The Effect of Positive and Negative Emotions on Young Drivers: A Simulator Study

Ahinoam Eherenfreund - Hager

Orit Taubman – Ben-Ari

The Louis and Gabi Weisfeld School of Social Work

Bar-Ilan University, Ramat Gan, Israel

Tomer Toledo

Faculty of Civil and Environmental Engineering

Technion – Israel Institute of Technology, Haifa, Israel

Haneen Farah

Faculty of Civil Engineering and Geosciences

TU Delft, Delft, The Netherlands

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ABSTRACT

The study examined the influence of affect induction on actual risk-taking behavior in a driving simulator, as well as the links between personal variables (relevance of driving to self-esteem, sensation seeking) and the level of risky driving. Eighty young drivers aged 18–21 ($M = 19.24$, $SD = 0.75$) were randomly divided into four induction groups: relaxing positive affect; arousing positive affect; negative affect; and neutral affect. The participants drove on a simulator, with various parameters of risky driving measured before and after emotion priming.

As predicted, arousing positive affect and negative affect led to increased risky driving, whereas relaxing positive affect moderated risk-taking. In addition, the results confirm previous findings regarding the personal variables, revealing that higher levels of relevance of driving to self-esteem and sensation seeking are associated with higher levels of risk-taking in the simulated driving.

The findings indicate that the driver's emotional state has a significant effect on risk-taking on the road. Moreover, they show that the conventional use of negative affect in safe driving campaigns is liable to heighten the tendency for risky driving rather than reduce it. In contrast, relaxing positive affect was found to lead to lower risk-taking. The study is unique in revealing a correlation between results previously obtained for the willingness to drive recklessly and actual risky driving behavior observed on a driving simulator. By expanding the understanding of the motivations for youngsters' risky driving, the study may aid in designing effective, theoretically sound, interventions aimed at reducing the tendency for dangerous driving among young drivers.

THE EFFECT OF EMOTIONS ON RISKY DRIVING ON A SIMULATOR

Considerable efforts have been invested by researchers and practitioners alike in the attempt to reduce reckless driving among young drivers, the population at greatest risk of involvement in car crashes all over the world (Williams, 2003). As part of these efforts, various factors that may help explain youngsters' risk-taking on the road have been identified, including driving patterns, personal traits, emotional state, and motivations, as well as situational, environmental, and social factors (Shope & Bingham, 2008).

Although safe driving campaigns commonly make use of negative affect, especially fear appeals, research casts doubt on this approach, indicating that it may actually achieve the opposite result (Tay, 2005). On the other hand, it has been found that positive emotions are associated with increased sensitivity to loss, and consequently a tendency to avoid risks and opt for safer alternatives (Isen, 2000). Messages employing positive affect have been shown to lead to adaptive behavioral change in a variety of contexts, including driving (Lewis, Watson, & White, 2008; Sibley & Harre, 2009; Whittam, Dwyer, Simpson, & Leeming, 2006). Moreover, while studies show that various negative emotions differentially affect judgment and behavior (Maheswaran & Chen, 2006), much less attention has been paid to the differential effects of specific positive emotions (Cavanaugh, Bettman, Luce, & Payne, 2007).

In a recent series of studies examining the effect of positive emotions on self-reported intentions for risky driving, it was found that relaxing positive affect priming led youngsters to express a lower level of willingness to drive recklessly than inductions priming negative, arousing, positive, or neutral (control group) affect. In addition, negative and stimulating positive affect inductions led to a higher willingness for risky driving than those priming relaxing positive and neutral affect. The studies also

showed that high relevance of driving to self-esteem and high sensation seeking are associated with a greater willingness to take risks behind the wheel (Ehrenfreund-Hager & Taubman – Ben-Ari, 2016; Taubman – Ben-Ari, 2012). The current study continues this avenue of investigation. However, rather than relying on the self-report questionnaires employed in previous studies, which tapped the willingness for reckless driving, it examines the effect of emotion priming and personal variables on actual driving behavior as observed on a simulator. Two personal variables were examined: relevance of driving to self-esteem and sensation seeking.

Relevance of Driving to Self-Esteem - For some people, driving plays a major role in defining self-esteem. Thus, among many young drivers who use a vehicle to enhance their self-esteem, reckless driving may offer a range of potential benefits (Taubman – Ben-Ari, Florian, & Mikulincer, 1999). Indeed, it has been found that youngsters who perceive driving as highly relevant to self-esteem are characterized by a higher willingness to take risks on the road (Ehrenfreund-Hager & Taubman - Ben-Ari, 2016; Taubman – Ben-Ari et al., 1999).

