Journal of Affective Disorders 264 (2020) 365–369

Contents lists available at ScienceDirect

Journal of Affective Disorders

journal homepage: www.elsevier.com/locate/jad

Research paper

Tonic immobility predicts poorer recovery from posttraumatic stress disorder

Muriel A. Hagenaars[a,*], Jacques A.P. Hagenaars[b]

[a] Department of Clinical Psychology, Utrecht University, Utrecht, the Netherlands
[b] Department of Methodology and Statistics, Tilburg University, Tilburg, the Netherlands

ARTICLE INFO

Keywords:
Posttraumatic stress disorder
Tonic immobility
Dissociation
Fear
Peritraumatic reactions
Recovery

ABSTRACT

Background: Tonic immobility (TI; a state of motor arrest during threat) and has been found to be associated with the development of psychopathology. It also hindered recovery from posttraumatic stress disorder (PTSD) after pharmacological treatment. The present study investigated the role of TI in recovery from PTSD in a large representative community sample with mixed traumas outside an exclusive treatment context.
Methods: Participants with PTSD from the panel for Longitudinal Internet Studies for the Social Sciences (LISS) completed measures for trauma, PTSD symptoms, and peritraumatic responses (fear, dissociation, and TI) in two subsequent years. Traumatized participants with PTSD were selected for the analyses ($N = 262$).
Results: TI was a relevant predictor for increased PTSD symptoms in year 2 after controlling for peritraumatic fear, peritraumatic dissociation, and PTSD symptoms in year 1, especially in abuse victims. Peritraumatic fear and dissociation no longer predicted PTSD in year 2 after entering TI in the model.
Conclusions: Our results indicate that TI may indeed hinder recovery from PTSD. TI may thus be a relevant factor to take into account after trauma and in treatment. The effects of TI may be especially negative for abuse victims.

1. Introduction

Tonic immobility (TI) is a response to threat characterized by profound motor inhibition, hyper tonicity, and suppressed vocal behavior (Marx et al., 2008). In animals, TI may occur when freezing, fight or flight are no longer options for survival, for example, when there is physical contact with the predator. It is an innate, unlearned reaction and thereby different from learned helplessness (i.e., a learned dissociation between behavior and outcome; Maier and Seligman, 1976). It should also be distinguished from freezing, a cessation of movement after encountering threat to minimize detection and prepare action (Hagenaars et al., 2014; Kozlowska et al., 2015). TI increases survival chances because many predators lose interest in the seemingly dead prey animal (Bracha, 2004; Gallup et al., 2008). Suarez and Gallup (1979) were the first to suggest that TI can occur in humans too, when exposed to traumas that involve contact with the "predator", for example rape. Humans were indeed found to display a TI-like response, with symptoms that resemble TI in non-human animals (Galliano et al., 1993). Based on this overlap in symptoms, a questionnaire was developed measuring TI by items closely linked to animal TI symptoms: The Tonic Immobility Scale (TIS; Fusé et al., 2007).

Although initially linked to sexual trauma, human TI responses may also occur during other trauma types, such as physical assault or accident-related trauma (Abrams et al., 2009; Hagenaars, 2016; Kalaf et al., 2017). Importantly, like in animals, human TI was found to be linked with perceived inescapability (Bovin et al., 2008), which may explain its occurrence during non-contact trauma types. Human TI is not uncommon; 25%−37% (Galliano et al., 1993; Hagenaars, 2016; Heidt et al., 2005) experienced TI during trauma. Despite being potentially useful in specific circumstances in terms of survival and reduced injury (De Heer and Jones, 2017) there are also negative long-term consequences: Individuals who experienced TI during trauma were more likely to develop posttraumatic stress disorder (PTSD; Galliano et al., 1993; Bovin et al., 2008; Heidt et al., 2005; Humphreys et al., 2010; Moller et al., 2017; Rocha-Rego et al., 2009). Moreover, TI effects do not seem to simply reflect trauma severity: Elicited and spontaneous TI predicted the development of intrusive memories of an analogue trauma, which was the same for all participants (Hagenaars et al., 2008, 2010; Hagenaars and Putman, 2011; Kuiling et al., 2019). Given the immense individual and societal burden of PTSD (Marciniak, 2005), it is important to map factors that hinder recovery.

