Journal of Clinical and Experimental Neuropsychology

ISSN: 1380-3395 (Print) 1744-411X (Online) Journal homepage: http://www.tandfonline.com/loi/ncen20

Diagnosis threat and underperformance: The threat must be relevant and implicit

Megan Fresson, Benoit Dardenne & Thierry Meulemans

To cite this article: Megan Fresson, Benoit Dardenne & Thierry Meulemans (2018): Diagnosis threat and underperformance: The threat must be relevant and implicit, Journal of Clinical and Experimental Neuropsychology, DOI: 10.1080/13803395.2017.1420143

To link to this article: https://doi.org/10.1080/13803395.2017.1420143

JOURNAL OF CLINICAL AND EXPERIMENTAL NEUROPSYCHOLOGY, 2018
https://doi.org/10.1080/13803395.2017.1420143

Diagnosis threat and underperformance: The threat must be relevant and implicit

Megan Fresson, Benoit Dardenne and Thierry Meulemans

Psychology and Neurosciences of Cognition Unit, University of Liège (Belgium), Liège, Belgium

ABSTRACT

Introduction: The diagnosis threat (DT) phenomenon shows that, in some cases, reminding people with mild traumatic brain injury (mTBI) about their past neurological history diminishes subsequent cognitive performance. The aim of the present study was to investigate the role of personal relevance (i.e., domain identification) and type of threat (i.e., implicit vs. explicit) as moderating variables. We investigated intrusive thoughts as a potential mediator.
Method: Control (non-mTBI) and mTBI participants were recruited and completed a domain identification questionnaire. Under either an implicit or an explicit DT condition, they completed neuropsychological tasks assessing working memory, episodic memory, and executive processing, as well as measures of intrusive thoughts.
Results: As expected, the main results showed that, for working memory and episodic memory, high identifier mTBI participants scored worse in the implicit DT condition than in the explicit condition. The implicit DT condition also led high identifier mTBI participants to score worse than low identifiers for working memory. Conversely, the explicit DT condition led high identifier mTBI participants to perform *better* than low identifiers for both working and episodic memory. Unexpectedly, low identifier mTBI participants scored *better* on working memory tasks in the implicit DT condition than in the explicit condition. We found no evidence of mediation by intrusive thoughts.
Conclusions: Domain identification and the explicit or implicit nature of the DT must be taken into account, as they can impact mTBI participants' cognitive performance. This study suggests the influence of DT as a factor biasing neuropsychological assessment.

ARTICLE HISTORY
Received 30 April 2017
Accepted 12 December 2017

KEYWORDS
Contrast effect; diagnosis threat; domain identification; neuropsychological assessment; stereotype threat

In the United States, mild traumatic brain injury (mTBI) represents between 70 and 90% of treated traumatic brain injury (TBI), with incidence rates estimated at between 100 and 500/100,000 (Bazarian et al., 2005; Holm, Cassidy, Carroll, & Borg, 2005). mTBI and its outcomes therefore constitute a major public health concern. It is known that mTBI symptoms usually disappear within the first three months post injury (Rohling et al., 2011). However, as many as 15–20% of patients have been shown to exhibit symptoms that persist beyond the typical recovery period (Konrad et al., 2011; Lannsjö, af Geijerstam, Johansson, Bring, & Borg, 2009; Vanderploeg, Curtiss, & Belanger, 2005). This cluster of persistent symptoms is called "postconcussion syndrome" and includes somatic (e.g., headache), psychological (e.g., depression), and cognitive (e.g., distractibility) complaints (McCrea, 2008; Williams, Potter, & Ryland, 2010). Among the factors thought to account for these persistent symptoms, some authors (Iverson & Lange, 2011; Rohling, Larrabee, & Millis, 2012) have highlighted the potential impact of stereotype threat (Steele & Aronson, 1995).

Stereotype threat refers to a situational phenomenon in which individuals in a stigmatized group underperform in a particular domain when situational cues remind them of their supposed inferiority in this domain (Steele & Aronson, 1995). In fact, activating the negative stereotypic view of their group generally leads individuals to underperform. This pattern of results is referred to as an "assimilation effect." However, in some cases, participants exhibit a "contrast effect": In response to stereotype threat, they outperform (Wheeler & Petty, 2001). The assimilation and contrast effects of a threat may depend on several moderators. Particularly important for this paper, the personal relevance of the threat (i.e., domain identification; *does the threat attack an important part of who I am?*) and its salience (e.g., blatant/explicit vs. subtle/

CONTACT Megan Fresson megan.fresson@ulg.ac.be Psychology and Neurosciences of Cognition Unit (B33 Trifacultaire–Quartier Agora), University of Liège (Belgium), Place des Orateurs 1, 4000 Liège, Belgium

implicit threat), as well as their conjunction (e.g., *a blatant threat to a core aspect of who I am*), are essential determinants of the contrast and the assimilation effects of stereotype threat. According to Wheeler and Petty (2001), a contrast effect should be particularly apparent when the threat is both relevant and blatant.

Diagnosis threat (DT) is a particular case of stereotype threat applied to individuals with a history of neurological issues (Kit, Tuokko, & Mateer, 2008). Suhr and Gunstad (2002) showed that, after being reminded of their past mTBI and its potential consequences (DT condition), undergraduate students underperformed in a set of neuropsychological tasks compared to their counterparts in the neutral condition, thereby exhibiting the "classic" assimilation effect. To the best of our knowledge, only three studies have replicated this assimilation effect with people who had sustained an mTBI (Pavawalla, Salazar, Cimino, Belanger, & Vanderploeg, 2013; Suhr & Gunstad, 2005) or people with acquired brain injury (Kit, Mateer, Tuokko, & Spencer-Rodgers, 2014). Other studies did not find an assimilation effect with DT in people with mTBI (Blaine, Sullivan, & Edmed, 2013) or found an assimilation effect only on subjective assessment but not on objective performance (Ozen & Fernandes, 2011; Trontel, Hall, Ashendorf, & O'Connor, 2013). Interestingly, Fresson, Dardenne, Geurten, and Meulemans (2017) showed that contact-sport players (at risk for mTBI) with a high internal locus of control performed *better* following highly explicit DT instructions than their peers in the neutral condition. That was the first study to show a contrast effect following DT instructions. In this study, we propose that the occurrence of the DT effect (either assimilation or contrast) could be explained by a specific combination of contextual and psychosocial variables. More specifically, we hypothesize that the salience of the threat (blatant vs. subtle) does or does not trigger a detrimental effect on performance depending on the personal relevance of the threat (whether or not the person with mTBI values the domain that is threatened).

Regarding the salience of the threat, a distinction is classically made between implicit and explicit stereotype activation (Wheeler & Petty, 2001). Generally speaking, very explicit stereotype activation is more likely to trigger contrast effects than implicit activation, which triggers primarily assimilation effects (Nguyen & Ryan, 2008; Wheeler & Petty, 2001). For instance, regarding the stereotype that women are cooperative in negotiations, Kray, Thompson, and Galinsky (2001) showed that implicit activation of the stereotype (Experiment 1) led women participants to underperform in negotiation tasks, whereas explicit activation of the stereotype (Experiment 3) led women participants to outperform in negotiations. In explicit activation, the stereotype cues are quite blatant. For instance, in the case of age-based stereotypes, the experimenter explicitly tells older adults that "recent research on memory has indicated that older adults obtain poorer results in a memory task by comparison with young people" (Fernández-Ballesteros, Bustillos, & Huici, 2015, p. 417). This kind of blatant threat is similar to what Lamont, Swift, and Abrams (2015) called a "fact-based stereotype threat manipulation." In implicit activation, researchers activate the stereotype by more subtle cues. For example, the experimenter simply tells older adult participants that both young and older adults are participating in the study (Mazerolle, Regner, Morisset, Rigalleau, & Huguet, 2012) or the experimenter emphasizes the domain (memory) assessed by the task by explaining that the task assesses memory and that strong performance will reveal good memory capacities (Desrichard & Kopetz, 2005). Such an implicit, subtle threat is similar to what Lamont et al. (2015) described as a "stereotype-based threat." In such a case, the threat comes only from societal stereotypes. The assumption that assimilation is more likely to occur after subtle threats also applies when the threat concerns gender. Female participants confronted by a benevolent, subtle, and apparently positive threat underperformed on various cognitive and behavioral tasks compared to situations in which the threat was hostile, blatant, and negative and even compared to a control situation in which no threat was made (Dardenne, Dumont, & Bollier, 2007; Dumont, Sarlet, & Dardenne, 2010).