Sensation Seeking - Sensation seeking refers to the tendency to seek out experiences that are "varied, novel, complex and intense," and the readiness to take risks to do so, and reflects individual differences in the optimal level of arousal and stimulation (Zuckerman, 1990). People high on sensation seeking have been found to engage in more risky driving and to be involved in more traffic accidents than those low on this trait (Jonah, 1997; McKenna & Horswill, 2006).

The Current Study

Previous studies examining the influence of positive affect on risky driving have relied on self-report questionnaires to assess the willingness to take risks on the road. The current study goes one step further, observing actual driving behavior on a simulator. In order to examine the effect of positive affect priming and the contribution of the personal variables, the participants were randomly divided

into four experimental groups: relaxing positive affect; arousing positive affect; negative affect; and neutral affect (control group). During their time on the simulator, they were exposed to a pair of emotionally charged words in accordance with the study condition to which they were assigned. Various parameters indicative of reckless driving were measured, including speed, headway, and lane changes. The participants also completed questionnaires relating to relevance of driving to self-esteem, sensation seeking, and demographic characteristics in order to examine the role of these personal factors in their driving behavior.

The following hypotheses were formulated:

1. The group exposed to relaxing positive affect priming will display less risky driving on the simulator than the other three groups. The group exposed to negative affect or to aroused positive affect priming will display more risky driving than the other groups.
2. The higher the relevance of driving to self-esteem and the higher the tendency for sensation seeking, the more risky driving will be observed on the simulator.

METHOD

Participants

The sample consisted of 80 young drivers (40 males and 40 females) aged 18-21 (M=19.24, SD=0.75), who were randomly assigned to one of the four induction groups (each consisting of 20 participants, 10 males and 10 females). Each of the participants was paid 50 Israeli shekels (around $13) for their part in the study, and was reimbursed for travel expenses.

Instruments

Driving Simulator STISIM Drive (Rosenthal, 1999), a fixed-base interactive driving simulator which was set on automatic control conditions. It has a 60^0 wide and 40^0 high field of view. The simulator updates the images at a rate of 30 frames/s. A pre-determined driving scenario was screened on a laptop computer, and the participant drove by means of a steering wheel and pedals connected to the computer. Data was collected every tenth of a second according to pre-set parameters. The scenario involved driving along a two-lane rural highway of a total length of 7.5 kilometers with no intersections and a speed limit of 90 km/h. The cross section of the road consisted of a lane width of 3.0 meters and a shoulder width of 2.25 meters in a level terrain. Vehicles were planned to travel in both directions, the driver's and the opposite lane. The driving speeds of the vehicles were randomly selected from a uniform distribution between 40 and 120 km/h in both directions. In all scenarios, daytime and good weather conditions were designed, which allowed good visibility. At the end of each driving scenario, the raw data which contained information on the location, speeds and acceleration of the subject vehicle and all other vehicles in the scenario was saved. A MATLAB program was written to calculate relevant measures of risky driving: average headway (seconds); average speed (meters per second); length of time exceeding the speed limit of 90 km/h (seconds); number of movements across a solid white line; and duration of travel in the opposite lane (seconds) (Farah, Yechiam, Bekhor, Toledo, & Polus, 2008).

Affect priming. While driving on the simulator, the participant was exposed to a pair of emotionally charged words according to the study condition to which they were assigned: "peaceful" and "calm" for relaxing positive affect; "exciting" and "fun" for arousing positive affect; "sad" and "crying" for negative affect; and "hat" and "chair" for neutral affect. The words appeared on a sign positioned above the road and were colored yellow against a blue background in order to stand out. Around 15

seconds elapsed between the appearance of the sign on the screen and the time the car passed beneath it, so that the words could be read clearly for about 5 seconds. In order to ensure that the words employed primed the desired emotion, a pilot study was conducted among 120 students at Bar Ilan University. The participants were divided into six groups, each of which was exposed to one of the six words and were asked to write down the associations it aroused. Analysis of the responses indicated that the words indeed aroused the relevant affect.