It is not know which mechanisms are involved in the negative consequences of human TI, but there are several options. First, TI may

* Corresponding author.
E-mail address: m.a.hagenaars@uu.nl (M.A. Hagenaars).

https://doi.org/10.1016/j.jad.2019.11.027
Received 23 November 2018; Received in revised form 7 June 2019; Accepted 8 November 2019
Available online 09 November 2019
0165-0327/

contribute to PTSD development by its association with inescapability (Bovin et al., 2008) and may interact with controllability (Hagenaars and Putman, 2011; Kuiling et al., 2019; Rodd et al., 1997), supposedly important factors in PTSD development (Foa et al., 1992). Second, TI may elicit feelings of guilt in the victim (Bovin et al., 2014), and increase being blamed by others (McCaul, Veltum, Boyechko & Crawford, 1990). Guilt, shame and social support are known to predict PTSD (Cunningham et al., 2017). Finally, TI may be associated with altered attentional processing, possibly enhancing sensory processing of trauma information (Rodd et al., 1997), resulting in vivid, trauma memories (Brewin, 2001; Lang, Bradley & Cuthbert, 1997; see also Hagenaars et al., 2008, 2010). Note that some mechanisms may be specific for humans (guilt), whereas others (uncontrollability and enhanced sensory processing) are not.

TI is considered to be a "hard-wired" response, with high genetic influences, suggesting a strong "nature" component. For example, different rodent species are characterized by distinct TI susceptibility (Webster et al., 1981) and the heritability component was extremely large in chicken (Gallup, 1974). Thus, individuals that experienced TI during trauma are likely to experience it again during later stressors. Indeed, TI during a previous trauma was found to be associated with elevated levels of TI during current laboratory stressors (eye closure and trauma script, respectively: Fragkaki et al., 2016; Volchan et al., 2011) and re-experiencing symptoms (De Kleine, Hagenaars and Van Minnen, 2018). This way, the mechanisms that drive the association between peritraumatic TI and PTSD development may play a more chronic role and thereby hinder recovery (e.g., by provoking a sense of current threat; Ehlers and Clark, 2000). In line with this, two studies have showed poorer recovery from PTSD after pharmacological treatment for patients with higher peritraumatic TI (Fiszman et al., 2008; Lima et al., 2010). To our knowledge, studies using a larger, representative traumatized population outside an exclusive treatment context have not been done. One study examined immobility in panic disorder; Panic disorder patients who had experienced immobilization during a panic attack were characterized with more disabling chronic anxiety relative to those without immobilization panic (Cortese and Uhde, 2006).

The primary aim of the present study was to investigate the role of TI on recovery from PTSD. We expected that TI during trauma would predict poorer recovery, i.e., more PTSD symptoms during the second measurement. We controlled for peritraumatic fear as a possible confound, to rule out that TI effects are merely reflecting trauma severity (Lin et al., 2015; Ozer et al., 2003). We also control for peritraumatic dissoctiation, because it was found to predict PTSD (Ozer et al., 2003; Hagenaars and Krans, 2011) and because it is not clear whether dissociation and TI are separate constructs (Abrams et al., 2007; Zoellner, 2008). Finally, we tested whether the effects of TI would hold after controlling for initial PTSD symptoms (Marshall and Schell, 2002).

2. Methods

2.1. Participants

We used data of the Longitudinal Internet Studies for the Social Sciences (LISS)-panel, administered by CentERdata by Tilburg University (The Netherlands). This panel consists of a representative sample of Dutch individuals, forming a true probability sample of households out of the population register (see www.lissdata.nl for more information). We included participants who completed all relevant questionnaires in year 1 and year 2 (3410 participants), experienced trauma (2671 participants), and had PTSD in year 1 (as indicated by a cut-off score of 15 on the PSS-SR) (Wohlfarth et al., 2003). Based on these criteria, 262 participants were included (170 females; 64.9%). Age ranged from 18 to 86 years (M = 53.1; SD = 15.4). Education was low for 100 participants (38.2%), medium for 92 participants (35.1%), and high for 70 participants (26.7%). All participants gave written informed consent.

