

Predictors of tonic immobility during traumatic events

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Título: Predictores de la inmovilidad tónica ante eventos traumáticos.

Resumen: La inmovilidad tónica (TI) es una posible reacción ante el peligro que es facilitada por el miedo intenso, la restricción física y la incapacidad percibida de escapar. Otras variables que podrían influir, tales como el tipo de eventos traumáticos, características de los mismos y características personales han sido poco o nada estudiadas. El presente estudio evaluó la capacidad de estas variables para predecir la TI en una muestra de 273 universitarios que habían experimentado al menos un suceso traumático. El 7.7% y el 13.2% de participantes reaccionaron con TI según las dos definiciones más estrictas adoptadas. La mayoría de las variables estuvieron significativamente asociadas con la TI en análisis univariantes. Sin embargo, en un análisis de regresión múltiple, sólo ciertas características de los eventos (ocurrencia de maltrato físico/ abuso sexual, número de tipos diferentes de eventos experimentados) y determinadas reacciones ante los mismos (percepción de lo traumáticos que fueron, respuesta de miedo intenso) fueron predictores significativos de la TI. Puesto que estos predictores sólo explicaron el 25% de la varianza, debería investigarse la influencia de otras variables, tales como el neuroticismo, la afectividad negativa y la sensación de falta de control personal o de recursos para afrontar los eventos traumáticos.

Palabras clave: inmovilidad tónica; eventos traumáticos; trauma; Escala de Inmovilidad Tónica; Cuestionario de Eventos Traumáticos.

Abstract: Tonic immobility (TI) is a possible reaction to danger that is facilitated by intense fear, physical restraint and perceived inability to escape. Other variables that could affect TI, such as the type and characteristics of traumatic events and personal characteristics have been little or no studied. The present study evaluated the power of these variables to predict TI in a sample of 273 college students who had experienced at least one traumatic event. Of the sample, 7.7% and 13.2% responded with TI according to the two stricter definitions adopted. Most of the variables were significantly associated with TI in univariate analyses. However, in a multiple regression analysis, only certain features of the events (occurrence of physical/sexual abuse, number of different types of events experienced) and certain reactions to them (perception of how traumatic were the events, severe fear response) were significant predictors of TI. Since these predictors explained only 25% of the variance, the influence of other variables –such as neuroticism, negative affectivity and perceived lack of personal control or resources to cope with traumatic events– should be investigated.

Key words: tonic immobility; traumatic events; trauma; Tonic Immobility Scale; Traumatic Events Questionnaire.

Introduction

Various authors have described a sequence of four defensive responses linked to the proximity of danger: hypervigilance or freezing, escape, fighting and tonic immobility (Gray, 1987; Marx, Forsyth, Gallup, Fusé, & Lexington, 2008). Tonic immobility (TI) is characterized by profound physical immobility, suppressed vocal behaviour, trembling, muscular rigidity, a decrease in body temperature (cold sensations) and lack of sensitivity to intense or painful stimuli, although an awareness of surroundings remains. TI is triggered by situations of intense fear and physical restraint, although as it may occur without the latter it is likely that the perceived inability to escape is what matters (Heidt, Marx, & Forsyth, 2005; Marx, Forsyth, Gallup, Fusé, & Lexington, 2008; Moskowitz, 2004).

In animals, TI can be an adaptive response when there is no possibility of escaping or winning a fight. In these cases, TI reduces the likelihood that the predator will continue to attack and thus increases the chances of escape and survival (Bracha, 2004; Moskowitz, 2004). TI has not been widely studied in humans, and although some authors argue that it may have an adaptive value in certain situations of physical or sexual aggression where fighting or escape is not possible (see Heidt et al., 2005), it has been found to be moderately correlated with post-traumatic symptoms (Abrams, Carleton,

Taylor, & Asmundson, 2009; Abrams, Carleton, & Asmundson, 2012; Bovin, Jager-Hyman, Gold, Marx, & Sloan, 2008; Humphreys, Sauder, Martin, & Marx, 2010; Heidt et al., 2005; Rocha-Rego et al., 2009) and to be a predictor for the emergence of intrusive memories (Hagenaars & Putman, 2011), the development of post-traumatic symptoms (Bovin et al., 2008; Humphreys et al., 2010; Rocha-Rego et al., 2009) and a poorer response to pharmacological treatment for post-traumatic stress disorder (PTSD) (Fiszman et al., 2008; Lima et al., 2010).

