526.
631 doi:http://dx.doi.org/10/1371/journal.pone.0061526
632 Goverover, Y., Johnston, M.V., Toglia, J., Deluca, J., 2007. Treatment to improve self-
633 awareness in persons with acquired brain injury. Brain Inj. 21, 913–923.
634 Haag, H.., Caringal, M., Sokoloff, S., Kontos, P., Yoshida, K., Colantonio, A., 2016.
635 Being a woman with acquired brain injury: Challenges and implications for practice.
636 Arch. Phys. Med. Rehabil. 97, S64–S70.
637 Hatfield, E., Rapson, R.., Le, Y.L., 2009. Emotional contagion and empathy, in: Decety,
638 J., Ickes, W. (Eds.), The Social Neuroscience of Empathy. The MIT Press,
639 Cambridge, MA, pp. 19–30.
640 Hillis, A.E., 2014. Inability to empathize: Brain lesions that disrupt sharing and
641 understanding another's emotions. Brain A J. Neurol. 137, 981–997. doi:doi:
642 10.1093//brain/awt317
643 Hodgson, L.K., Wertheim, E.H., 2007. Does good emotion management aid forgiving?
644 Multiple dimensions of empathy, emotion management and forgiveness of self and

645 others. J. Soc. Pers. Relat. 24, 931–949. doi:10.1177/0265407507084191
646 Holm, S., 1979. A simple sequentially rejective multiple test procedure. Scand. J. Stat.
647 75, 800–802.
648 Hooker, C.I., Verosky, S.C., Germine, L.T., Knight, R.T., D'Esposito, M., 2010. Neural
649 activity during social signal perception correlates with self-reported empathy. Brain
650 Res. 1308, 100–113.
651 Killgore, W.D.S., Oki, M., Yurgelun-Todd, D.A., 2001. Sex-specific developmental
652 changes in amygdala responses to affective faces. Brain Imaging 12, 427–433.
653 Klein, K.J.., Hodges, S.., 2001. Gender differences, motivation, and empathic accuracy:
654 When it pays to understand. Personal. Soc. Psychol. Bull. 27, 720–730.
655 Krach, S., Blumel, I., Marjoram, D., Lataster, T., Krabbendam, L., Weber, J., van Os, J.,
656 Kircher, T., 2009. Are women better mind readers? Sex differences in neural
657 correlates of mentalizing detected with functional MRI. BMC Neurosci. 10.
658 doi:10.1186/1471-2202-10-9
659 Lauterbach, O., Hosser, D., 2007. Assessing empathy in prisoners - A shortened version
660 of the Interpersonal Reactivity Index. Swiss J. Psychol. 66, 91–101.
661 doi:10.1024/1421-0185.66.2.91
662 Lee, T.M.C., Liu, H.-L., Hoosain, R., Liao, W.-T., Wu, C.-T., Yuen, K.S.L., Chan,
663 C.C.H., Fox, P.T., Gao, J.-H., 2002. Gender differences in neural correlates of
664 recognition of happy and sad faces in humans assessed by functional magnetic
665 resonance imaging. Neurosci. Lett. 333, 13–16.
666 Li, H., Yuan, J., Lin, C., 2008. The neural mechanism underlying the female advantage in
667 identifying negative emotions: An event-related potential study. Neuroimage 40,

668 1921–1929.
669 Lundquist, L.O., 1995. Facial EMG reactions to facial expressions: A case of facial
670 emotional contagion? Scand. J. Psychol. 36, 130–141.
671 MacDonald, A., 2003. I feel your pain (and joy): New theories about empathy. Brain
672 Work 13, 1–3.
673 Marzoli, D., Palumbo, R., Di Domenico, A., Penolazzi, B., Garganese, P., Tommasi, L.,
674 2011. The relation between self-reported empathy and motor identification with
675 imagined agents. PLoS One 6, e14595. doi:10.1371/journal.pone.0014595
676 McDonald, S., 2013. Impairments in social cognition following severe traumatic brain
677 injury. J. Int. Neuropsychol. Soc. 19, 1–16. doi:10.1017/S1355617712001506
678 Mehrabian, A., 2000. Manual for the balanced emotional empathy scale (BEES),
679 Available from Albert Mehrabian. 1130 Alta Mesa Road, Monterey CA 93040.
680 Meltzoff, A.., Decety, J., 2003. What imitation tells us about social cognition. A
681 rapprochement between developmental psychology and cognitive neuroscience.
682 Philos. Trans. R. Soc. London 358, 491–500. doi:10.1098/rstb.2002.1261
683 Muller, F., Simion, A., Reviriego, E., Galera, C., Mazaux, J.-M., Barat, M., Joseph, P.-A.,
684 2010. Exploring theory of mind after severe traumatic brain injury. Cortex. 46,
685 1088–99. doi:10.1016/j.cortex.2009.08.014
686 Nalder, E., Fleming, J., Cornwell, P., Foster, M., Skidmore, E., Bottari, C., Dawson, D.,
687 2016. Sentinel events during the transition from hospital to home: A longitudinal
688 study of women with traumatic brain injury. Arch. Phys. Med. Rehabil. 2, 546–553.
689 Neumann, D., Zupan, B., Babbage, D.R., Radnovich, A.J., Tomita, M., Hammond, F.,
690 Willer, B., 2012. Affect recognition, empathy, and dysosmia after traumatic brain