2.2. Materials and measures

Peritraumatic responses. The Tonic Immobility subscale of the Tonic Immobility Scale (TIS-TI) (Fusé et al., 2007) was used to measure immobility reactions during trauma. The TIS-TI subscale contains 7 self-report items which are scored on a 7-point Likert scale, ranging from 0 (not at all) to 6 (extremely/very much). Total scores range from 0 to 42. An example item is "Rate the degree to which you were unable to move even though not restrained". Internal consistency was acceptable to strong for TIS-TI in larger samples (Cronbach's α = 0.71 to 0.94) (Fusé et al., 2007; Hagenaars, 2016; De Kleine et al., 2018). Following Hagenaars (2016) we used two items of the TIS subscale for Fear to assess peritraumatic fear (TIS-Fear). An example item is "Rate the extent to which you felt feelings of fear/panic during the event". The original Fear subscale consisted of 3 items. However, one item of this subscale assesses peritraumatic dissociation and did not load on the fear factor in several studies (Abrams et al., 2009; Hagenaars, 2016). Following Hagenaars (2016), this item was used to assess peritraumatic dissociation (TIS-Diss; "Rate the extent to which you felt detached from what was going on around you during the event"). Total scores range from 0 to 12 for TIS-Fear and 0 to 6 for TIS-Diss.

Posttraumatic stress symptoms. Posttraumatic stress symptoms were assessed with the Posttraumatic Stress Symptom Scale, Self-Report (PSS-SR), a 17-item self-report questionnaire that measures the frequency of PTSD symptoms (Engelhard et al., 2007; Foa et al., 1993). The PSS-SR has three subscales (reexperiencing symptoms, avoidance symptoms and arousal symptoms), with each item corresponding to one of the DSM-IV criteria for PTSD. Items have be answered on a 4-point Likert scale. Analyses showed a high internal consistency (α = 0.91), and a good test-retest reliability of overall PTSD severity (r = 0.74) (Foa et al., 1993).

Trauma. The Negative Life Experiences and Trauma Questionnaire (NLETQ) was used to assess trauma experiences. The NLETQ consists of 24 items describing various events and one open-ended item ("other, namely") for unlisted events (Engelhard et al., 2003; Morgan and Janoff-Bulman, 1994). Participants have to indicate whether they experienced the event.

2.3. Procedure

LISS panel members completed the NLETQ in year 1. TIS-TI, TIS-Fear, TIS-Diss and PSS-SR were completed one month later. In year 2, participants completed the PSS-SR again.

2.4. Analyses

Data were analysed with hierarchical regression analyses with PTSD symptoms (PSS-SR in year 2) as dependent variable. In order to examine the additional predictive value of TIS-TI, we entered general variables in step 1, TIS-Fear and TIS-Diss in step 2 and TIS-TI in step 3. By entering PSS-SR in 2011 in step 4, we tested whether the effects of TI would remain significant. Multicolinearity was checked because predictors may be related. Significance was set at α = 0.05.

3. Results

3.1. Descriptives

Sample descriptives (means and SDs) are listed in Table 1. The mean number of days between Year 1 and Year 2 was 396.4 (SD = 9.44; range 370 to 420). Notably, PTSD symptoms decreased from year 1 to year 2, indicating a general improvement. Participants experienced various events: childhood sexual abuse (n = 19), childhood physical abuse (n = 23), childhood emotional abuse (n = 52), sexual assault (n = 36), physical assault (n = 32), war-related trauma (n = 34), serious accident (n = 31), disaster or fire (n = 9), life-threatening illness

Table 1
Means in the total sample (N = 262).