Scaer (2014) has put forward one explanation for the association between a TI response, of which dissociation is a central element, and PTSD. TI appears as a reaction to traumatic events that induce a state of helplessness, which in turn may be favoured by a history of traumatic experiences during childhood (e.g. sexual and/or physical abuse, serious illness, death of a loved one). Once a traumatic event is over, wild animals will discharge the somatic energy that has built up during TI by means of involuntary movements such as shaking, trembling and deep breathing. Humans, however, tend not to engage in this kind of discharge, most likely because the process of enculturation suppresses behaviours regarded as inappropriate. This lack of discharge prevents completion of the frustrated behaviour of defence or escape in the person's implicit memory, the consequence being that the implicit sensory and motor memories of the threat are not erased and the brain continues to operate as if the threat were still present. The repeated activation of this implicit memory by internal or external signals associated with the trauma eventually gives rise to lasting or even permanent neurosensitization or kindling of certain interconnected

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brain structures (cortical and brainstem regions involved in implicit memory, amygdala, locus coeruleus, hippocampus), which in turn facilitates the onset of PTSD and related somatic problems (e.g. chronic pain).

The prevalence of TI, in studies that have considered it as either experienced or not (yes/no), varies depending on the criterion used. With the cut-off point set at equal to or above the theoretical mean on the scale used, TI was reported by 41.5-52% of women who had suffered sexual abuse or assault (Fusé, Forsyth, Marx, Gallup, & Weaver, 2007; Heidt et al., 2005) and by 43% of patients with PTSD subsequent to urban violence (Fizman et al., 2008). More extreme immobility, defined as a score at least five points above the theoretical mean on the scale, was reported by 10.5-12.5% of women who had suffered sexual abuse or assault (Fusé et al., 2007; Heidt et al., 2005). Although these latter percentages are much lower they nonetheless represent a considerable number of people.

Little is known about the conditions which may trigger TI, apart from the factors already mentioned, namely intense fear, physical restraint and the perceived inability to escape. One of the few variables that have been studied is the kind of traumatic event experienced. TI is reported by a significant proportion of victims of sexual abuse and/or assault (Fusé et al., 2007; Heidt et al., 2005), although it also occurs after other types of trauma such as robberies, assaults, traffic accidents, natural and industrial disasters, and receiving news of the violent or unexpected death of a loved one (Abrams et al., 2009; Bados, Toribio, & García-Grau, 2008; Fizman et al., 2008; Leach, 2004).

Only two studies have examined whether TI varies depending on the type of traumatic experience. Bados et al. (2008) found that the group who had suffered sexual abuse or physical maltreatment reported more intense TI than did the group who had received news of the mutilation, serious injury or violent or unexpected death of a loved one, although the reports of the former group did not differ significantly from those of participants who had been the victims of a serious accident, violent crime or other traumatic events. The sample in this study was, however, small and it is likely, given the results of more recent research (Bados & Peró, 2015), that the psychometric properties of the scale used (the physical immobility subscale of the Tonic Immobility Scale developed by Forsyth et al., 2000) were not entirely adequate. Abrams et al. (2009), using the Tonic Immobility Questionnaire, found no differences in TI reports across four types of traumatic events: interpersonal violence, accidents, news of a death, and others. However, the sample size ($N = 78$) may have been too small to detect differences between the groups.

It is possible that in addition to the presence of intense fear and the type of trauma the TI response may also be influenced by other variables related to the characteristics of traumatic events (e.g. frequency of different types of events experienced, whether events were intentionally caused and whether events was directly experienced) or to personal

characteristics (e.g. gender, age when the worst traumatic event was first experienced, age when exposed to the first traumatic event, and subjective perception of how traumatic the worst event was). To date, no study has investigated this issue, despite the fact that several of these variables have been associated with the presence of current post-traumatic symptoms (Amir & Sol, 1999; Bados, Greco, & Toribio, 2013; Bedard-Gilligan & Zoellner, 2008; Bernat, Ronfeldt, Calhoun, & Arias, 1998; Frazier et al., 2009; Green et al., 2000; Irish et al., 2008; Martín & de Paúl, 2004; Owens & Chard, 2006) and that these symptoms are likewise related to a person having previously reacted with TI during a traumatic event (Bovin et al., 2008; Humphreys et al., 2010; Rocha-Rego et al., 2009).