In accordance with these findings from the stereotype and sexist threat literature, we predict that an assimilation effect (negative impact of the threat) will occur after implicit, subtle DT activation, while a contrast effect (positive effect of the threat) will be observed after explicit, blatant DT instructions (as in the Fresson et al., 2017, study). However, as with the effects of stereotype and sexist threat, we propose that the assimilation and contrast effects of the threat will not occur for all individuals. Quite obviously, a threat targeting people with mTBI is relevant only for them and not for control participants without mTBI (Hypothesis 1). As mentioned before, in the stereotype threat literature, a moderating variable—related to the personal relevance of the threat—that has received a great deal of attention is domain identification. Domain identification is the degree to which individuals value the domain in which they are stereotyped as being incompetent. Several studies have shown that the more individuals (e.g., women) value a domain (e.g., math), the more negatively they are impacted by the threat (e.g., Cadinu, Maass, Frigerio, Impagliazzo,

& Latinotti, 2003; Hess, Auman, Colcombe, & Rahhal, 2003; Keller, 2007). Thus, it is rather straightforward to predict a comparable assimilation effect for participants with mTBI who strongly identify with their cognitive functioning and are confronted by implicit DT instructions, compared to high identifiers in an explicit DT condition (Hypothesis 2a; see Kit et al., 2008, for a similar proposal). In other words, those highly identified individuals should perform better after explicit DT instructions than low identifiers confronted by the same explicit threat (Hypothesis 2b). Indeed, Wheeler and Petty (2001) suggested that a contrast effect is more likely to occur if the negative stereotype is consciously perceived by participants as highly divergent from their (valued) self. Explicit DT instructions would consequently trigger a contrast effect for high identifiers, because they value cognitive functioning highly and (presumably) want to perform well on tasks although, or because, they are explicitly and blatantly threatened. If the hypothesis that an implicit threat to a valued dimension of the self has a deleterious effect is correct, it could even lead these high identifiers to perform worse than low identifiers (i.e., those for whom the threat is irrelevant even though it targets their group) confronted by the same implicit, subtle threat (Hypothesis 3).

Concerning the mediating variables, after 20 years of research on stereotype threat, no single proposed mediator has unequivocal empirical support (Pennington, Heim, Levy, & Larkin, 2016). Schmader, Johns, and Forbes (2008) proposed that stereotype (and sexist) threat provokes a set of negative emotions and thoughts that participants try to suppress. These suppression processes rely on working memory and executive processes, which are therefore no longer available for the execution of cognitive tasks, leading to decreased performance (Schmader et al., 2008). For instance, using the thought probe technique, Cadinu, Maass, Rosabianca, and Kiesner (2005) showed that negative math-related thoughts (e.g., "I am not good at math") mediate the relationship between stereotype threat and math underperformance (see also Beilock, Rydell, & McConnell, 2007, Experiment 3). Using an indirect measure of intrusive thoughts, Mrazek et al. (2011) also showed that stereotype threat elicits mind-wandering (measured by the Sustained Attention to Response Task, SART; Robertson, Manly, Andrade, Baddeley, & Yiend, 1997), which mediates the detrimental impact of stereotype threat on performance. In another example, Schuster, Martiny, and Schmader (2015) showed that participants under stereotype threat who were asked to reappraise their intrusive thoughts as normal performed better than participants in a stereotype threat condition or in a neutral condition. That study confirmed that suppression of intrusive thoughts impairs cognitive performance and could explain underperformance in a stereotype or sexist threat condition (see also Dardenne et al., 2007; Logel, Iserman, Davies, Quinn, & Spencer, 2009). In this study (Hypothesis 4), we tested whether the assimilation effect (an implicit threat for high identifiers) is mediated by intrusive thoughts (by comparing that condition to conditions in which no assimilation effect is expected—that is, for high identifiers confronted by an explicit threat and low identifiers confronted by an implicit one).

Method

Participants

Participants (M_{age} = 22.1 years, SD = 2.4) were recruited through an online screening process using the university's online survey system (see procedure below). Participants from the University of Liège were mainly approached by e-mail, and other participants were recruited via social networks and by the snowball technique. Participants interested in joining the neuropsychology lab pool of participants were redirected to the University of Liège's online survey system. They did not receive any incentives for their participation. Participants in the mTBI group were contacted if they were between 18 and 35 years old and reported a history of mild TBI/concussion, defined as any blow to the head with a loss of consciousness not exceeding 30 minutes. Exclusion criteria were a history of other neurological disorders (e.g., stroke; attention-deficit/hyperactivity disorder, ADHD; moderate or severe TBI; etc.), a past hospitalization for a psychiatric condition, or a history of psychiatric disorders other than depression and anxiety. Participants had to have normal or corrected vision and hearing. Around 700 people responded to the screening test, and 68 individuals met the mTBI criterion. All participants who fulfilled the study criteria were contacted by phone and invited to participate in the study. Of the 68 individuals with a history of mTBI, 39 agreed to participate in the study. Participants were randomly assigned to the explicit DT condition (n = 18) or the implicit DT condition (n = 21). Participants in the control group (i.e., the non-mTBI participants) were also selected from the online screening test and were recruited if they denied having a history of mTBI. Control participants satisfied the same exclusion criteria as those for mTBI participants. They were recruited in order to match the mTBI participants for age and education (as well as gender when possible). Whenever we recruited a participant with mTBI, we tried to recruit a participant without mTBI (control participant) of the same gender with approximately the same age and educational level. They were randomly assigned to the explicit DT condition (n = 19) or the implicit DT condition (n = 19).

Material

Neuropsychological tasks

We selected neuropsychological tasks that assess the cognitive areas generally investigated with mTBI individuals—namely, memory and executive functioning (Konrad et al., 2011; Maruff et al., 2009). Thus, we administered the Flexibility subtest of the Test of Attentional Performance Battery Version 2.3 (TAP; Zimmermann & Fimm, 2010); the encoding phase of the California Verbal Learning Test (CVLT; Delis, Kramer, Kaplan, & Ober, 1987); the Working Memory subtest of the TAP (Zimmermann & Fimm, 2010); the Incompatibility subtest of the TAP (Zimmermann & Fimm, 2010); the Stroop task (Stroop, 1935); and the Brown–Peterson test (Geurten, Vincent, Van der Linden, Coyette, & Meulemans, 2016). These tasks (see Table 1 for a thorough description of the tasks) are known to recruit executive processes and could therefore be especially impacted by DT (Schmader et al., 2008).

In order to reduce the number of dependent variables and the occurrence of Type I errors, we calculated composite scores by averaging individual z-scores. We calculated a working memory score by averaging the z-scores for the number of omissions during the working memory subtest of the TAP (reversed) and the correct responses in the Brown-Peterson task (r = .25, p = .025). We calculated an executive score by averaging the reversed z-scores for errors made during the Stroop task, the Flexibility subtest of the TAP (r = .30, p = .007, for the Stroop task), and the Incompatibility subtest of the TAP (r = .33, p = .003 for the Stroop task, and r = .21, p = .073 for the Flexibility subtest of the TAP). Finally, we created an episodic memory score by averaging z-scores for the number of words recalled during the learning phase of the CVLT, the number of words recalled during the recall phases (short-term and long-term) of the CVLT (r = .81, p < .001 for the number of words recalled during the learning phase), and the number of correct words during the recognition phase of the CVLT (r = .59, p < .001, for the number of words recalled during the learning phase; r = .59, p < .001, for the number of words recalled during the recall). For these three composite cognitive scores, the higher the score, the better the performance.

The Sustained Attention to Response Task (SART; adapted from Stawarczyk, Majerus, Catale, & D'Argembeau, 2014)

This Go/No-Go task is known to assess mind-wandering/intrusive thoughts online (Cheyne, Solman, Carriere, & Smilek, 2009). Numbers from 1 to 9 appear sequentially in the center of the screen every 2 seconds for 500 ms. Participants have to press the key for each number, except for the number 3, as fast as they can. When the number 3 appears on the screen, they have to inhibit their response. The probability that the target stimulus (3) appears is 11%. The task comprises 15 blocks (between 10 and 26 stimuli) with a duration of between 25 and 65 seconds. Each block comprises one, two, or three target stimuli, but there is never a target stimulus during the last five stimuli of a block. At the end of each block, the task is interrupted by a thought

Table 1. Neuropsychological tasks.

Task	Task description	Data
Working Memory subtask of the TAP (Zimmermann & Fimm, 2010)	Numbers appear successively on the computer screen. Participants have to press the response button as quickly as possible when the number shown is the same as the penultimate one.	Number of omissions
Brown–Peterson Task (Geurten et al., 2016)	Participants have to remember consonant trigrams for between 0 and 20 s. During this period, they repeat pairs of numbers in the opposite order.	Percentage of correctly recalled letters
Stroop task (Godefroy & Grefex, 2008)	Participants have to name as quickly as possible the color in which names of colors are printed (e.g., "blue" printed in red).	Number of errors
Flexibility subtask of the TAP (Zimmermann & Fimm, 2010)	For each item, a pair of a letter and a number appears on the screen. Participants have to press the response button corresponding to the location of the letter, then to the number, and so on.	Number of errors
Incompatibility subtask of the TAP (Zimmermann & Fimm, 2010)	For each item, an arrow pointing toward the left or the right appears on the left or right side on the screen. Participants have to quickly press the button corresponding to the side indicated by the arrow.	Number of errors
CVLT (Delis et al., 1987)	During the encoding phase, participants hear a list of 16 words five times and then have to recall as many words as they can. There are then four recalls (short-term and long-term) and a recognition task.	Number of words correctly recalled during the encoding phase, the recalls, and the recognition tasks.