	Mean	SD
TIS-Fear	6.68	2.93
TIS-Diss	1.68	1.81
TIS-TI	14.91	8.18
PSS-SR year 1	23.55	7.88
PSS-SR year 2	15.80	10.18

Note: TIS-Fear = Tonic Immobility Scale-Fear; TIS-Diss = Tonic Immobility Scale-Dissociation; TIS-TI = Tonic Immobility Scale-Tonic Immobility; PSS-SR = Posttraumatic Stress Symptom Scale, Self-Report.

(n = 46), other (e.g., violent or sudden death of a loved one, armed burglary; n = 63).

3.2. TI and recovery

All variables were significantly related to each other (see Table 2 for bivariate correlations). Table 3 displays the results of the regression analyses. There was no multicollinearity problem (tolerance > 0.61 and VIF < 1.63 for all variables). The first model, including general demographic variables only, is not significant; General demographics did not predict PTSD symptoms in year 2. Model 2 is significant (ΔR^2 = 0.07). In this model, TISS-Diss -but not TIS-Fear- significantly predicts PTSD symptoms in year 2. The addition of TIS-TI in model 3 significantly improved the prediction (ΔR^2 = 0.07). Importantly, TIS-Diss no longer predicted PTSD in year 2, suggesting an independent effect for TIS-TI. Finally, as expected, model 4 was also significant (ΔR^2 = 0.07), with PTSD symptoms in year 1 being the strongest predictor of PTSD symptoms in year 2. However, TIS-TI still remained a significant predictor as well.[1]

Because TI may be associated with abuse trauma in particular, we analyzed the data for victims of childhood or adulthood sexual or physical assault or abuse (n = 88). See Table 4 for the results of the regression analyses. The results were similar to the findings for the total sample. In model 3, TI is a significant predictor of PTSD is year 2 (ΔR^2 = 0.11 relative to model 2). TI remained a significant predictor after controlling for PTSD in year 1. Note that the predictive power of TI in the final model was slightly larger this specific subsample (β = 0.29 versus β = 0.19 in the total sample).

Explorative analyses. Given the relatively recent interest in human TI, it is not yet clear how it is associated with dissociation. If dissociation is an inherent part of TI, participants with TI should always report dissociation. We therefore post hoc calculated the percentage of participants with TI (TIS-TI > 20, see Heidt et al., 2005) who experienced dissociation (TIS-Diss > 1). Following these cutoffs, 21% of those with TI did not experience dissociation.

4. Discussion

The present study investigated whether TI would hinder recovery from trauma in a representative, mixed trauma population. We found that TI in year 1 predicted PTSD symptoms in year 2. Moreover, these effects were independent from peritraumatic fear and dissociation and even remained after controlling for PTSD symptoms in year 1.

To our knowledge, this is the first study that addressed the role of TI in recovery from PTSD. Previous studies have shown that TI is

Table 2
Bivariate correlations for all variables (N = 262).

	Correlation coefficient (r)				
Variable	1	2	3	4	5
1 TIS-Fear	–				
2 TIS-Diss	.00	–			
3 TIS-TI	.01	.57*	–		
4 PSS-SR year 1	.07	.26*	.32*	–	
5 PSS-SR year 2	.03	.26*	.35*	.51*	–

*p < .001.
Note: TIS-Fear = Tonic Immobility Scale-Fear; TIS-Diss = Tonic Immobility Scale-Dissociation; TIS-TI = Tonic Immobility Scale-Tonic Immobility; PSS-SR = Posttraumatic Stress Symptom Scale, Self-Report.

associated with PTSD development. We now showed that in addition, it interferes with recovery. That is, those with PTSD that experienced TI during trauma were more likely to have higher PTSD symptoms one year later. This is in line with two previous studies that found that PTSD patients with peritraumatic TI profited less from a pharmacological treatment (Fiszman et al., 2008; Lima et al., 2010). We showed that this effect is not restricted to treatment, but rather generalized to PTSD recovery outside an explicit treatment context. Moreover, in contrast with these two former studies, we included a large and representative population with mixed traumas, promoting generalizability. Importantly, the effects of TI remained after controlling for PTSD symptoms in year 1, indicating a strong and additional effect of TI, which is not due to the presence of PTSD symptoms. Also, TI was even a stronger predictor in a subsample with victims of abuse, possibly indicating a higher relevance (or prevalence) of TI in this subgroup. Negative effects of TI are rather consistent in the literature and merit further exploration of potential mechanisms and eliciting circumstances. Future research may design and test mediation and moderation models for that purpose. Preferably, experimental studies would also be done in animals to facilitate translation and provide information about the specificity for humans of potential mediators (e.g., guilt).