In light of the above, the aim of the present study was to explore which of these variables are associated with TI in persons who have experienced a traumatic event and which of them are most important in terms of predicting such a response. This information would be useful for future theoretical formulations, for understanding the reactions of victims (who are often unfairly accused of passivity or even of having consented, a charge frequently levelled against rape victims) and for the design of programmes that seek to prevent or minimize TI. A further aim of the study was to determine, according to a range of criteria, the percentage of people who report having responded with TI to any kind of trauma in general and to specific types of traumatic events in particular.

Method

Participants

The initial participants were 313 third-year psychology undergraduates from the University of Barcelona, all of whom were enrolled in the same core subject and who reported having experienced at least one traumatic event according to PTSD Criterion A1 in the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV-TR; American Psychiatric Association, 2000). Of this initial sample, 29 participants were excluded for the following reasons: 1 did not specify whether the traumatic event had been responded to with intense fear, helplessness or horror, 18 chose as the worse event an experience that they did not wish to tell about (such that no information was available about the event to which TI referred, and whether the event had been intentional or no, or directly experienced or not) and 10 did not answer all the items on the brief modified version of the Tonic Immobility Scale.

We also excluded any traumatic event that was experienced by fewer than ten people, since the data obtained might not be representative. This led to the exclusion of a further 11 participants. The remaining 273 participants had a mean age of 23.1 years ($SD = 4.8$). A total of 82.1% were female and 82.4% were single.

Measures

Traumatic Events Questionnaire—Modified Spanish version (TEQ-M; Bados, Greco, & Toribio, 2012a). Derived from the original Traumatic Events Questionnaire (Vrana & Lauterbach, 1994) the TEQ-M evaluates the experience of 15 specific types of traumatic events: 1) serious industrial accident or large fire or explosion, 2) serious traffic accident, 3) natural disaster, 4) non-sexual violent crime, 5) severe physical maltreatment in childhood/adolescence, 6) sexual abuse in childhood/adolescence, 7) severe physical maltreatment during adulthood, 8) sexual assault during adulthood, 9) unexpectedly witnessing somebody who was mutilated, severely injured or violently killed, 10) serious danger of losing one's life or of being severely injured, 11) receiving news of the mutilation, serious injury or violent or unexpected death of a loved one, 12) witnessing a serious traffic accident, 13) witnessing a serious industrial accident or large fire or explosion, 14) any other highly traumatic event, and 15) a traumatic event that the respondent wishes not to tell about.

For each event experienced, respondents indicate how many times it has occurred (one, two, three or more), their age at the time of the event's first and most recent occurrence, whether or not they experienced intense fear, helplessness or horror, and, on a scale of 1 (not at all) to 7 (extremely), whether they were injured, whether they feel their life was in danger, and how traumatic the event was at the time and how traumatic is now. On all but one of the items (that referring to a traumatic event that the person wishes not to tell about) respondents are also asked to describe the traumatic event or are given a set of categories for doing so. If the person chooses more than one kind of event on the list he or she must indicate which was the most traumatic (this is then considered to be the worst event). Regarding the validity of the TEQ-M, people who have experienced at least one traumatic event report higher levels of depression, anxiety, stress and post-traumatic symptoms than do those who have not experienced any such event. In addition, the number and type of events and perceiving the worst event as highly traumatic have been shown to be significant predictors of one or more of the abovementioned variables (Bados et al., 2012a, 2013).

In the present study the events described in items 4 to 8 of the TEQ-M were regarded as being intentional, while those corresponding to items 1, 2, 3, 12 and 13 were treated as unintentional. Items 9, 10, 11 and 14 were assigned to one category or the other by two raters, depending on the description given by the respondent. For example, the death of a loved one was considered to be intentional if it was suicide, and unintentional if it was the result of an illness. The events referred to in items 1 to 8 and in item 10 were treated as directly experienced, while those of items 9, 11, 12 and 13 were regarded as indirectly experienced. Item 14 was assigned to one category or the other depending on the respondent's description of the event.