Note. TAP = Test of Attentional Performance; CVLT = California Verbal Learning Test.

probe. Each probe asks participants to categorize their ongoing conscious experience just before they were interrupted. Note that some stereotype threat studies have indicated that performance diminishes due to increasing task-related interference (TRI; thoughts directed at the performance) rather than mind-wandering (thoughts unrelated to the task at hand; Beilock et al., 2007; Cadinu et al., 2005). In the present study, we were specifically interested in TRI—that is, evaluative thinking about one's own performance. We consequently proposed five categories of thoughts in order to better isolate TRI: (a) on-task thinking—the participant was totally concentrated on the task; (b) TRI (excluding thoughts about physical features of the task)—the participant was thinking about his/her performance (e.g., "I think I am doing well"); (c) emotion-related thoughts—the participant was thinking about his/her feelings and emotions (e.g., "I feel stressed"); (d) thoughts about the external (including physical features of the task) and internal environment—the participant's attention was focused on things in the current physical environment (e.g., "The wallpaper in the experiment room is not very pretty") or bodily sensations (e.g., "I am thirsty"); (e) mind-wandering—thoughts that were not directed toward task completion, emotions, or the present environment (e.g., "The film I saw yesterday was very frightening"). As in Stawarczyk et al.'s (2014) study, before the completion of the task, participants were trained to classify thought exemplars into the five proposed categories. Finally, because it has been proposed that negative (but not positive) task-related thinking impedes performance under stereotype threat (Beilock et al., 2007; Cadinu et al., 2005), when participants classified their thoughts as either "task-related interference," "emotion-related thoughts," or "mind wandering," they were asked to rate their valence using a 7-point Likert scale ranging from "very negative" (−3) to "very positive" (+3).

To measure TRI, we analyzed two of the most common indicators of mind-wandering during the SART: (a) the response time coefficient of variability (RT CV = mean RT/standard deviation of RT), which is an indicator of attentional lapses (occasional speeding up or slowing down); and (b) false-alarm errors (pressing the response button for the 3). Moreover, we analyzed the number and valence of TRI by multiplying the occurrence of TRI by their valence (from −3 to +3). The lower the score, the more negative and frequent TRI was.

Domain identification questionnaire

This 16-item scale (Cronbach's alpha = .75) measures the degree to which it is important to participants to have good cognitive functioning. It was adapted from the Achievement subscale of the Metamemory in Adulthood questionnaire (Dixon & Hultsch, 1983; e.g., "It is important to me to have a good memory"). Participants respond using a 5-point Likert scale ranging from "totally agree" to "totally disagree." Higher scores represent higher domain identification.

Feeling of threat questionnaire

This 4-item questionnaire (Cronbach's alpha = .85) assesses feelings of threat (e.g., "I am afraid that the experimenter sees that I have difficulties with tasks due to my concussion/mild traumatic brain injury"). Participants respond using a 7-point Likert scale ranging from "totally disagree" to "totally agree." The higher the score, the higher the feelings of threat.

Manipulation check questionnaire

Participants were asked to respond to three questions about the instructions they had read at the beginning of the experiment using a 5-point Likert scale ranging from "totally disagree" to "totally agree" ("The goal of this study was to study memory and concentration capacities in people who had a mild traumatic brain injury/a concussion" (Item 1); "The goal of this study was to study memory and concentration capacities in deaf people" (Item 2); "The tests assessed memory, concentration, and information processing speed" (Item 3).

Procedure

This study was approved by the University of Liège Ethics committee. As explained above, participants completed an online screening survey (about 30 min). The alleged purpose of this screening was to join the Neuropsychology lab's participant pool. After giving their consent, participants filled in demographic and general medical questionnaires. When they reported having sustained a TBI, they completed a TBI-related questionnaire adapted from Ozen and Fernandes (2011; see Appendix A). Specifically, they were asked about the duration of loss of consciousness, loss of memory, confusion, and disorientation. As well, they indicated whether they had a doctor visit for their TBI. As part of (both implicit and explicit) DT instructions, participants reporting a past mTBI also responded to 10 questions related to their mTBI (e.g., "I often think of the fact that I am a person who has suffered from a brain injury") using a 7-point Likert scale (ranging from "totally disagree" to "totally agree"). This questionnaire was administered to mTBI participants in order to make their mTBI identity salient.[1] They then completed the Beck Depression

Inventory (BDI–II; Beck, Steer, & Brown, 1996), the State–Trait Anxiety Inventory, Trait form (STAI–YB; Spielberger, Gorsuch, & Lushene, 1983), and the domain identification questionnaire (Dixon & Hultsch, 1983). Three months after completing the online screening, participants were invited to participate in a neuropsychology study.

In the experimental session, participants were tested individually. After giving their written consent to participate in a study of cognitive capacities (including memory, concentration, and reaction speed), participants received an envelope containing instructions related to the condition to which they were randomly assigned (see Appendix B). Participants in the implicit DT condition read the title *Study of cognitive processes (memory, attention, and information processing speed)*. Participants then read that the study was about the processes involved in neuropsychological functioning, highlighting the fact that the tasks assessed cognitive functioning (Desrichard & Kopetz, 2005). Participants in the explicit DT condition read that they would participate in a study entitled *Study of cognitive processes (memory, attention, and information processing speed) in people who have sustained a head injury/concussion*. In this condition, they were also explicitly told that mTBI individuals have cognitive deficits and that the performance of people with mTBI people and without mTBI would be compared. These instructions constituted quite blatant stereotype activation (Wheeler & Petty, 2001). Participants were asked to read the instructions silently. Participants were asked to remain silent about the envelope's content and were told that any questions they might have would be answered at the end of the session. Consequently, since the participants were randomly assigned by the responsible researcher, the examiner (who was not the responsible researcher) was always blind to the condition to which the participants had been assigned. Then participants completed the neuropsychological tests in one of two task orders (randomly determined). Half of the participants completed the tasks in the following order: the Flexibility subtest of the TAP, the encoding phase of the CVLT, the Working Memory subtest of the TAP, the Incompatibility subtest of the TAP, the recall phase of the CVLT, the Stroop task, and the Brown–Peterson task. The other participants completed the tasks in the reverse order, except for the encoding phase of the CVLT, which was completed first. Then, participants completed the SART and the feeling of threat and manipulation check questionnaires. At the end of the experiment, participants were fully debriefed about the real purpose of the study. In particular, they were told that the symptoms of mTBI generally disappear one week to three months after the injury.

Results

Descriptive and preliminary analyses

Statistical analyses were conducted with SPSS 24. An analysis of variance (ANOVA) using group (mTBI vs. control) and condition (explicit DT vs. implicit DT) as between factors indicated no main effect or interaction on years of education or STAI–YB score, $ps > .114$. There was a main effect of group on age, $F(1, 73) = 5.98$, $p = .017$, with the mTBI group ($M_{years} = 21.48$, $SD = 0.38$) being younger than the control group ($M_{years} = 22.79$, $SD = 0.38$). There was a trend, $F(1, 73) = 3.15$, $p = .080$, for participants in the explicit DT condition ($M = 8.10$, $SD = 1.18$) to score lower on the BDI–II scale than participants in the implicit DT condition ($M = 11.0$, $SD = 1.14$). A chi-square test indicated no sex differences, $p = .91$). In the mTBI group, there was no difference between conditions regarding loss of consciousness duration, loss of memory, confusion, and disorientation, $ps > .177$. There was a significant difference between conditions for time elapsed since mTBI, $F(1) = 7.28$, $p = .010$. A chi-square test indicated no difference between conditions for medical consultations following the mTBI, $p = .777$. Demographic and mTBI-related characteristics are presented in Table 2.

We also tested for task order effects, and the results showed that order had no effect on working memory and executive scores, $ps > .232$. There was a trend toward an effect of order for episodic memory, $t(75) = 1.78$, $p = .080$. Controlling for order in the analyses did not change the pattern of results. For the sake of simplicity, we did not add this variable to the list of covariates.

On the manipulation check questionnaire, as expected, there was no effect of group or condition (nor was there an interaction) for Item 3, $ps > .100$ ($M = 4.39$ and $SD = 0.75$ for the total sample). As well, all participants disagreed ($M = 1.43$, $SD = 0.70$) with Item 2, although participants in the explicit DT condition ($M = 1.24$, $SD = 0.11$) disagreed more than participants in the implicit DT condition ($M = 1.61$, $SD = 0.11$), $F(1, 73) = 5.76$, $p = .019$. Participants in the explicit DT condition ($M = 4.14$, $SD = 1.03$) agreed significantly more with Item 1 than participants in the implicit DT condition ($M = 3.13$, $SD = 1.34$), $F(1,73) = 13.36$, $p < .001$. Examination of mean values in each cell indicated mean

Table 2. Demographic and mTBI characteristics.