Our results have implications for the treatment of PTSD. Importantly, research has been done on tailoring early PTSD interventions as a secondary prevention strategy. Our findings may indicate that the presence of TI may be a good mark for predicting chronic PTSD. However, if treatment itself is less effective in high-TI PTSD patients (see Fiszman et al., 2008; Lima et al., 2010), these particular patients may require a different approach. In any case, psychoeduction on TI, its involuntary character and possible positive consequences (e.g., survival or reduced harm) seems important and may reduce shame/guilt. In order to design specific (prevention) treatment interventions for high-TI PTSD patients, more insight is needed in the TI-PTSD link. For example, if reduced controllability during TI is a relevant factor, specific control-increasing strategies may be at place in the treatment of this subgroup (see also Hagenaars and Putman, 2011). Treatment strategies that reconstruct trauma-responses may be promising for this purpose. For example, in imagery rescripting, patients can address TI responses and change them retro-actively. Assumedly, this would change the meaning of the trauma-representation and associated responses.

TI is proposed to be associated with severe threat, and/or simply reflect fear. We therefore included peritraumatic fear in the model. The results showed that TI was not merely an indicator of trauma severity or fear, but an independent factor. We included peritraumatic dissociation for similar reasons. Although mostly interpreted as two separate constructs, dissociation and TI seem to overlap, and it is not completely clear whether these are indeed two related but distinct constructs (see Zoellner, 2008), whether dissociation is an inherent part of TI (see Lloyd et al., 2019), or whether the two phenomena are situated on a dimensional scale (see Abrams et al., 2009). However, although proposed to be on the extreme end of this continuum, TI may occur during

[1] Note that the regression coefficients may be biased by differences in alpha due to different scale sizes. However, the estimated bias ($\sqrt{\alpha_{TIS\text{-}TI}}/\sqrt{\alpha_{TIS\text{-}Fear}}$) was .10, whereas the differences in standardized regression coefficients ($\beta_{TIS\text{-}TI}/\beta_{TIS\text{-}Fear}$) was 19. Thus, it is highly unlikely that the results are accounted for by differences in scale size.

Table 3
Summary of hierarchical regression analysis for variables predicting PTSD symptoms in year 2 ($N = 262$).

	Model 1			Model 2			Model 3			Model 4		
Variable	*B*	*SE B*	*β*	*B*	*SE B*	*β*	*B*	*SE B*	*β*	*B*	*SE B*	*β*
Gender[a]	−2.18	1.33	−0.10	−2.02	1.31	−0.09	−2.76	1.28	**−0.13*****	−1.45	1.17	−0.07
Age	−0.06	.04	−0.09	−0.03	.04	−0.05	−0.02	.04	−0.04	.02	.04	.03
Education[a]	−0.65	.44	−0.09	−0.43	.43	−0.06	−0.44	.41	−0.06	.18	.38	.03
TIS-Fear				.14	.21	.04	.15	.20	.04	.04	.19	.01
TIS-Diss				1.4	.35	**.25***	.40	.41	.07	.24	.37	.04
TIS-TI							.39	.09	**.31***	.24	.08	**.19****
PSS-SR year 1										.56	.07	**.44***
R^2		.01			.08			.12			.28	
F for ΔR^2		1.80			8.39			18.82			57.68	
p		.148			< 0.0-01			< 0.0-01			< 0.0-01	

*$p < .001$; **$p < .01$; ***$p < .05$.
Note: TIS-Fear = Tonic Immobility Scale-Fear; TIS-Diss = Tonic Immobility Scale-Dissociation; TIS-TI = Tonic Immobility Scale-Tonic Immobility; PSS-SR = Posttraumatic Stress Symptom Scale, Self-Report.
[a]Negative coefficients indicate more PTSD symptoms for females than males and more PTSD symptoms for those with lower versus higher education.