Tonic Immobility Scale—Brief, modified Spanish version (TIS-BM, Bados & Peró, 2015). This instrument includes five of the seven items from the physical immobility subscale of the Tonic Immobility Scale (Forsyth, Marx, Fusé, Heidt, & Gallup, 2000). In contrast to the original scale the instructions and items of the TIS-BM do not refer to the most recent sexual assault but, rather, to the worst traumatic event experienced. Respondents rate on a scale of 0 to 6 the extent to which they: 1) froze or felt paralysed, 2) were unable to move even without physical restraint, 3) were unable of shouting or screaming, 4) felt cold, and 5) felt detached from themselves. The TIS-BM has a single factor and has shown acceptable levels of reliability, convergent validity with post-traumatic symptoms, discriminant validity with respect to measures of depression and anxiety, and criterion validity in that it differentiates between groups who have and have not experienced traumatic events (Bados & Peró, 2015). Internal consistency in the present sample was acceptable ($\alpha = .76$).

Procedure

The abovementioned questionnaires were administered in a single session in a classroom setting, with students sat sufficiently far apart. The response rate was 98% (432 of 440). Students were told that a study was being conducted about the emotions that people normally experience in relation to various life events, some of which might be traumatic, and also about how people respond to these events. It was made clear that participation was entirely voluntary and that all responses would remain confidential. The students did not receive course credits or any kind of compensation for taking part in the study. The order of questionnaire administration was the TEQ-M followed by the TIS-BM. As noted earlier, 313 students (of the 432 who initially responded to the questionnaires) reported having experienced at least one traumatic event. This study was approved by the Bioethics Committee of the University of Barcelona (reference IRB00003099).

Statistical analysis

In order to study the association between TI and the different variables considered we calculated Pearson's r correlation coefficients for the continuous variables (frequency of events, age at time of first traumatic event, perception of how traumatic the worst event was), point-biserial correlation coefficients for the dichotomous variables (gender, intentionality, direct experiences) and biserial correlation coefficients for the dichotomized variables (reaction of intense fear). Analysis of variance was used to examine differences in TI across the various types of worst traumatic events, coupled with Hochberg's GT2 test for *post hoc* comparisons. When comparing pairs of groups the effect size was calculated using Cohen's d , a measure of the difference between two standardized means divided by the pooled standard deviation. Following Cohen (1988), values of 0.20-0.49, 0.50-0.79 and 0.80 were considered to indicate low, moder-

ate and high effect sizes, respectively. Finally, hierarchical regression analysis was applied to determine which variables were important in terms of predicting TI.

Results

Variables associated with TI

Table 1 shows the correlations between TI and the different continuous and dichotomized variables considered. All the correlations were significant, with the exception of those for gender and age at which the worst traumatic event was first experienced. The strongest correlations corresponded to the reaction to the event (how traumatic it was felt to be, the fear it produced) and the frequency of events. The intercorrelations between the remaining variables ranged in absolute values between .01 and .57, except for the two age-related variables, where the value reached .76.

Table 1. Correlations between different variables and tonic immobility.

	Tonic immobility
Frequency of different types of traumatic events experienced	.29**
Traumatic events caused intentionally or not	.14*
Traumatic events experienced directly or not	.14*
Gender	.10
Age when worst traumatic event was first experienced	-.06
Age when any traumatic event was first experienced	-.16**
Perception of how traumatic the worst event was	.42**
Reaction of intense fear, helplessness or horror to the worst event	.42**

Note. $N = 273$, except for the two age-related variables, which had $n = 269$ and 270, respectively.

* $p < .05$; ** $p < .01$.

Regarding the association between trauma type and TI, we first sought to increase the group size for the event categories to be compared. Specifically, the ten events experienced by at least ten participants were grouped into the following five categories of similar events: a) physical maltreatment in childhood/adolescence ($n = 11$), sexual abuse in childhood/adolescence ($n = 20$) or physical maltreatment in adulthood ($n = 11$); b) non-sexual violent crime ($n = 26$); c) being involved in a serious traffic accident ($n = 28$) or being at serious risk of losing one's life or of being severely injured ($n = 14$); d) receiving news of the mutilation, serious injury or violent or unexpected death of a loved one ($n = 93$), or another highly traumatic event ($n = 19$) — the news almost always referred to the death of a loved one, whereas the other highly traumatic events mainly concerned the death of a loved one (without it being specified whether it was unexpected or not) or severe illness affecting either oneself or loved ones; and e) unexpectedly witnessing somebody who was mutilated, severely injured or violently killed ($n = 33$), or witnessing a serious traffic accident ($n = 18$). Application of the Student's t test confirmed that the two or three

trauma types that were combined within each category did not differ significantly in terms of TI ($p > .44$; $d < 0.30$).

