Correction

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Correction for "Interaction of natural survival instincts and internalized social norms exploring the *Titanic* and *Lusitania* disasters," by Bruno S. Frey, David A. Savage, and Benno Torgler, which appeared in issue 11, March 16, 2010, of *Proc Natl Acad Sci USA* (107:4862–4865; first published March 1, 2010; 10.1073/pnas.0911303107).

The authors note the following: "We wish to bring to your attention an issue regarding our PNAS publication referenced above. We had previously published much of the data and results discussing the *Titanic* (1) and had not properly cited this paper in our PNAS article. In addition, we could have cited refs. 2–5. We apologize for not properly citing our related work and for not citing earlier work of others."

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CORRECTION

Interaction of natural survival instincts and internalized social norms exploring the *Titanic* and *Lusitania* disasters

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To understand human behavior, it is important to know under what conditions people deviate from selfish rationality. This study explores the interaction of natural survival instincts and internalized social norms using data on the sinking of the *Titanic* and the *Lusitania*. We show that time pressure appears to be crucial when explaining behavior under extreme conditions of life and death. Even though the two vessels and the composition of their passengers were quite similar, the behavior of the individuals on board was dramatically different. On the *Lusitania*, selfish behavior dominated (which corresponds to the classical homo economicus); on the *Titanic*, social norms and social status (class) dominated, which contradicts standard economics. This difference could be attributed to the fact that the *Lusitania* sank in 18 min, creating a situation in which the short-run flight impulse dominated behavior. On the slowly sinking *Titanic* (2 h, 40 min), there was time for socially determined behavioral patterns to reemerge. Maritime disasters are traditionally not analyzed in a comparative manner with advanced statistical (econometric) techniques using individual data of the passengers and crew. Knowing human behavior under extreme conditions provides insight into how widely human behavior can vary, depending on differing external conditions.

altruism and self-interest | decisions under pressure | fight and flight | tragic events | Quasi-Natural Experiment

On the night of April 14, 1912, the *Titanic* collided with an iceberg and sank, resulting in the death of 1,517 people. Three years later, on May 7, 1915, the *Lusitania* was torpedoed by a German U-boat and sank; 1,198 people died in this tragedy. We explore the interaction of survival instincts and the materialization of internalized social norms using data on these two disasters, both of which demonstrate a similar shortage of lifeboats and survival rates (~30%), a comparable number of crew members in relation to passengers (~40%), and similarities in passengers' sociodemographic and socioeconomic structures (Table 1). Because the two maritime disasters occurred within 3 years of each other, stable historical norms can be assumed.

Maritime disasters, specifically shipping disasters such as the sinking of the *Titanic* or *Lusitania*, are in general not analyzed in a comparative manner with advanced statistical (econometric) techniques using individual data of the passengers and crew. This analysis provides innovative insights into the behavior of individuals under extreme conditions. Economics traditionally assumes that human beings behave in a rational and selfish way, which is shaped by external conditions (1, 2). Recent research has provided evidence that these assumptions do not always hold, however (3–5). Even though the two vessels and the composition of the passengers were quite similar, the behavior of the individuals on board was dramatically different. On the *Lusitania*, selfish behavior prevailed (which corresponds to the classical homo economicus), whereas on the *Titanic*, the adherence to social norms and social status (class) dominated. This difference could be attributed to the fact that the *Lusitania* sank in only 18 min, creating a situation in which the short-run flight impulse dominates behavior, whereas on the slowly sinking *Titanic* (2 h, 40 min), there was time for socially determined behavioral patterns to reemerge. It also can be argued that the fact that the *Lusitania* was sunk during a time of war might have provoked different reactions. For example, the passengers on the *Lusitania* might be have been less risk-averse. Warning notices had been printed in the leading newspapers reminding transatlantic passengers that a state of war was in effect, that any vessel traveling under the British flag was liable to destruction, and that passengers sailed at their own risk. On the other hand, there are several reasonable suppositions supporting the idea that the *Lusitania* should not have been at risk, primarily because it was capable of sufficient speed to outrun enemy torpedoes. The *Lusitania* held the transatlantic Blue Riband award for speed at the time, and it was a vessel carrying civilian passengers, not a warship. Finally, it was carrying a number of neutral American civilians. Maritime law states that in wartime, merchant vessels must be given a warning before attack, whereas warships should not expect any warning. The *Lusitania* was never given such a warning by the attacking German U-boat (6). The cargo was generally of the ordinary kind, but also included a number of cases of cartridges (about 5,000). Contrary to German claims, the steamer carried no masked guns, trained gunners, or special ammunition, nor was she transporting troops (7).