Table 4
Summary of hierarchical regression analysis for variables predicting PTSD symptoms in year 2 in victims with childhood abuse ($n = 88$).

	Model 1			Model 2			Model 3			Model 4		
Variable	*B*	*SE B*	*β*	*B*	*SE B*	*β*	*B*	*SE B*	*β*	*B*	*SE B*	*β*
Gender[a]	−0.50	2.56	−0.02	−2.03	2.66	−0.09	−2.53	2.51	−0.11	−1.27	2.39	−0.05
Age	−0.13	.09	−0.16	−0.13	.09	−0.17	−0.10	.08	−0.13	−0.07	.08	−0.08
Education[a]	−0.46	.82	−0.06	−0.46	.80	−0.06	.00	.77	.00	.52	.74	.07
TIS-Fear				.38	.37	.11	.35	.35	.10	.15	.34	.05
TIS-Diss				1.18	.56	**.22****	.02	.63	.00	−0.27	.60	−0.05
TIS-TI							.50	.15	**.41***	.35	.15	**.29****
PSS-SR year 1										.44	.13	**.37***
R^2		.03			.09			.20			.30	
F for ΔR^2		.82			2.73			11.35			11.81	
p		.488			.071			.001			.001	

*$p < .01$; **$p < .05$.
Note: TIS-Fear = Tonic Immobility Scale-Fear; TIS-Diss = Tonic Immobility Scale-Dissociation; TIS-TI = Tonic Immobility Scale-Tonic Immobility; PSS-SR = Posttraumatic Stress Symptom Scale, Self-Report.
[a]Negative coefficients indicate more PTSD symptoms for females than males and more PTSD symptoms for those with lower versus higher education.

non life-threat trauma (Hagenaars, 2016; Bados et al., 2008) or after laboratory stressors (Fragkaki et al., 2016; Hagenaars and Putman, 2011; Kuiling et al., 2019). Theoretically, TI and dissociation are proposed to be distinct, as reflected by intact or even enhanced versus impaired cognitive processing for TI (Gallup et al., 1980) and dissociation (Spiegel, 1995), respectively. Our post hoc analyses showed that a substantial number of those with TI did not experience dissociation. The fact that dissociation was no longer a relevant predictor after entering TI may also suggest that the two constructs contribute independently. However, our data do not confirm or falsify the dimension-theory and research into shared and distinctive markers of both phenomena is needed.

Our study has several limitations. First, peritraumatic fear was measured with 2 items (with questionable reliability; see Hagenaars, 2016) and peritraumatic dissociation with 1 item. Future studies may include standardized instruments for assessing these constructs, preferably assessed shortly after the event. Second, the diagnosis was based on DSM-IV criteria. Third, survey data in a representative population provide high ecological validity, but circumstances are typically not controlled. For example, some participants may have received treatment between year 1 and year 2. Future research may use experimental designs to verify the findings in a well-controlled setting.

In conclusion, together with previous findings, our results suggest that TI is an important factor to assess after trauma, as it may hinder recovery from PTSD. Future studies may target mechanisms underlying the TI-PTSD association in order to design appropriate intervention strategies.

Author statement

MH and JH both contributed to the study design. MH managed the analyses and wrote the first draft of the manuscript. JH contributed to and approved the final manuscript. Both authors take full responsibility.

Declarations of interest

None

Acknowledgements

This research was supported the Netherlands Organization for Science (NWO) with a grant for innovative research awarded to Muriel Hagenaars (VENI #451-07-08). The LISS panel data were collected by CentERdata (Tilburg University, The Netherlands) through its MESS project funded by NWO.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.jad.2019.11.027.

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