Table 2 gives the means and standard deviations for these five categories of traumatic events. The analysis of variance showed that there were no significant differences between them: $F(4, 268) = 6.462$, $p < .0001$. As the group sizes differed considerably, Hochberg's GT2 test was applied in the *post hoc* comparisons. According to this test, the physical maltreatment/sexual abuse group differed significantly in TI from the non-sexual violent crime ($p = .015$; $d = 0.77$), news of unexpected death ($p = .027$; $d = 0.51$) and witnessing traumatic events groups ($p = .00001$; $d = 1.04$), but not from the serious accident/serious risk of losing one's life group ($p = .192$; $d = 0.6$). There was also a significant difference between the unexpected death and the witnessing traumatic events groups ($p = .047$; $d = 0.49$). None of the remaining comparisons were significant: four of them yielded $p > .93$ and $d < 0.31$, while the comparison of the serious accident and the witnessing traumatic events groups produced $p = .12$ and $d = 0.56$.

Table 2. Means (M) and standard deviations (SD) for tonic immobility according to the type of worst traumatic event experienced.

Type of worst traumatic event	n	M	DT
Physical maltreatment or sexual abuse	42	15.57	7.72
Non-sexual violent crime	26	10.19	5.60
Serious accident or serious risk of losing one's life	42	12.17	6.99
News of a loved one's violent or unexpected death, or another highly traumatic event	112	11.89	6.93
Unexpectedly witnessing a violent death or witnessing a serious accident	51	8.67	5.62

Predictors of TI in the hierarchical regression analysis

In order to determine the importance of the different variables in terms of predicting TI we carried out a hierarchical regression analysis. In the first step we entered the variable intense fear, since previous studies have established that this induces TI. The remaining variables that were shown in the univariate analyses to be significantly associated with TI were then entered by means of the stepwise method, as there is no published evidence regarding the effect of these variables. For the polytomous variable 'type of traumatic event', and given the pattern of results obtained, two dummy variables were also entered in the second step: the reference group (unexpectedly witnessing someone die violently or witnessing a serious accident) was contrasted with the physical maltreatment/sexual abuse group, on the one hand, and with the remaining traumatic events, on the other. The assumptions of regression analysis (linearity, independent errors, normally distributed errors and homoscedasticity) were all met, and the analysis for possible multicollinearity and outliers and influential cases yielded satisfactory results.

Table 3 presents the results of the hierarchical regression. Intense fear, helplessness or horror initially explained 8.9% of the variance in TI, but the addition of three other predictors (perception of how traumatic the event was, physical maltreatment/sexual abuse and number of different

types of traumatic events) enabled 25.2% of the variance to be explained. The beta coefficients indicate that the most important predictor was the person's own sense of how traumatic the event was, followed by physical maltreatment/sexual abuse and the other two variables.

Table 3. Results of the hierarchical regression analysis to predict tonic immobility.

	B (confidence interval)	Standard error of B	β	p
Step 1				
- Intense fear, helplessness or horror	5.06 (3.11-7.01)	0.99	.30	< 0.0001
Step 2				
- Intense fear, helplessness or horror	2.35 (0.29-4.41)	1.05	.14	< 0.03
- Perception of how traumatic the event was	1.70 (1.11-2.28)	0.30	.36	< 0.0001
Step 3				
- Intense fear, helplessness or horror	2.26 (0.26-4.27)	1.02	.13	< 0.03
- Perception of how traumatic the event was	1.65 (1.09-2.22)	0.29	.35	< 0.0001
- Physical maltreatment or sexual abuse versus witnessing traumatic event	4.38 (2.31-6.45)	1.05	.22	< 0.0001
Step 4				
- Intense fear, helplessness or horror	2.27 (0.28-4.26)	1.01	.13	< 0.03
- Perception of how traumatic the event was	1.46 (0.88-2.05)	0.30	.31	< 0.0001
- Physical maltreatment or sexual abuse versus witnessing traumatic event	3.93 (1.83-6.03)	1.07	.20	< 0.0003
- Number of different types of traumatic event	0.84 (0.07-1.61)	0.39	.12	< 0.05

Note. $R^2 = .089$ ($p < .0001$) in Step 1, $\Delta R^2 = .100$ ($p < .0001$) in Step 2, $\Delta R^2 = .050$ ($p < .0001$) in Step 3, $\Delta R^2 = .013$ ($p < .05$) in Step 4.