Variables	Explicit DT condition Control (n = 19)	Explicit DT condition mTBI (n = 18)	Implicit DT condition Control (n = 19)	Implicit DT condition mTBI (n = 21)
Age (years)*	23.26 (0.54)	21.67 (0.55)	22.32 (0.54)	21.29 (0.51)
Education (years)	14.21 (0.38)	14.00 (0.39)	14.53 (0.38)	13.52 (0.36)
BDI–II	8.53 (1.65)	7.67 (1.69)	10.05 (1.65)	11.95 (1.57)
STAI–YB	37.84 (3.01)	39.39 (3.10)	40.74 (3.01)	45.24 (2.87)
Sex (% female)	55.6	63.2	66.7	63.2
LOC median (in s)		1		1
LOM median (in s)		1		1
Confusion median (in s)		1		2
Disorientation median (in s)		1		1
TSI (months)*		59.39 (60.44)		113.86 (64.79)
Doc. visit (% visit)		68.4		76.2

Note. mTBI = mild traumatic brain injury; DT = diagnosis threat; education = years of education; BDI–II = Beck Depression Inventory–II, total score; STAI–YB = State–Trait Anxiety Inventory, Trait form, total score; LOC median = median response for loss of consciousness; LOM median = median response for loss of memory; confusion median = median response for confusion duration; disorientation median = median response for disorientation duration; TSI = time elapsed since injury; doc. visit = % of participants who consulted a doctor following their mTBI.
*p < .05.

scores at or above the neutral point, showing that all participants tended to consider that the study's purpose was to assess the cognitive issues affecting mTBI people.

Is the effect of diagnosis threat on cognitive assessment moderated by domain identification?

Regression-based analyses were conducted on each composite score, with one analysis for each dependent variable (Hayes, 2013). For these analyses, the independent and moderating variables were contrast coded or mean centered. This enabled us to examine conditional effects (when all the other predictors are equal to their average, and the scores are the same for any covariates) simultaneously in moderation models. The explicit DT condition was contrast coded +0.5, while the implicit DT condition was contrast coded −0.5. The mTBI group was contrast coded +0.5, and the control group was contrast coded −0.5. Demographic analyses indicated that there was an age difference between groups and a BDI–II score difference between conditions. We therefore controlled for these variables across all analyses. For mTBI participants, there was a difference between conditions regarding the time elapsed since the mTBI. When necessary, we therefore conducted a subsidiary set of analyses for mTBI participants in order to add the time elapsed since injury as a supplemental covariate.

Working memory

There was a three-way interaction between condition, group, and domain identification on working memory, b = 2.89, SE = 0.95, t = 3.05, p = .003, η^2 = .11 (all remaining ps > .131). As predicted in Hypothesis 1, for the control group, there was no effect of condition regardless of the participants' level of domain identification. The conditional effects of condition for both low and high identifiers (i.e., at mean −1 SD and mean +1 SD) were nonsignificant, ps > .251.

For mTBI participants, as predicted in Hypothesis 2a, there was a significant effect of condition for high identifiers, b = 0.93, SE = 0.40, t = 2.30, p = .025 (95% confidence interval, CI [0.12, 1.73]), revealing that, compared to the explicit DT condition, high domain identification mTBI participants performed worse in the implicit DT condition (see Figure 1). This conditional effect remained significant when time elapsed since injury was added as a covariate, b = 1.07, SE = 0.48, t = 2.23, p = .033, η^2 = .11. Unexpectedly, there was also a significant effect of condition for mTBI participants with low domain identification, b = −0.89, SE = 0.36, t = −2.45, p = .017 (95% CI [−1.62, −0.17]). These participants scored worse on working memory tasks in the explicit DT condition than in the implicit DT condition. This conditional effect remained significant when time elapsed since injury was added as a covariate, b = −0.87, SE = 0.40, t = −2.15, p = .039, η^2 = .10.

Decomposition of the three-way interaction also revealed an effect of domain identification in mTBI participants, in the implicit DT condition, b = −1.03, SE = 0.37, t = −2.78, p = .007 (95% CI [−1.76, −0.29]) and in the explicit DT condition, b = 1.15, SE = 0.58, t = 1.99, p = .051 (95% CI [−0.00, 2.30]). In other words, domain identification had a detrimental effect on working memory in the implicit DT condition (Hypothesis 3) but a positive one in the explicit DT condition (Hypothesis 2b). The same conditional effects emerged in the implicit DT condition, b = −1.05, SE = 0.41, t = −2.56, p = .015 (95% CI [−1.88, −0.21]), and in the explicit DT condition, b = 1.25, SE = 0.64, t = 1.96, p = .059 (95% CI [−0.05, 2.56]),

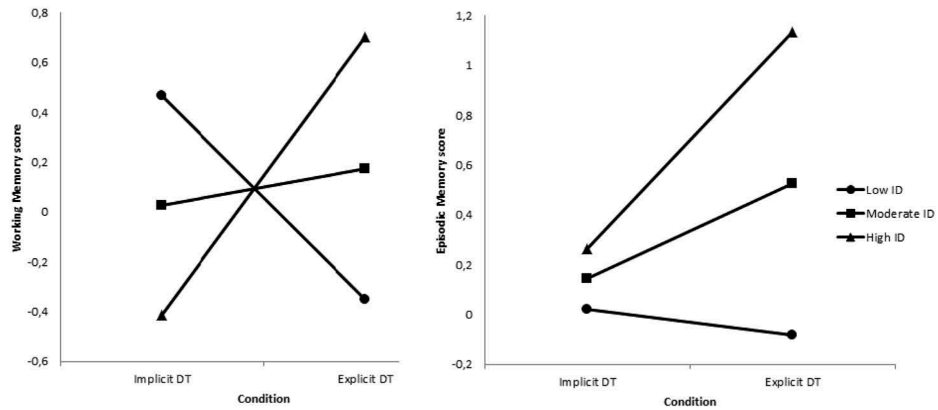

Figure 1. Assimilation and contrast effects on working memory and episodic memory scores for mild traumatic brain injury (mTBI) participants. DT = diagnosis threat; ID = domain identification.

when time elapsed since injury was added as a covariate. Not surprisingly, there was no such effect of domain identification for control group participants, regardless of the condition, *ps* > .163.

Episodic memory

Main analyses revealed a significant effect of group, $b = 0.68$, $SE = 0.20$, $t = 3.41$, $p = .001$, $\eta^2 = .13$, indicating better performance in the mTBI group than in the control group. There was a positive effect of age on performance, $b = 0.12$, $SE = 0.04$, $t = 2.88$, $p = .005$, $\eta^2 = .09$. There was a marginal interaction between condition and domain identification, $b = 0.50$, $SE = 0.25$, $t = 1.96$, $p = .055$, $\eta^2 = .04$, revealing an effect of condition only for high domain identification participants, $b = 0.60$, $SE = 0.31$, $t = 1.94$, $p = .057$ (95% CI [−0.02, 1.21]). Overall, participants scored better in the explicit DT condition than in the implicit DT condition. There was no three-way interaction, $p = .847$. However, we directly tested our specific hypotheses separately for control and mTBI participants.

As predicted in Hypothesis 1, for the control group, there was no effect of condition regardless of the participant's level of domain identification. The conditional effects of condition for both low and high identifiers were nonsignificant, *ps* > .451. In this analysis, no effect was significant, all *ps* > .12, and, in particular, there was no interaction between condition and domain identification, $p = .293$.

For mTBI participants, as predicted in Hypothesis 2a, there was a significant effect of condition for high identifiers (with time since injury as a supplemental covariate), $b = 0.84$, $SE = 0.36$, $t = 2.35$, $p = .025$, $\eta^2 = .11$. Compared to the explicit DT condition, high domain identification mTBI participants scored worse in the implicit DT condition (see Figure 1). For low identifiers, there was no condition effect, $p = .73$. The pattern of these conditional effects resulted in a significant interaction between condition and domain identification, $b = 1.16$, $SE = 0.57$, $t = 2.05$, $p = .018$, $\eta^2 = .08$.

This interaction also revealed a positive impact of domain identification in the explicit DT condition (Hypothesis 2b; $b = 1.45$, $SE = 0.48$, $t = 3.01$, $p = .005$; 95% CI [0.47, 2.43]). In the implicit DT condition, there was no effect of domain identification, $p = .353$. The same interaction between condition and domain identification also qualified a conditional effect of domain identification. Overall, highly identified participants performed better than lower identifiers, $b = 0.87$, $SE = 0.29$, $t = 3.02$, $p = .005$, $\eta^2 = .18$. Age was also a significant predictor, $b = 0.12$, $SE = 0.05$, $t = 2.51$, $p = .018$, $\eta^2 = .12$.