The likelihood that the passengers of the *Lusitania* knew about the tragic events of the sinking of the *Titanic* should not be excluded. For example, whereas many of the passengers on the *Titanic* may have (wrongly) believed that they would ultimately be rescued (8), those on the *Lusitania* may have learned from the experience of the *Titanic*. This may have led those passengers to change their behavior (i.e., increase self-preserving behavior). Nevertheless, maritime disasters have similarities to quasi-natural experiments, whose great advantage is randomization and realism (9–11). The disasters occurred due to an exogenous event, and the resulting life-and-death situation affected every person aboard equally.

Many social scientists assume that in a life-and-death situation, self-interested reactions predominate. Social cohesion is expected to disappear, and the desire to act in accordance with self-interest takes over (12, 13). In states of extreme privatization (14), "the social contract is thrown away, and each man single-mindedly attempts to save his own life at whatever cost to others" (15). On the other hand, social norms are followed for intrinsic reasons; people believe them to be "right" (16) or fear social sanctions when violating them (17). The emerging disaster literature suggests that prosocial behavior predominates in such contexts (18). Laboratory experiments have shown that strategic incentives are important to the understanding of whether self-regarding or other-regarding preferences dominate (19).

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Table 1. Passenger structure

Variable	Lusitania	Titanic
Survived, mean	0.326	0.32
Female, mean	0.26	0.22
Age, years, mean	31.57	30.04
First class, mean	0.149	0.147

Table 2. Determinants of passenger survival on the *Titanic* (T) and the *Lusitania* (L)

	Reference group			
	Male/female age >35, third class, and no children		Male, adults, and third class	
Probit	(T)	(L)	(T)	(L)
Female			1.468*	−0.0336
			17.44	*−0.36*
			0.53	**−0.011**
Age < 16 years	0.797*	−0.019	0.382*	−0.163
	5.29	*−0.11*	*2.83*	*−1.28*
	0.309	**−0.007**	**0.148**	**−0.053**
Male age 16–35 years	−0.176†	0.228‡		
	−1.69	*2.00*		
	−0.065	**0.079**		
Female age 16–35 years	1.297*	0.293‡		
	10.76	*2.29*		
	0.483	**0.104**		
First class	1.167*	−0.359*	1.066*	−0.439*
	10.78	*−3.02*	*10.62*	*−3.87*
	0.439	**−0.115**	**0.403**	**−0.139**
Second class	0.448*	0.003	0.387*	0.0145
	4.41	*0.02*	*3.74*	*0.14*
	0.172	**0.001**	**0.148**	**0.005**
Has children	0.502*	0.026		
	2.80	*0.18*		
	0.196	**0.009**		
Observations	1,300	933	1,300	933
Probability > χ^2	0.000	0.000	0.000	0.001
Pseudo-R^2	0.216	0.023	0.28	0.017

The dependent variable in this probit model is individuals' survival. Survival takes a value of 1. Coefficients are in roman type, *z* statistics are in italics, and marginal effects are in bold.
*Statistical significance at the 1% level.
†Statistical significance at the 10% level.
‡Statistical significance at the 5% level.

Our study proposes that context differences matter. Time appears to be a key parameter for explaining the adoption of either social or self-interested behaviors. Our results indicate that adherence to social norms and social power requires time to manifest (evolve) and cannot compete against individual self-interested flight behavior in a shorter window of opportunity, where competition for survival of the fittest prevails. The rapid sinking of the *Lusitania* very likely created a situation in which simple physical prowess and may be also good fortune or randomness played a larger role, whereas social norms were much more influential in the case of the *Titanic*. Having more time on the *Titanic* also may have eased the restrictions on bargaining for lifeboats and facilitated information generating advantages, which may have benefited first-class and second-class passengers compared with third-class passengers (with the crew favoring the rich and powerful). An information advantage could be obtained by the upper class passengers, such as advanced access to critical/life-saving information or a more accurate risk assessment from officers. However, this advantage may have been difficult or impossible to implement under the conditions reigning on the rapidly sinking *Lusitania*. The research on fight-or-flight behavior may provide further insights into how people reacted in these different conditions. Fight-or-flight behavior as the instinctual reaction to a perceived danger has been explored in various disciplines, including biology, psychology, and sociology (20–23). Biologically, fight-or-flight behavior has two distinctly separate stages (24). The short-term response triggers a surge in adrenaline production via the hypothalamus and can last from a few seconds to a few minutes. This response is limited to a few minutes, because adrenaline degrades rapidly and leaves the body in a state of exhaustion (25). The elevated operational state is maintained for a short period after the threat has passed, after which the response mechanism switches off and the system returns to homeostasis (26). The duration extends beyond the active flight response time and includes a cool-down period. Only after returning to homeostasis do the higher-order brain functions of the neocortex begin to override instinctual responses, which may lead to a change toward prosocial individual behaviors.