Prevalence of TI

Finally, in order to examine the prevalence of TI we began by loosely defining significant TI as a score equal to or above the theoretical mean (15) on the TIS-BM, the same approach as was used by Fusé et al. (2007). Based on this criterion, 39.2% of the total sample had experienced TI in response to their worst traumatic experience. Table 4 shows the prevalence for the different types of events. The difference between events was significant: $\chi^2(4, N = 273) = 23.09$, $p < .0005$; $\phi = .291$. With a higher cut-off point of 20, a criterion also used by Fusé et al. (2007), only 13.2% of the sample was considered to have reacted with a high level of TI. The difference between events continued to be significant: $\chi^2(4, N = 273) = 18.68$, $p < .001$; $\phi = .262$. Finally, when a strict definition of TI as physical immobility was used, namely a score of at least 5 out of 6 on each of the first three items of the TIS-BM, only 7.7% of the sample was regarded as having experienced a high degree of TI. As 40% of the cells in this case had an expected frequency less than 5, we applied Fisher's exact test, which showed that the difference between events was almost significant: Fisher = 8.56, $p = .053$; $\phi = .182$. For all three criteria used the highest prevalence of TI corresponded to physical maltreatment or sexual abuse (see Table 4).

Discussion

Almost all the variables studied were correlated with TI, the exceptions being gender and the age at which the worst traumatic event first occurred. Instead, the age at which a traumatic event was first experienced regardless of whether

it was the worst one or not was associated with TI. A possible explanation for this is that the mean for the latter age-related variable is lower (14 vs. 16 years), implying that the young persons involved may have fewer resources for dealing with the traumatic event.

Table 4. Percentage of participants who responded with tonic immobility to the worst traumatic event they had experienced, according to the three criteria used.

Type of worst traumatic event	Criterion A	Criterion B	Criterion C
Physical maltreatment or sexual abuse ($n = 42$)	64.3%	28.6%	16.7%
Non-sexual violent crime ($n = 26$)	30.8%	14.3%	7.7%
Serious accident or serious risk of losing one's life ($n = 42$)	47.6%	15.2%	11.9%
News of a loved one's violent or unexpected death ($n = 112$)	38.4%	0.0%	5.4%
Unexpectedly witnessing a violent death or witnessing a serious accident ($n = 51$)	17.6%	2.0%	2.0%

Note. Criterion A = score equal to or above the theoretical mean (15) of the TIS-BM (brief, modified version of the Tonic Immobility Scale). Criterion B = score of 20 or more on the TIS-BM. Criterion C = score of 5 or more on each of the three physical immobility items on the TIS-BM.

The person's age when the first traumatic event occurred, the intentionality of the event, and whether or not it was directly experienced were only correlated with TI in the univariate analyses, whereas the type of trauma, the reaction to it and the number of different types of traumatic events were also significant predictors in the multiple regression analysis. This suggests that the relationship between the first group of variables and TI is partially mediated by the latter three. Regarding trauma type, physical maltreatment/sexual abuse emerged as a significant predictor of TI in both the univariate and multivariate analyses, this being consistent

with the findings of Bados et al. (2008). Likewise, given the known association between TI and post-traumatic symptoms (Bovin et al., 2008; Humphreys et al., 2010; Rocha-Rego et al., 2009) the importance of this type of event is congruent with the observation of current post-traumatic symptoms being greater when the earlier trauma involved physical violence in the family, sexual violence or childhood sexual abuse (Frazier et al., 2009; Owens & Chard, 2006; Vrana & Lauterbach, 1994).

The number of different types of traumatic events experienced was also a significant predictor of TI, although it was less important than physical maltreatment/sexual abuse. It is likely that the occurrence of different traumatic events exceeds the person's coping resources, although it is also possible that the susceptibility to respond to stressful or traumatic events with TI is also relevant. In this regard, research on the association between subsequent exposure to new traumatic events and the development of PTSD suggests that the susceptibility to respond pathologically to traumatic events (Breslau, Peterson, & Edward, 2010; Breslau, Peterson, & Schultz, 2008) and the frequency of these events (Cogle, Resnick, & Kilpatrick, 2009; Sledjeski, Speisman, & Dierker, 2010) are both important factors.