injury. Arch. Phys. Med. Rehabil. 93, 1414–20. doi:10.1016/j.apmr.2012.03.009

Neumann, D., Zupan, B., Malec, J.F., Hammond, F.M., 2014. Relationships between alexithymia, affect recognition, and empathy after traumatic brain injury. J. Head Trauma Rehabil. 29, E18-27.

Oswald, P.., 2003. Does the Interpersonal Reactivity Index perspective-taking scale predict who will volunteer time to counsel adults entering college? Percept. Mot. Skills 97, 1184–1186.

Ownsworth, T., Fleming, J., Desbois, J., Strong, J., Kuipers, P., 2006. A metacognitive contextual intervention to enhance error awareness and functional outcome following traumatic brain injury: A single-case experimental design. J. Int. Neuropsychol. Soc. 12, 54–63. doi:10.1017/S135561770606005X

Ownsworth, T.L., McFarland, K., Young, R.M., 2000. Self-awareness and psychosocial functioning following acquired brain injury: An evaluation of group support programme. Neuropsychol. Rehabil. 10, 465–484.

Pelphrey, K.., Morris, J.., McCarthy, G., 2004. Grasping the intentions of others: The perceived intentionality of an action influences activity in the superior temporal sulcus during social perception. J. Cogn. Neurosci. 16, 1706–1716.

Prentice, D.., Carranza, E., 2002. What women and men should be, shouldn't be, are allowed to be, and don't have to be: The contents of prescriptive gender stereotypes. Pscyhology Women Q. 26, 269–281.

Reniers, R.L.E.., Corcoran, R., Drake, R., Shryane, N.., Vollm, B.A., 2011. The QCAE: A questionnaire of cognitive and affective empathy. J. Pers. Assess. 93, 84–95.

Rigon, A., Turkstra, L., Mutlu, B., Duff, M., 2016. The female advantage: Sex as a

possible protective factor against emotion recognition impairment following traumatic brain injury. Cogn. Affect. Behav. Neurosci. Published. doi:10.3758/s13415-016-0437-0

Rosip, J.C., Hall, J. a., 2004. Knowledge of Nonverbal Cues, Gender, and Nonverbal Decoding Accuracy. J. Nonverbal Behav. 28, 267–286. doi:10.1007/s10919-004-4159-6

Rueckert, L., Naybar, N., 2008. Gender differences in empathy: The role of the right hemisphere. Brain Cogn. 67, 162–167.

Rushby, J.., McDonald, S., Fisher, A.., Kornfeld, E.., De Blasio, F.., Parks, N., Piguet, O., 2016. Brain volume loss contributes to arousal and empathy dysregulation following severe traumatic brain injury. NeuroImage Clin. 12, 607–614.

Schirmer, A., Kotz, S.A., 2003. ERP Evidence for a Sex-Specific Stroop Effect in Emotional Speech. J. Cogn. Neurosci. 15, 1135–1148.

Schirmer, A., Striano, T., Friederici, A.D., 2005. Sex differences in the preattentive processing of vocal emotional expressions. Cogn. Neurosci. Neuropsychol. 16, 635–639.

Schulte-Ruther, M., Markowitsch, H.J., Shah, N.J., Fink, Gereon, R., Piefke, M., 2008. Gender differences in brain networks supporting empathy. Neuroimage 42, 393–403.