Executive score

Except for overall effects of domain identification, $b = -0.49$, $SE = 0.22$, $t = -2.25$, $p = .028$, $\eta^2 = .06$, indicating worse executive performance with increasing domain identification, and age, $b = 0.10$, $SE = 0.03$, $t = 2.80$, $p = .007$, $\eta^2 = .09$, revealing better performance with increasing age, there was no other effect, *ps* > .462.

As predicted in Hypothesis 1, for the control group, there were no effects of condition regardless of the participants' level of domain identification. The conditional effects of condition for low and high identifiers were both nonsignificant, *ps* > .709. In this analysis, no effect was significant, all *ps* > .10, and, in particular, there was no interaction between condition and domain identification, $p = .942$. In the mTBI group, there was no significant effect of condition for high identifiers (with time since injury as a supplemental covariate, $p = .890$). For low identifiers, there was no condition effect either, $p = .546$. There was no effect of domain identification in the explicit DT condition ($p > .552$; Hypothesis 2b) and in the implicit DT condition ($p > .076$; Hypothesis 3). Age was a significant predictor, $b = 0.12$, $SE = 0.05$, $t = 2.17$, $p = .038$, $\eta^2 = .11$. The other effects were all nonsignificant, all *p*s > .148.

Does diagnosis threat impact the thought content of mTBI participants?

According to Hypothesis 4, the assimilation effect (observed in the implicit DT condition for high identifiers) could be mediated by intrusive thoughts (by comparing that condition to the conditions in which no assimilation effect was expected, and a contrast effect was observed—that is, for high identifiers confronted by an explicit threat and low identifiers confronted by an implicit threat). Therefore, we tested the effect of assimilation and contrast on the measures of interference. The assimilation cell was coded +1, and the two contrast cells were coded −1.

Regardless of the indices of TRI, there was no effect of assimilation or contrast on these measures of interference, nor did the covariates have an effect, *p*s > .101. In a subsidiary analysis, we also tested whether the subjective feeling of threat could have been higher in the case of an assimilation effect than for a contrast effect (with the same coding as that for the analysis above). The feeling of threat reported by the participants was the same in both conditions, $p = .811$.

Discussion

A few studies have shown that DT led individuals with mTBI to underperform on neuropsychological tasks (Pavawalla et al., 2013; Suhr & Gunstad, 2002, 2005) and to report more cognitive difficulties (Ozen & Fernandes, 2011; Trontel et al., 2013). However, some other studies did not find an assimilation effect of DT on cognitive performance (Blaine et al., 2013; Ozen & Fernandes, 2011; Trontel et al., 2013) or they found a contrast effect (Fresson et al., 2017). Due to its potential impact on the neuropsychological assessment of persons with mTBI, this DT phenomenon needs to be further investigated (Iverson & Lange, 2011; Rohling et al., 2012).

First of all, our results confirmed that, because they are not targeted by the threat, the performance of participants with no history of mTBI was not influenced by the explicit or implicit nature of the DT, regardless of their domain identification (Hypothesis 1). As expected, for mTBI participants for whom the threat was particularly relevant—that is, high domain identifiers—our results indicated a negative effect (suggesting an assimilation effect) of the implicit DT condition on both working and episodic memory scores. Compared to the explicit DT condition, the performance of mTBI participants with high domain identification was lower in the implicit DT condition (Hypothesis 2a). Likewise, for both working and episodic memory scores, domain identification had a positive impact on mTBI participants in the explicit DT condition (Hypothesis 2b) but a negative impact in the implicit DT condition (for working memory only; Hypothesis 3). Compared to the implicit DT condition, in which mTBI participants with high domain identification scored low on the working memory tasks, the same individuals performed better in the explicit DT condition for both episodic and working memory. Unexpectedly, low domain identifier mTBI participants showed a decrease in working memory performance in the explicit condition compared to the implicit condition. There was no mediation by feelings of threat or intrusive thoughts (Hypothesis 4).

One of the most important results of this study is that the explicit or implicit nature of the threat alone is not sufficient to determine the impact of DT on the cognitive assessment of mTBI participants. This confirms the results of previous studies (Blaine et al., 2013; Ozen & Fernandes, 2011; Trontel et al., 2013) and shows the need for future studies of DT to assess moderating variables (see Fresson et al., 2017). In previous studies, the lack of effect on cognitive performance could have been due to moderating variables (especially domain identification) that were not measured and consequently were not taken into account. While those authors recruited university students, which could constitute an indicator of relatively high identification with cognitive performance, they did not take interindividual differences in domain identification into account (i.e., they did not measure them). In our study, we showed that the effect of DT on cognitive performance in participants with mTBI is moderated by the personal relevance of the domain that is threatened.

The finding that mTBI participants who value cognitive functioning highly showed a decrease in both working and episodic memory performance following implicit DT instructions compared to the explicit DT condition (and also that domain identification had a negative impact on working memory performance in implicit DT conditions) is in accordance with several studies of stereotype threat. On the one hand, for example, in the study by Good, Aronson, and Harder (2008), highly math-identified female participants (i.e., female students in the upper levels of university mathematics) performed worse in the implicit stereotype threat condition—in which the fact that the task assessed mathematical skills was emphasized—than in the neutral condition. As well, Schmader and Johns (2003) recruited only female participants who highly valued quantitative-mathematical capacity (i.e., participants who reported Scholastic Assessment Test, SAT, scores of 500 or higher in this domain) and assigned them to either an implicit stereotype threat condition or a neutral condition. In two experiments, their results showed that highly math-identified women underperformed on working memory and math tasks when facing implicit stereotype threat compared to the neutral condition. These studies showed that participants with high domain identification performed worse in implicit stereotype threat conditions (see also Schuster et al., 2015).

On the other hand, it has been proposed that a highly explicit, blatant stereotype fosters contrast effects (Nguyen & Ryan, 2008; Wheeler & Petty, 2001). For example, our result is in accordance with the study by Kray et al. (2001), who showed that blatant stereotype instructions led their female participants to outperform in a negotiation task. It has been proposed that a feeling of discrepancy between the activated stereotype and a valued aspect of the self triggers a contrast effect (Wheeler & Petty, 2001). As well, Fresson et al. (2017) showed that contact-sport players scored better on cognitive tasks following explicit DT instructions than in the neutral condition. Thus, it is conceivable that our highly domain-identified mTBI participants—who attribute importance to cognitive functioning and consider that having good cognitive functioning is an important part of who they are—considered our explicit DT condition to be unjustified (discordant). Consequently, they may not have felt overwhelmed by the instructions and may even have wanted to prove them false, leading them to score higher in the explicit DT condition than both high identifiers in the implicit DT condition and low identifiers in the explicit DT condition.

Concerning the relationship between domain identification and the type of DT (implicit or explicit), it is nonetheless important to recall that some studies showed poorer performance by highly domain-identified participants in response to an "explicit" (i.e., with explicit reference to a difference between groups) stereotype threat condition (Cadinu et al., 2003; Hess et al., 2003). This apparent discrepancy between our results and those of studies showing underperformance by high identified individuals following explicit threat may perhaps be better understood by considering the distinction made by Lamont et al. (2015). According to these authors, stereotype-based instructions (e.g., "Older adults are supposed to perform worse than young adults on memory tasks") are rather ambiguous and therefore have a more detrimental impact on performance. Conversely, fact-based instructions (e.g., "Studies have shown that older adults have poorer memory capacities than young adults") are unequivocal and are much less harmful than stereotype-based instructions (*d* nonsignificant in their meta-analyses). We think that, although Cadinu et al.'s (2003) and Hess et al.'s (2003) stereotype instructions can be considered explicit (like our explicit DT instructions), they were not unequivocal; in fact, they were rather ambiguous. They did indeed state that studies had shown differences between groups (female vs. male and older vs. younger), but their instructions also mentioned that these differences were not found in every domain (Cadinu et al., 2003) or that cognitive difficulties do not lead to significant difficulties in everyday functioning (Hess et al., 2003). We therefore suggest that the remaining ambiguity of their stereotype instructions might have triggered an assimilation effect.

As a result, we propose that ambiguity could be a key element when stereotype instructions induce underperformance. Indeed, according to Schmader et al. (2008), stereotype threat creates a state of imbalance that elicits a set of negative emotions that people try to resolve. These regulation processes occupy the participants' working memory capacities, and thus their task performance declines. If stereotype activation does not elicit ambiguity or imbalance and if participants can easily reject the stereotype, they want to prove it false. In that case, they might outperform, especially if it is important for them to excel in the tasks (i.e., if they highly value the domain). We think that our explicit DT instructions were not only explicit but also unequivocal. We clearly mentioned the results of scientific studies that reported differences between mTBI participants and neurologically normal individuals (contrary to Cadinu et al., 2003). Moreover, we told participants that their performance would be compared to that of people who had not have experienced an mTBI; these instructions result in a comparison of the self to a standard, which is thought to trigger a contrast effect (Biernat, 2005).