Our results also show that the subjective perception of how traumatic the worst event was and the presence of intense fear, helplessness or horror were significant predictors of TI, a finding that underlines the importance of a person's initial reaction to trauma. Notably, the first of these variables also had greater weight than did physical maltreatment/sexual abuse, the number of different types of traumatic events and the experience of intense fear. All this suggests two things: 1) as occurs with the development of post-traumatic symptoms and PTSD (Brewin et al., 2000; Rubin, Berntsen, & Bohni, 2008) the contribution of these personal variables is greater than that of the characteristics of the event itself, and 2) the initial reaction to the event is not limited to intense fear, helplessness or horror, but may also involve other emotional reactions such as anger, shame, guilt and disgust (Bados et al., 2012b; O'Donnell, Creamer, McFarlane, Silove, & Bryant, 2010). It should be remembered, however, that the present study is retrospective in nature, and therefore an alternative interpretation of these results would be that people who experience greater TI remember the event as being more traumatic.

People's perceptions of how traumatic an event was and of their reacting with TI to it may be the result of an interaction between event characteristics (e.g. its severity) and certain personal variables that have not been considered in the present study, such as neuroticism, negative affect and a perceived lack of personal control or resources for coping with or escaping from the situation (Connor & Butterfield, 2003/2005). These variables, which are the consequence of biological vulnerability and of early developmental experiences (Barlow, 2002), could be risk factors for TI, just as they are for PTSD (see the meta-analyses by Brewin et al., 2000, and Ozer, Best, Lipsey, & Weiss, 2003). Interventions

aimed at increasing individual resources for coping with traumatic events or at preventing their occurrence or repetition may possibly reduce the likelihood of a person responding to such events with TI, should such events occur. Examples of such interventions include programmes designed to enhance the preparedness of children and teenagers in relation to rocket attacks (Wolmer, Hamiel, & Laor, 2011) and earthquakes (Tamanas & Manos, 2004), programmes used to train emergency workers, flight or ship crews, firefighters, security forces and military personnel (Griffith & West, 2013; O'Connor et al., 2008), and programmes that seek to prevent childhood sexual abuse (del Campo & López, 2006; Zwi et al., 2007) and maltreatment of youth and adults (Foshee et al., 2004; Whitaker et al., 2006).¹ Moreover, even in situations of physical or sexual assault in which it is not possible to resist or escape and where it is said that IT could have adaptive value by reducing the probability of harm (see Heidt et al., 2005), an alternative survival strategy would be to learn to respond not with involuntary TI but with volitional acquiescence (Zoellner, 2008). The advantage of such a response would be that it may reduce the feelings of guilt associated with TI, since the person would decide to resist or acquiesce depending on which response was considered most adaptive in a given situation.

Given the association between a TI response and the subsequent development of post-traumatic symptoms (Bovin et al., 2008; Humphreys et al., 2010; Rocha-Rego et al., 2009), prevention programmes could also be targeted at persons who reacted with significant TI to a traumatic event, the aim being to reduce the likelihood that they would go on to develop PTSD. Brief cognitive-behavioural programmes (lasting 5-8 hours) have in fact been developed for recent victims of traumatic events, and the data suggest that compared with control groups these interventions reduce post-traumatic symptoms and prevent the emergence or consolidation of PTSD (for reviews, see Ehlers & Clark, 2003; Feldner et al., 2007; Hoffman & Smits, 2008). The meta-analysis conducted by Rolfsnes and Idsoe (2011) likewise suggests that cognitive-behavioural programmes in schools are effective at reducing PTSD symptoms in children and adolescents who have suffered various kinds of trauma (although sexual abuse and physical maltreatment were not considered). Research is needed to investigate whether these kinds of programmes are equally useful for people who react with TI to a traumatic event.

Scaer (2014), in accordance with the model presented in the introduction, has suggested that somatic-oriented therapies which focus more on implicit sensorimotor memories

¹ Obviously, seeking to prevent abuse or maltreatment by focusing on potential victims is only one of several dimensions that need to be addressed when it comes to preventing such events. Other factors that must be considered are the family, the social context and work with perpetrators.

may also be useful. These approaches include somatic experiencing, thought field therapy, emotional freedom technique, neurofeedback, and eye movement desensitization and reprocessing (EMDR). However, there are hardly any randomized controlled studies of the effectiveness of these therapies, with the exception of EMDR, and even there, the effectiveness of EMDR for recent victims of traumatic events who reacted with TI has yet to be investigated.