Shamay-Tsoory, S.G., Tomer, R., Berger, B.D., Aharon-Peretz, J., 2003. Characterization of empathy deficits following prefrontal brain damage: the role of the right ventromedial prefrontal cortex. J. Cogn. Neurosci. 15, 324–37. doi:10.1162/089892903321593063

737 Shamay-Tsoory, S.G., Tomer, R., Goldsher, D., Berger, B.D., Aharon-Peretz, J., 2004.
738 Impairment in cognitive and affective empathy in patients with brain lesions:
739 Anatomical and cognitive correlates. J. Clin. Exp. Neuropsychol. 26, 1112–1127.
740 Silani, G., Bird, G., Brindley, R., Singer, T., Frith, C., Frith, U., 2008. Levels of
741 emotional awareness and autism: An fMRI study. Soc. Neurosci. 3, 97–112.
742 doi:http://dx.doi.org/10.1080/17470910701577020
743 Sonnby-Borgstrom, M., Jonsson, P., Svensson, O., 2008. Gender differences in facial
744 imitation and verbally reported emotional contagion from spontaneous to
745 emotionally regulated processing levels. Scand. J. Psychol. 49, 111–122.
746 Sonnby-Borgstrom, M., Jonsson, P., Svensson, O., 2003. Emotional empathy: Affective
747 empathy as related to mimicry reactions at different levels of information
748 processing. J. Nonverbal Behav. 27, 3–23.
749 Spikman, J.., Timmerman, M.., Milders, M. V, Veenstra, W.S., van der Naalt, J., 2012.
750 Social cognition impairments in relation to general cognitive deficits, injury
751 severity, and prefrontal lesions in traumatic brain injury patients. J. Neurotrauma 29,
752 101–111. doi:10.1089/neu.2011.2084
753 Spikman, J.M., Boelen, D.H.E., Lamberts, K.F., Brouwer, W.H., Fasotti, L., 2010.
754 Effects of a multifaceted treatment program for executive dysfunction after acquired
755 brain injury on indications of executive functioning in daily life. J. Int.
756 Neuropsychol. Soc. 16, 118–129.
757 Toglia, J.P., Kirk, U., 2000. Understanding awareness deficits following traumatic brain
758 injury. NeuroRehabilitation 15, 57–70.
759 Turkstra, L.S., 2008. Conversation-based assessment of social cognition in adults with

760 traumatic brain injury. Brain Inj. 22, 397–409. doi:10.1080/02699050802027059
761 Wells, R., Dywan, J., Dumas, J., 2005. Life satisfaction and distress in family caregivers
762 as related to specific behavioural changes after traumatic brain injury. Brain Inj. 19,
763 1105–1115.
764 Wildgruber, D., Pihan, H., Ackermann, H., Erb, M., Grodd, W., 2002. Dynamic Brain
765 Activation during Processing of Emotional Intonation : Influence of Acoustic
766 Parameters , Emotional Valence , and Sex. Neuroimage 15, 856–869.
767 doi:10.1006/nimg.2001.0998
768 Williams, C., Wood, R., 2010. Alexithymia and emotional empathy following traumatic
769 brain injury. J. Clin. Exp. Neuropsychol. 32, 259–67.
770 doi:10.1080/13803390902976940
771 Wood, R., Williams, C., 2008. Inability to empathize following traumatic brain injury. J.
772 Int. Neuropsychol. Soc. 14, 289–96. doi:10.1017/S1355617708080326
773 Wood, W., Eagly, A.., 2000. Once again, the origins of sex differences. Am. Psychol. 55,
774 1062–1063.
775 Yarnold, P.., Bryant, F.., Nightingale, S.., Martin, G.., 1996. Assessing physician
776 empathy usng the interpersonal reactivity index: A measurement model and cross-
777 sectional analysis. Psychol. Health Med. 1, 207–221.
778 doi:http://dx.doi.org/10.1080/13548509608400019
779 Zupan, B., Babbage, D.R., Neumann, D., Willer, B., 2017. Sex differences in emotion
780 recognition and emotional inferencing following severe traumatic brain injury. Brain
781 Impair. 18, 36–48. doi:10.1017/BrImp.2016.22
782

Table 1. Relationship to participants and sex of observers who completed questionnaires about the participant.

	Males (n=116)				Females (n=44)			
Observers	*Male*	*Female*	*Unknown*	*Total (%)*	*Male*	*Female*	*Unknown*	*Total (%)*
Parent	6	36	0	42 (44%)	1	14	0	15 (40%)
Spouse/Partner	1	25	0	26 (27%)	10	1	0	11 (29%)
Sibling	0	4	0	4 (4%)	1	1	0	2 (5%)
Adult Child	2	0	0	2 (2%)	2	2	0	3 (8%)
Friend	0	0	6	6 (6%)	1	0	4	5 (13%)
Support Worker	1	0	12	13 (13%)	0	0	0	0 (0%)
Other/Unknown	0	2	1	3 (3%)	0	2	0	2 (5%)
Total Completed	10	67	19	96	14	20	4	38

Table 2. Demographic variables by sex for male and female participants.