An unexpected result emerged from the pattern of working memory performance by mTBI participants with low domain identification. They outperformed in the implicit DT condition (or vice versa, they underperformed in the explicit DT condition). It could be that in the explicit DT condition, low identifier participants—for whom performing well in cognitive tasks is not particularly important—disinvested from the tasks because of the instructions (which indicated that they would perform poorly). Another explanation could be that, with explicit DT instructions, contrary to high identifiers, their motivation was insufficient to overcome the threat, and they choked under pressure (Baumeister, 1984). As well, it could be that, because it is not important for them to be good at cognitive tasks, the implicit, ambiguous instructions were not threatening, and they did not feel pressure to perform. Consequently, they felt free of pressure to do well, and their performance improved compared to the explicit condition. However, these explanations are speculative and should be specifically investigated.

It is noteworthy that our explicit DT instructions were almost identical to the instructions used by Suhr and Gunstad (2002, 2005), who found decreased performance in their DT condition compared to the neutral one. In our explicit DT condition, we found that high identifiers outperformed low identifiers on episodic and working memory. In other words, low identifiers scored worse on both kinds of tasks in the explicit condition than in the implicit condition. Although Suhr and Gunstad (2002, 2005) found a (total) negative impact of their DT condition on performance, it could be that distinguishing between low and high identifiers in their study would have shown a pattern of assimilation and contrast effect. However, this explanation is hypothetical, and further studies are needed to better understand the impact of the explicitness/implicitness characteristic of DT.

Although, according to Schmader et al. (2008), stereotype threat preferentially affects tasks involving executive processes, in this study, quite unexpectedly, executive tasks were not impacted by DT instructions. We can rule out the involvement of an order effect since executive tasks were well apportioned during the testing session, and there was no order effect. Overall, compared to our episodic memory and working memory tasks, executive tasks were not influenced by DT. One hypothetical explanation is that, compared to the working memory and episodic memory tasks administered in this study, the executive tasks may have induced less cognitive load. Indeed, contrary to our executive tasks, both kinds of memory tasks involved both memorizing information and mobilizing executive resources. If participants perceived the executive tasks as easier than the memory tasks, they would have been less impacted by DT instructions (Schuster et al., 2015). Although this explanation is hypothetical and must be investigated, it makes sense in view of our highly educated sample (mean number of years of education = 14.05), who may have been less challenged by tasks that did not entail cognitive load.

Considering mediation analyses, we expected that depletion of the cognitive performance of high identifiers under implicit threat would be mediated by intrusive thoughts. However, our results indicated no evidence of DT effects on intrusive thoughts. This could be because our intrusive thoughts measures were administered at the end of the task battery. In this regard, Cadinu et al. (2005) showed that stereotype threat has an immediate impact on intrusive thoughts whereas the decrease in performance (resulting from these intrusive thoughts) occurs rather later (in the second part of the task). Interestingly, the direct effect of stereotype threat on intrusive thoughts in the second part of the task was not significant (whereas it was significant in the first part). Measuring intrusive thoughts only at the end of the task battery may have diminished the predictive power of our intrusive thoughts measures.

Ben-Zeev et al. (2005) explained that how participants interpret the evaluation situation—as challenging or threatening—affects the subsequent pattern of performance (contrast or assimilation effect). In our results, DT had no effect on feeling of threat, but the descriptive statistics showed that all mTBI participants experienced a slight feeling of threat. We think that future studies should measure these two types of feelings (challenge and threat), because they may act jointly. Along with this cognitive appraisal model of stereotype threat, some authors have argued that stereotype threat could elicit either a prevention-focused regulation style (participants act more cautiously and try to avoid doing badly) or a promotion-focused style (participants strive to do well), which leads to different cognitive styles. When stereotype threat elicits a prevention focus, performance diminishes on tasks based on promotion, while if it elicits a promotion focus, performance on those tasks increases (Grimm, Markman, Maddox, & Baldwin, 2009; Seibt & Forster, 2004). Concerning our results, our implicit DT condition could have elicited a prevention focus in high identifier participants because of the ambiguous stereotype instructions. Conversely, when they faced our explicit and unequivocal stereotype instructions, they may have engaged in a promotion-focused regulation style because these instructions did not trigger doubts or imbalance. These mediational hypotheses are speculative but open up new avenues for future DT studies.

Limitations and future directions

The first limitation on our study was that we did not include a neutral condition, which prevents us from determining the relative contributions of an assimilation and a contrast effect (compared to a neutral condition). Nonetheless, we found that domain identification had a negative effect on working memory score in the implicit DT condition, which might reveal the "classical" assimilation effect observed in the stereotype threat literature for high identifiers (e.g., Hess et al., 2003). Our results also showed that this effect is reversed in the explicit condition: High identifiers scored better than low identifiers, which is suggestive of a contrast effect (Kray et al., 2001). Although it appears that implicit and explicit DT instructions had different effects on mTBI participants with high levels of domain identification, the lack of a neutral condition limits the conclusions that can be drawn from these results. Replicating this study with the inclusion of a neutral condition would certainly contribute to a better understanding of the relative involvement of the two phenomena, as well as their mediating mechanisms. When it comes to including a neutral condition, recruiting mTBI participants without letting them understand that their mTBI is the reason for their inclusion is complicated. Possibly, simply asking for mTBI history (one item) during the screening and asking about TBI characteristics (loss of consciousness, etc.) after the completion of the whole experiment would reduce the saliency of their group identity before the experiment. In turn, this might lead to less of a perceived threat.

Another limitation was that mTBI participants were recruited based on self-report measures; the limitations of this procedure have been highlighted in previous DT studies. However, participants in the mTBI group identified themselves as having sustained an mTBI, which constitutes a prerequisite for stereotype threat effects (Martiny, Roth, Jelenec, Steffens, & Croizet, 2012). Nonetheless, future studies should consider examining DT effects with individuals with mTBI for whom medical records are available. As well, after the debriefing, participants were given the opportunity to ask questions or report (medical) information related to the study. However, they were not specifically asked whether they had suffered a brain injury in the last three months (since their recruitment). Nonetheless, if some control participants had sustained a brain injury during the three months interval this would have diminished the effect of DT in our study (not inflated it).

While we tried to control for the most relevant mTBI characteristics (time elapsed since injury, loss of consciousness, etc.) that may have influenced our results, we did not ask for the number of mTBIs sustained. People who had sustained several mTBIs may have responded differently to DT instructions than persons who had had only one (e.g., Aungst, Kabadi, Thompson, Stoica, & Faden, 2014). Nonetheless, participants were asked to respond to the TBI questionnaire by referring to the most severe TBI they had experienced (e.g., respond according to the moderate TBI if they had sustained both a mild and a moderate TBI). None of them reported a moderate or severe TBI.

Regarding the clinical relevance of the study, it should be noted that the instructions that we used to explicitly activate DT are not the same as those used in clinical practice. Future studies on the DT phenomenon should consider the influence of the instructions that are generally conveyed to patients with mTBI in a clinical setting. As well, our sample of participants with mTBI was quite heterogeneous in terms of the time since injury. Because feelings of threat or DT effects could be related to time since injury, future studies should consider DT separately in the case of recent and long-ago mTBI. A recent injury could be associated with a greater feeling of threat due to the fear of experiencing sequelae, but a remote injury could also be associated with a greater sense of threat in people who have been aware of cognitive difficulties for a long time. This kind of investigation would help to identify the contribution of DT in postconcussion syndrome.

In our study, DT has a medium effect size, which is consistent with the results of previous DT studies (see Iverson, 2007; Rohling et al., 2012). However, a post hoc power analysis on the whole sample, assuming a medium effect size ($f^2 = 0.15$) and using seven predictors at alpha = .05, indicated that $n = 77$ would provide around 64% power (G*Power 3.1.9.2; Faul, Erdfelder, Buchner, & Lang, 2009). Considering the participants with mTBI only, and assuming a medium effect size ($f^2 = 0.15$), with three predictors at alpha = .05, a power analysis indicated that $n = 39$ would provide only 46% power. Then, our study lacks statistical power. While our study helps disentangling the diverging results in the DT literature by suggesting the moderating role of the nature of the threat and domain identification, our results should be replicated with a larger sample size in order to reach more statistical power.

Conclusions

Our results add to our understanding of the DT phenomenon, showing that not all individuals are vulnerable to the detrimental impact of DT and that in some conditions (explicit and unequivocal DT condition), some individuals (those for whom the threat is personally relevant) can outperform. Our results show that not considering certain moderating variables can hide

DT effects (e.g., opposite effects depending on certain psychosocial variables and types of instructions). In conclusion, this study suggests that DT may be a biasing factor in the neuropsychological assessment of some mTBI participants; consequently, clinical neuropsychologists should take this phenomenon into account when they assess the cognitive performance of individuals who have had an mTBI.