In terms of the prevalence of TI, which was here defined dichotomously, it would appear to be a relatively common response to various kinds of traumatic events, especially those that involve physical maltreatment, sexual abuse or violence. The observed percentages in the case of physical maltreatment or sexual abuse were slightly higher than those obtained by other authors (Fusé et al., 2007; Heidt et al., 2005) when studying people who had suffered sexual abuse or assault. However, the observed percentages for violent crime were lower than those reported by Fiszman et al., (2008), which is as expected given that these authors studied patients with PTSD subsequent to being victims of violent crime. At all events, the data from different studies can only be adequately compared once the nature of the traumatic events involved is defined more specifically. For example, several types and levels of severity of violent crime may be experienced. Nonetheless, the data obtained in all these studies suggest that a high level of TI is reported by a considerable proportion of people; in the present study, when using a strict criterion to define TI, the figure ranged between 2% and 17% depending on the type of event.

Tonic immobility should be seen as a natural involuntary response that occurs when a person experiences intense fear or perceives that fighting or escape is not possible. This fact needs to be more widely communicated to society so as to promote understanding and support of victims, especially in cases such as rape, where survivors are often misunderstood or even blamed for not having resisted. Likewise, the nature of TI should also be explained to victims so as to challenge a) the belief that they could have done more to resist, and b) the associated feelings of guilt (Marx et al., 2008). However, it is also necessary to recognize that TI may be counterproductive when there is a possibility of escape (e.g. from a plane that has crash landed or a boat that is sinking). In these cases, it is necessary, as Leach (2004) points out, to teach people survival strategies. This training would be more systematic in the case of flight or ship crews, firefighters, security forces and military personnel, whereas that aimed at passengers or others potentially involved in a disaster could be more basic. Industry can also play an important role by designing safety procedures and materials that are as easy as possible to apply and use, thereby reducing the cognitive demands involved and increasing people's capacity to react.

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This study has several limitations. First, it is susceptible to the memory-related biases inherent to retrospective reports. Since the degree of TI experienced may be under- or overestimated by respondents there is a need for research that assesses its occurrence immediately or as soon as possible after a traumatic event. Second, and aside from the retrospective bias, it is unclear to what extent self-report questionnaires can truly capture the degree of TI experienced, which may be more accurately measured through interviews or, even better, through direct observation after the event; indeed, a significant number of false positive reports cannot be ruled out (Zoellner, 2008). It is worth noting, however, that in a study which used a measure similar to the TIS-BM, Volchan et al. (2011) found an association between retrospective self-reports of TI during a traumatic event and restricted area of body sway when participants listened to a script of their traumatic experience. A third limitation of our study is that the results are based on the worst traumatic event experienced and this may not be representative of other events of the same type; for instance, the worst traffic accident a person experiences might not be representative of other motor vehicle accidents (Breslau et al., 1998; Frazier et al., 2009). Fourth, the fact that our data are correlational means that the predictors of TI we identified cannot be assumed to be its cause; indeed, there may be other variables that explain the relationship between the two, and current emotional distress may also influence the perception of past events. A fifth limitation is that intense fear, helplessness or horror was assessed by means of a dichotomized variable, and future studies should therefore seek to measure it using an interval scale. Finally, the sample was wholly comprised of psychology undergraduates, who may not be representative of students as a whole or of other populations, thus limiting the generalizability of our results.

While acknowledging these limitations, this is the first study to have examined a series of possible predictors of TI in humans, doing so with a relatively large sample and using a validated measure of TI. The results suggest that certain characteristics of traumatic events (experience of physical maltreatment or sexual abuse, number of different types of events experienced) and the person's reaction to them (perception of how traumatic the experience was, a reaction of intense fear) are both significant predictors of TI. The most important predictor was the individual perception of how traumatic the event was, followed by the experience of physical maltreatment or sexual abuse. However, the fact that all these predictors only explained 25% of the variance in TI means that the influence of other variables, such as neuroticism, negative affect and a perceived lack of personal control or resources for dealing with traumatic events, now needs to be investigated.

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