We were able to collect unique data sets containing detailed information about gender, age, ticket price, and thus the passenger-class status for both the *Titanic* and the *Lusitania* to use in testing these propositions. The dependent variable in the multivariate analysis is a 0/1 variable that indicates whether an individual did or did not survive the disaster (survived = 1). Table 2 shows the estimated parameters, the significance level (indicated by *z* values), and the quantitative (marginal) effects for the *Titanic* and the *Lusitania*. The results focus only on passengers (without crew members).

Results

Because the *Lusitania* sank in under 18 min, we would expect a stronger competition for survival (of the fittest) on that ship than on the *Titanic*. People in their prime (age 16–35 years) are expected to have higher survival probabilities. However, a higher survival rate may be a result not only of the struggle for a place on a lifeboat, but also of an inefficient launching of lifeboats on the *Lusitania*. Individuals who were strong and agile enough to stay in the boats or to get back into the boats after being pitched into the water had a higher survival rate (7). The results of Eq. (**1**), given in Table 2, suggest that persons age 16–35 had a higher probability of surviving (7.9% for males and 10.4 for females) compared with other age groups. In contrast, on the *Titanic*, only females in the reproductive age group (16–35 years) had a higher probability of surviving (48.3%), supporting the importance of the procreation instinct (27). Conversely, males age 16–35 had a lower probability of surviving. The results of Eq. (**2**) in Table 2 show that the social norm of "women and children first" was deferred to only on the *Titanic*. This social norm was enforced by the crew members and considered acceptable by the passengers; otherwise, the passengers could have easily revolted against such a protocol. In both disasters, the captains issued orders to their officers and crew to follow the social norm of "women and children first." These orders were successfully carried out on the *Titanic*, but not on the *Lusitania,* due to time constraints and problems launching the lifeboats (10, 26).

It also should be noted that the *Lusitania* regressions had lower pseudo-R^2 values. This might be due to the rapidity of the sinking, which induced much randomness into the survival process. Although it certainly is true that a higher pseudo-R^2 value is better, we have no reason to reject the model, because we still have clear confirmation that people in their prime (age 16–35) had a higher survival probability. Moreover, a global test of significance, testing the null hypothesis that all of the coefficients are 0, clearly can be rejected (Table 2).

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Discussion

Children had a 14.8% higher probability of surviving than adults, and a person accompanying a child had a 19.6% higher probability of survival than a person without a child. Moreover, being female increased the probability of surviving by more than 50%. These results suggest a stronger competition for survival (of the fittest) on the *Lusitania*. In the environment of the *Titanic*, social norms were enforced more often, and there was also a higher willingness among males to surrender a seat on a lifeboat.

Economic class or social power conferred a relative advantage. First-class passengers, and to some extent second-class passengers as well, tried to secure the same preferential treatment with respect to lifeboat access that they were used to receiving on the vessel. But the generation of such a relative advantage takes time. Indeed, Table 2 shows a higher survival rate for first-class passengers on the *Titanic*, but not on the *Lusitania*, where first-class passengers fared even worse than third-class passengers. The question remains as to whether the structure of the ship biased such results. It should be noted that there were no restrictions on the movements of any passengers, including those in steerage. Crew members made their way through steerage calling out and warning passengers shouting "All up on deck!" A gate was temporally locked; however, this was rectified, and the steerage passengers had as much opportunity to survive as both first-class and second-class passengers (7).

Our empirical analysis suggests that the adoption of a specific behavior might depend on time as a factor, although time may not be the only factor at work. Such a natural environment is less controlled than an experimental setting. In other words, there can be no absolute proof of the hypothesis that only time led to such behavioral differences. Ideally, more observations (comparable shipwrecks) are needed to better isolate the potential relevance of time. Nonetheless, it seems that on the more slowly sinking *Titanic*, prosocial behavior predominated (in a stronger manner), whereas more selfish conduct prevailed on the rapidly sinking *Lusitania*.