Note

1. There was no difference between conditions on this questionnaire (p = .411). Mean scores in each condition were low: mTBI participants in the implicit condition got a mean score of 1.96 (SD = 0.8) while mTBI participants in the explicit condition got a mean score of 2.19 (SD = 0.9). On this scale, 2 corresponds to "disagree."

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

This work was supported by the Belgian Fund for Scientific Research (Fonds De La Recherche Scientifique; FRS–FNRS).

References

Aungst, S. L., Kabadi, S. V., Thompson, S. M., Stoica, B. A., & Faden, A. I. (2014). Repeated mild traumatic brain injury causes chronic neuroinflammation, changes in hippocampal synaptic plasticity, and associated cognitive deficits. *Journal of Cerebral Blood Flow & Metabolism*, *34*, 1223–1232.

Baumeister, R. F. (1984). Choking under pressure: Self-consciousness and paradoxical effects of incentives on skillful performance. *Journal of Personality and Social Psychology*, *46*, 610–620.

Bazarian, J. J., McClung, J., Shah, M. N., Cheng, Y. T., Flesher, W., & Kraus, J. (2005). Mild traumatic brain injury in the United States, 1998–2000. *Brain Injury*, *19*, 85–91.

Beck, A. T., Steer, R. A., & Brown, G. K. (1996). *Beck depression inventory – Second edition manual*. San Antonio, TX: The Psychological Corporation.

Beilock, S. L., Rydell, R. J., & McConnell, A. R. (2007). Stereotype threat and working memory: Mechanisms, alleviation, and spillover. *Journal of Experimental Psychology: General*, *136*, 256–276.

Ben-Zeev, T., Carrasquillo, C. M., Ching, A. M., Kliengklom, T. J., McDonald, K. L., Newhall, D. C., … Inzlicht, M. (2005). "Math is hard!" (Barbie™, 1994): Responses of threat vs. challenge-mediated arousal to stereotypes alleging intellectual inferiority. In A. M. Gallagher & J. C. Kaufman (Eds.), *Gender differences in mathematics: An integrative psychological approach* (pp. 189–206). Cambridge, UK: Cambridge University Press.

Biernat, M. (2005). *Standards and expectancies. Contrast and assimilation in judgments of self and others*. New York: Psychology Press.

Blaine, H., Sullivan, K. A., & Edmed, S. L. (2013). The effect of varied test instructions on neuropsychological performance following mild traumatic brain injury: An investigation of "diagnosis threat". *Journal of Neurotrauma*, *30*, 1405–1414.

Cadinu, M., Maass, A., Frigerio, S., Impagliazzo, L., & Latinotti, S. (2003). Stereotype threat: The effect of expectancy on performance. *European Journal of Social Psychology*, *33*, 267–285.

Cadinu, M., Maass, A., Rosabianca, A., & Kiesner, J. (2005). Why do women underperform under stereotype threat? Evidence for the role of negative thinking. *Psychological Science*, *16*, 572–578.

Cheyne, J. A., Solman, G. J., Carriere, J. S., & Smilek, D. (2009). Anatomy of an error: A bidirectional state model of task engagement/disengagement and attention-related errors. *Cognition*, *111*, 98–113.

Dardenne, B., Dumont, M., & Bollier, T. (2007). Insidious dangers of benevolent sexism: Consequences for women's performance. *Journal of Personality and Social Psychology*, *93*, 764–779.

Delis, D., Kramer, J., Kaplan, E., & Ober, B. (1987). *The California verbal learning test: Reliability, validity, and factor structure*. New York: The Psychological Corporation.

Desrichard, O., & Kopetz, C. (2005). A threat in the elder: The impact of task instructions, self-efficacy and performance expectations on memory performance in the elderly. *European Journal of Social Psychology*, *35*, 537–552.

Dixon, R., & Hultsch, D. (1983). Structure and development of metamemory in adulthood. *Journal of Gerontology*, *38*, 682–688.

Dumont, M., Sarlet, M., & Dardenne, B. (2010). Be too kind to a woman, she'll feel incompetent: Benevolent sexism shifts self-construal and autobiographical memories toward incompetence. *Sex Roles: A Journal of Research*, *62*, 545–553.

Faul, F., Erdfelder, E., Buchner, A., & Lang, A.-G. (2009). Statistical power analyses using G* power 3.1: Tests for correlation and regression analyses. *Behavior Research Methods*, *41*, 1149–1160.

Fernández-Ballesteros, R., Bustillos, A., & Huici, C. (2015). Positive perception of aging and performance in a memory task: Compensating for stereotype threat? *Experimental Aging Research*, *41*, 410–425.

Fresson, M., Dardenne, B., Geurten, M., & Meulemans, T. (2017). Stereotype contrast effect on neuropsychological assessment of contact-sport players: The moderating role of locus of control. *Journal of Clinical and Experimental Neuropsychology*, *39*, 913–930.

Geurten, M., Vincent, E., Van der Linden, M., Coyette, F., & Meulemans, T. (2016). Working memory assessment: Construct validity of the Brown-Peterson test. *Canadian Journal of Behavioural Science/Revue Canadienne des Sciences du Comportement*, *48*, 328–336.

Godefroy, A., & GREFEX. (2008). *Fonctions exécutives et pathologies neurologiques et psychiatriques* [Executive functions and neurological and psychiatric conditions]. Marseille: Solal.

Good, C., Aronson, J., & Harder, J. A. (2008). Problems in the pipeline: Stereotype threat and women's achievement in high-level math courses. *Journal of Applied Developmental Psychology*, *29*, 17–28.

Grimm, L. R., Markman, A. B., Maddox, W. T., & Baldwin, G. C. (2009). Stereotype threat reinterpreted as a regulatory mismatch. *Journal of Personality and Social Psychology*, *96*, 288–304.

Hayes, A. F. (2013). *Introduction to mediation, moderation, and conditional process analysis. A regression-based approach*. New York: The Guilford Press.

Hess, T. M., Auman, C., Colcombe, S. J., & Rahhal, T. A. (2003). The impact of stereotype threat on age differences in memory performance. *The Journals of Gerontology: Series B: Psychological Sciences and Social Sciences*, *58*, 3–11.

Holm, L., Cassidy, J. D., Carroll, L., & Borg, J. (2005). Summary of the WHO collaborating centre for neurotrauma task force on mild traumatic brain injury. *Journal of Rehabilitation Medicine*, *37*, 137–141.

Iverson, G. L. (2007). Identifying exaggeration and malingering. *Pain Practice*, *7*, 94–102.

Iverson, G. L., & Lange, R. T. (2011). Mild traumatic brain injury. In M. R. Schoenberg & J. G. Scott (Eds.), *The little black book of neuropsychology: A syndrome-based approach* (pp. 697–719). New York: Springer.

Keller, J. (2007). Stereotype threat in classroom settings: The interactive effect of domain identification, task difficulty and stereotype threat on female students' maths performance. *British Journal of Educational Psychology*, *77*, 323–338.

Kit, K. A., Mateer, C. A., Tuokko, H. A., & Spencer-Rodgers, J. (2014). Influence of negative stereotypes and beliefs on neuropsychological test performance in a traumatic brain injury population. *Journal of the International Neuropsychological Society*, *20*, 157–167.

Kit, K. A., Tuokko, H. A., & Mateer, C. A. (2008). A review of the stereotype threat literature and its application in a neurological population. *Neuropsychology Review*, *18*, 132–148.

Konrad, C., Geburek, A. J., Rist, F., Blumenroth, H., Fischer, B., Husstedt, I., … Lohmann, H. (2011). Long-term cognitive and emotional consequences of mild traumatic brain injury. *Psychological Medicine*, *41*, 1197–1211.

Kray, L. J., Thompson, L., & Galinsky, A. (2001). Battle of the sexes: Gender stereotype confirmation and reactance in negotiations. *Journal of Personality and Social Psychology*, *80*, 942–958.

Lamont, R. A., Swift, H. J., & Abrams, D. (2015). A review and meta-analysis of age-based stereotype threat: Negative stereotypes, not facts, do the damage. *Psychology and Aging*, *30*, 180–193.

Lannsjö, M., af Geijerstam, J.-L., Johansson, U., Bring, J., & Borg, J. (2009). Prevalence and structure of symptoms at 3 months after mild traumatic brain injury in a national cohort. *Brain Injury*, *23*, 213–219.

Logel, C., Iserman, E. C., Davies, P. G., Quinn, D. M., & Spencer, S. J. (2009). The perils of double consciousness: The role of thought suppression in stereotype threat. *Journal of Experimental Social Psychology*, *45*, 299–312.

Martiny, S. E., Roth, J., Jelenec, P., Steffens, M. C., & Croizet, J.-C. (2012). When a new group identity does harm on the spot: Stereotype threat in newly created groups. *European Journal of Social Psychology*, *42*, 65–71.