	Male (n=116) Mean *(SD)*	**Female (n=44)** Mean *(SD)*	**Difference**
Age	41.32 *(11.81)*	40.71 *(13.23)*	$F(1,158)=0.079$, $p=.778$
Education, in years	13.05 *(2.36)*	13.14 *(2.21)*	$F(1,137)=0.040$, $p=.841$
Age at Injury	32.56 *(12.15)*	31.59 *(13.58)*	$F(1,158)=0.190$, $p=.663$
Time since injury, in years	8.84*(8.01)*	8.83 *(8.43)*	$F(1,156)=0.000$, $p=.996$

795 Table 3. Subscale and total raw scores for IRI for males and females with TBI.
796

	Males (n=116) Mean *(SD)*	**Females (n=44) Mean *(SD)***
Empathic Concern	19.20 (5.01)	18.86 (4.25)
Perspective Taking	15.20 (6.24)	14.18 (5.39)
Personal Distress	10.90 (5.92)	12.11 (5.61)
Fantasy	12.68 (5.53)	13.00 (6.05)
Total Score	57.86 (14.68)	58.14 (13.07)

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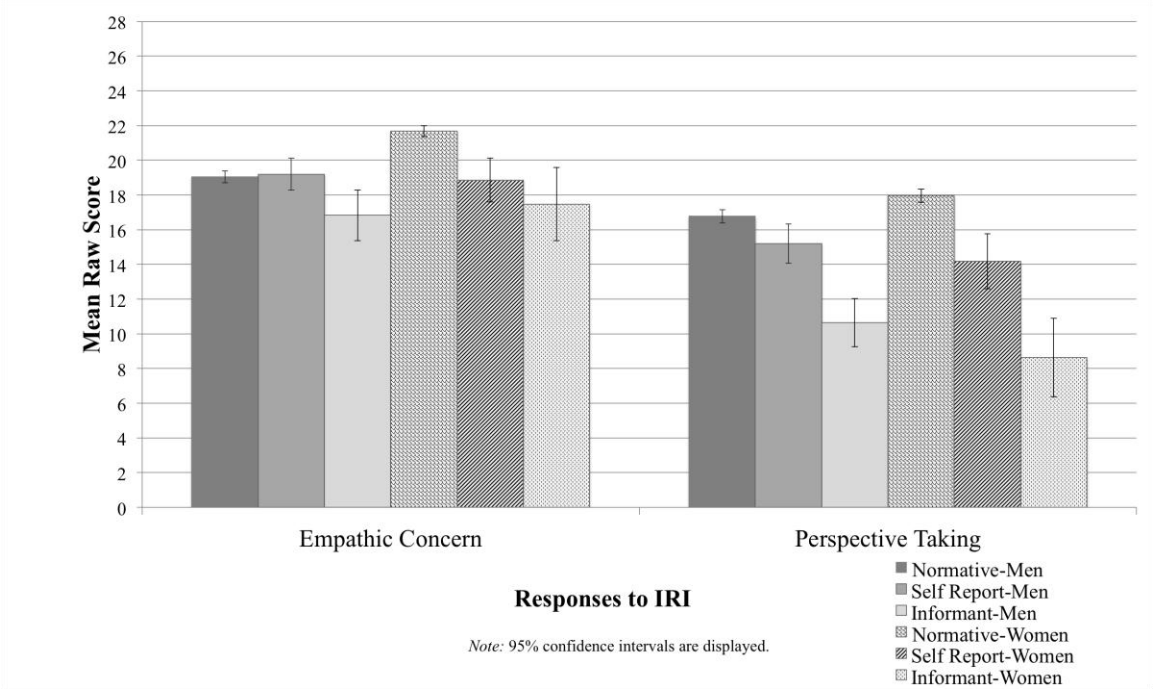
Table 4. Normative means and self-report scores of men and women with TBI for IRI subscales, and proportion of impairment within sample.

	Empathic Concern ***Mean (SD)***	**Perspective Taking** ***(Mean (SD)***
Men		
Self Report (TBI)	19.20 *(5.01)*	15.20 *(6.24)*
Normative	19.04 *(4.21)*	16.78 *(4.72)*
% Impaired (n)	17 *(20)*	32 *(37)*
Women		
Self Report (TBI)	18.86 *(4.25)*	14.18 *(5.39)*
Normative	21.67 *(3.83)*	17.96 *(4.85)*
% Impaired (n)	44 *(19)*	41 *(18)*

Figure Captions.

Figure 1. Mean raw scores for men and women for affective and cognitive empathy. Scores shown include mean normative scores, mean self-report ratings for participants with TBI, and mean informant ratings for those participants.

809 Figure 1.



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