Methods

Titanic Data. The Titanic data set consists of 2,207 persons confirmed to be aboard the R.M.S. *Titanic*. The data were gathered from the *Encyclopedia Titanica* and cross-checked with other sources (28–36). The dependent variable is whether someone survived or not. Of the 2,207 passengers and crew members, 1,517 died. Information was obtained for all but 21 of those onboard; the age variable was unobtainable for these 21, and as such they have been omitted from all regressions that include the age variable. The 2,186 people on board included 1,300 passengers and 886 crew members. In the empirical study, we focus only on the passengers. Among the passengers, 43 were servants, 840 were male (65%), and 460 of the 1,300 passengers were female (35%). Aboard the *Titanic*, lifeboats were a scarce commodity. The vessel only had 20 lifeboats, which could accommodate a maximum of 1,178 persons, or 52% of the people aboard. There were more lifeboats than required by the rules of the British Board of Trade, drafted in 1894, which determined the number of lifeboats based on a ship's gross register tonnage, rather than on the number of persons aboard. Because the *Titanic* initially showed no signs of being in imminent danger, passengers were reluctant to leave the apparent security of the vessel to board small lifeboats. Consequently, in the beginning, most of the lifeboats were launched partially empty, which increased the demand for lifeboat seats once the people on board realized that the ship was indeed sinking.

Lusitania Data. The *Lusitania* data consist of 1,949 persons confirmed to be aboard the R.M.S. *Lusitania*. The data were gathered from numerous sources and cross-checked with other sources (7, 37, 38). The dependent variable is whether someone survived or not. Of 1,949 passengers and crew members, 1,313 died. The 1,949 persons on board included 258 passengers and 691 crew members. Among the passengers, 19 were servants, 775 were male (62%), and 483 of the 1,258 passengers were female (38%). The shortage of lifeboats occurred not because of an original physical shortage of boats, but from an inability to launch all of the available boats. Approximately 10 seconds after the torpedo struck, the vessel listed heavily to starboard (15 degrees), making it very difficult to launch the lifeboats on the port side (7), because they could not clear the rail. In addition, the starboard boats were difficult to enter for the opposite reason; the lifeboats swung out too far, making them difficult to load.

Additional Data and Definitions. Based on the records, we were able to gather information about passengers' gender, age, nationality, port of boarding, ticket price, and passenger-class status (first, second, or third class). In addition, we were able to generate individual information related to travel plans and companions (i.e., having children). Because the impact of age is prominent in this investigation, it is important to use generally accepted groupings: children, adults, and older people. We used the United Nations standard for age (39), which classifies children as persons 15 years of age or under. In humans, the peak reproductive age, as defined by the American Society for Reproductive Medicine (40), is between 15 and 35 years of age.

Analytic Method. We used a probit model of the survival probability for a typical passenger,

$$\Pr(y = 1 \mid x_1, x_2, \ldots, x_k) = \Phi(\alpha + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_k x_k).$$

Here y is a dummy variable indicating whether the passenger survived ($y = 1$) or not ($y = 0$); the variables ($x_1, x_2, \ldots, x_k$) are explanatory variables, such as gender and age; ($\alpha, \beta_1, \beta_2, \ldots \beta_k$) are parameters to be estimated; and Φ is the cumulative standard normal distribution function. The role of Φ, which is increasing in its argument, is to keep the probability, $\Pr(y = 1)$, in the 0–1 interval. Each passenger contributes one observation on ($y, x_1, x_2, \ldots, x_k$). From a sample of such observations, assumed to be independent, the parameters can be estimated by the maximum likelihood method. This is a standard probit model (41, 42). Because the coefficients are difficult to interpret directly, the marginal effect of a continuous explanatory variable, x_j, will, as usual, be interpreted through the partial derivative,

$$\frac{\partial \Pr(y = 1 \mid x_1, x_2, \ldots, x_k)}{\partial x_j} = \beta_j \phi(\alpha + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_k x_k),$$

evaluated at the means, where ϕ is the standard normal density function (not the cumulative density Φ). Because $\phi > 0$, the sign of the marginal effect is the same as the sign of β_j. For a discrete x_j, a difference is used in place of a partial derivative.

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