Maruff, P., Thomas, E., Cysique, L., Brew, B., Collie, A., Snyder, P., & Pietrzak, R. H. (2009). Validity of the CogState brief battery: Relationship to standardized tests and sensitivity to cognitive impairment in mild traumatic brain injury, schizophrenia, and AIDS dementia complex. *Archives of Clinical Neuropsychology*, *24*, 165–178.

Mazerolle, M., Regner, I., Morisset, P., Rigalleau, F., & Huguet, P. (2012). Stereotype threat strengthens automatic recall and undermines controlled processes in older adults. *Psychological Science*, *23*, 723–727.

McCrea, M. (2008). *Mild traumatic brain injury and post-concussion syndrome: The new evidence base for diagnosis and treatment*. New York, NY: Oxford University Press.

Mrazek, M. D., Chin, J. M., Schmader, T., Hartson, K. A., Smallwood, J., & Schooler, J. W. (2011). Threatened to distraction: Mind-wandering as a consequence of stereotype threat. *Journal of Experimental Social Psychology*, *47*, 1243–1248.

Nguyen, -H.-H. D., & Ryan, A. M. (2008). Does stereotype threat affect test performance of minorities and women? A meta-analysis of experimental evidence. *Journal of Applied Psychology*, *93*, 1314–1334.

Ozen, L. J., & Fernandes, M. A. (2011). Effects of "diagnosis threat" on cognitive and affective functioning long after mild head injury. *Journal of the International Neuropsychological Society*, *17*, 219–229.

Pavawalla, S. P., Salazar, R., Cimino, C., Belanger, H. G., & Vanderploeg, R. D. (2013). An exploration of diagnosis threat and group identification following concussion injury. *Journal of the International Neuropsychological Society*, *19*, 305–313.

Pennington, C. R., Heim, D., Levy, A. R., & Larkin, D. T. (2016). Twenty years of stereotype threat research: A review of psychological mediators. *Plos One*, *11*, e0146487.

Robertson, I. H., Manly, T., Andrade, J., Baddeley, B. T., & Yiend, J. (1997). 'Oops!': Performance correlates of everyday attentional failures in traumatic brain injured and normal subjects. *Neuropsychologia*, *35*, 747–758.

Rohling, M. L., Binder, L. M., Demakis, G. J., Larrabee, G. J., Ploetz, D. M., & Langhinrichsen-Rohling, J. (2011). A meta-analysis of neuropsychological outcome after mild traumatic brain injury: Re-analyses and reconsiderations of Binder et al., Frencham et al., and Pertab et al. *The Clinical Neuropsychologist*, *25*, 608–623.

Rohling, M. L., Larrabee, G. J., & Millis, S. R. (2012). The "miserable minority" following mild traumatic brain injury: Who are they and do meta-analyses hide them? *The Clinical Neuropsychologist*, *26*, 197–213.

Schmader, T., & Johns, M. (2003). Converging evidence that stereotype threat reduces working memory capacity. *Journal of Personality and Social Psychology*, *85*, 440–452.

Schmader, T., Johns, M., & Forbes, C. (2008). An integrated process model of stereotype threat effects on performance. *Psychological Review*, *115*, 336–356.

Schuster, C., Martiny, S. E., & Schmader, T. (2015). Distracted by the unthought – Suppression and reappraisal of mind wandering under stereotype threat. *Plos One*, *10*, e0122207.

Seibt, B., & Forster, J. (2004). Stereotype threat and performance: How self-stereotypes influence processing by inducing regulatory foci. *Journal of Personality and Social Psychology*, *87*, 38–56.

Spielberger, C., Gorsuch, R., & Lushene, R. (1983). *Manual for the state-trait anxiety inventory*. Palo Alto, CA: Consulting Psychologists Press.

Stawarczyk, D., Majerus, S., Catale, C., & D'Argembeau, A. (2014). Relationships between mind-wandering and attentional control abilities in young adults and adolescents. *Acta Psychologica*, *148*, 25–36.

Steele, C. M., & Aronson, J. (1995). Stereotype threat and the intellectual test performance of African Americans. *Journal of Personality and Social Psychology*, *69*, 797–811.

Stroop, J. R. (1935). Studies of interference in serial verbal reactions. *Journal of Experimental Psychology*, *18*, 643–662.

Suhr, J. A., & Gunstad, J. (2002). "Diagnosis threat": The effect of negative expectations on cognitive performance in head injury. *Journal of Clinical and Experimental Neuropsychology*, *24*, 448–457.

Suhr, J. A., & Gunstad, J. (2005). Further exploration of the effect of "diagnosis threat" on cognitive performance in individuals with mild head injury. *Journal of the International Neuropsychological Society*, *11*, 23–29.

Trontel, H. G., Hall, S., Ashendorf, L., & O'Connor, M. K. (2013). Impact of diagnosis threat on academic self-efficacy in mild traumatic brain injury. *Journal of Clinical and Experimental Neuropsychology*, *35*, 960–970.

Vanderploeg, R. D., Curtiss, G., & Belanger, H. G. (2005). Long-term neuropsychological outcomes following mild traumatic brain injury. *Journal of the International Neuropsychological Society*, *11*, 228–236.

Wheeler, S. C., & Petty, R. E. (2001). The effects of stereotype activation on behavior: A review of possible mechanisms. *Psychological Bulletin*, *127*, 797–826.

Williams, W. H., Potter, S., & Ryland, H. (2010). Mild traumatic brain injury and postconcussion syndrome: A neuropsychological perspective. *Journal of Neurology, Neurosurgery and Psychiatry*, *81*, 1116–1122.

Zimmermann, P., & Fimm, B. (2010). *Test of attentional performance, version 2.3*. Herzogenrath, Germany: Psychologische Testsysteme.

Appendices

Appendix A

You previously indicated that you have had a concussion or a traumatic brain injury.
You had a . . .

(If you had several brain injuries, please respond based on the most severe brain injury you had)

- Concussion/mild traumatic brain injury
- Moderate traumatic brain injury
- Severe brain injury
- I don't know

How long did you lose consciousness?

- (1) 0 seconds (did not experience loss of consciousness)
- (2) 1–59 seconds
- (3) 1–5 minutes
- (4) 5–15 minutes
- (5) 15–30 minutes
- (6) more than 30 minutes

How long did you experience a loss of memory (brief amnesia)?

- (1) 0 seconds (did not experience)
- (2) 1–59 seconds
- (3) 1–60 minutes
- (4) 1–24 hours
- (5) more than 24 hours

How long did you experience confusion (inability to focus your attention on things)?

- (1) 0 seconds (did not experience)
- (2) 1–59 seconds
- (3) 1–60 minutes
- (4) 1–24 hours
- (5) more than 24 hours

How long did you experience disorientation (difficulty with regard to direction or position/loss of physical bearings)?

- (1) 0 seconds (did not experience)
- (2) 1–59 seconds
- (3) 1–60 minutes
- (4) 1–24 hours
- (5) more than 24 hours

How much time has elapsed since your injury? ___________ months

Did you see a doctor about this TBI/concussion?

- Yes
- No

Appendix B

Explicit DT instructions (TBI/control)

You have been invited to participate in this study because you have completed questionnaires in order to join the pool of participants for neuropsychology research. Your responses indicated that you (have sustained/have not sustained) a head injury/concussion. A growing number of neuropsychological studies have found that many individuals with head injuries/concussions show cognitive deficits on neuropsychological tests. Deficits in areas such as memory, attention, and information processing speed are common—though other deficits sometimes emerge. These deficits may be present even long after the head injury/concussion. This study examines the role that head injury may play in these cognitive areas in order to better understand the nature of the disorder. To do so, we will compare the performance of individuals who have not sustained a head injury/concussion with that of people who have. We are therefore asking you to complete a brief set of common neuropsychological tests. These tests will assess skills such as attention, memory, information processing speed, problem-solving skills, etc. They are used to observe and examine the different processes and mechanisms underlying cognitive capacities. Some of the tests are easy, and some are more difficult. Please make your best effort on all the tests. Questions about individual tests can be answered following the testing.

Implicit DT instructions

You have been invited to participate in this study because you have completed questionnaires in order to join the pool of participants for neuropsychology research. Your responses indicated that you are interested in participating in neuropsychology studies. A growing number of neuropsychological studies are looking at the functioning of memory, attention (concentration), reaction speed, and, in particular, the different underlying cognitive processes. Processes (mechanisms) in areas such as memory, attention, and information processing speed are common—though other studies are sometimes conducted. These studies examine several different cognitive components. This study will examine the role that these mechanisms/processes may play in these cognitive areas to better understand the nature of the processes. To do so, we will administer a set of neuropsychological tasks and analyze participants' performance regarding the processes we are interested in. We are therefore asking you to complete a brief set of common neuropsychological tests. These tests will assess skills such as attention, memory, information processing speed, problem-solving skills, etc. They are used to observe and examine the different processes and mechanisms underlying cognitive capacities. Some of the tests are easy, and some are more difficult. Please make your best effort on all the tests. Questions about individual tests can be answered following the testing.