Affect priming by means of exposure to words is an established method (Bargh, 2006) that has been found to influence the participant's perceptions, judgment, and behavior (Chartrand & Bargh, 2002). It has been shown to modify a variety of social behaviors, without the individual being aware that he or she is being directed toward a certain behavior (Harris, Bargh, & Brownell, 2009), and has been proven effective (Kawada, Oettingen, Gollwitzer, & Bargh, 2004; Thompson, Roman, Moskowitz, Chaiken, & Bargh, 1994). At the end of the session, the first author spoke briefly with the participants, all of whom indicated that they had noticed the words. However, when they were asked what they thought their purpose was and what the study examined, none linked exposure to the words to the aim of the study.

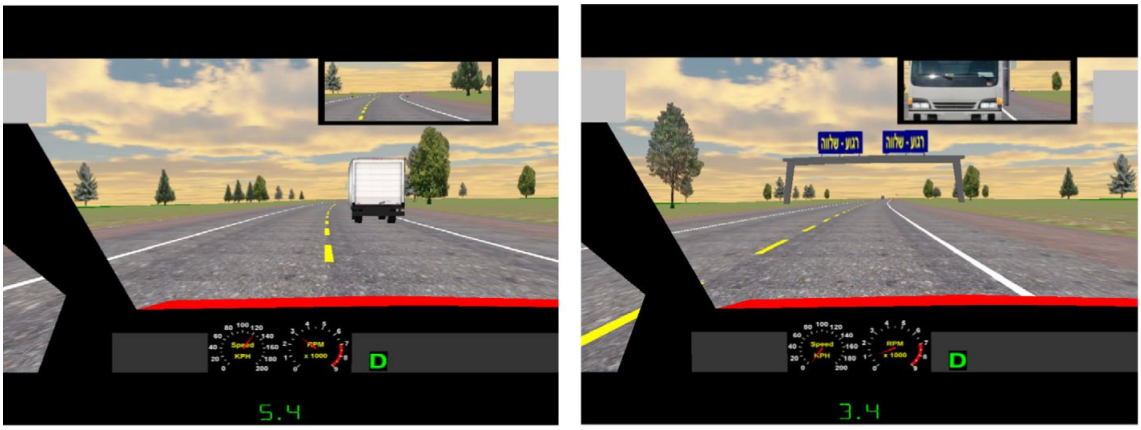
Relevance of Driving to Self-Esteem (Taubman – Ben-Ari, 1999), a 15-item instrument assessing the perceived costs and benefits of driving to self-esteem. Seven items relate to the potential benefits and 8 to the potential negative consequences. Participants were asked to indicate the degree to which they agreed with the statement in each item on a scale ranging from 1 (*totally disagree*) to 7 (*strongly agree*). Cronbach's alpha in the current study was 0.91. A single score was therefore calculated by averaging the responses to all items, with higher scores indicating a higher perception of driving as relevant to self-esteem.

Sensation Seeking Scale (SSS-V; Zuckerman, 1994). The study made use of the ten items in the thrill and adventure seeking factor of the scale, which was found in a comprehensive review of the literature to yield the strongest correlations with risky driving (Jonah, 1997). Each item consists of two contradictory statements, one relating to thrill seeking and the other unrelated to this trait. Participants were asked to choose the sentence that most closely applies to them. A score was assigned to each participant, representing the total number of items in which the thrill seeking statement was selected, with higher scores indicating a higher level of sensation seeking. Cronbach's alpha in a previous study was 0.78 (Miller & Taubman – Ben-Ari, 2010).

A **demographic and driving history questionnaire** was used to obtain background information, including age, gender, religiosity, time since licensure, involvement in traffic accidents, and average number of driving hours per day and per week.

Procedure

The participants were recruited by means of convenience sampling. When they arrived at the site, they received a brief explanation about the operation of the simulator. They were then each given five minutes to familiarize themselves with the simulator and practice using the driving controls, after which the study scenario was begun. Participants were asked to drive the way they normally do for the duration of the scenario, which involved driving for 7.5 kilometers. After about 3.5 kilometers, they were exposed to the pair of words which remained on the screen for around 15 seconds, as described above. (see an example in Figure 1). Following the session on the simulator, the participant completed the questionnaires tapping relevance of driving to self-esteem, sensation seeking, and background data. The total time required for each participant was 15-20 minutes. When the tasks were completed, the first author thanked the participant and spoke with them briefly, explaining the aim of the study.



(a) (b)

Figure 1 Examples from the Simulator on a Regular Drive (a) and when Affect Words were Shown on Signs (b).

RESULTS

Gender Differences

In order to determine whether gender differences appeared in the risky driving parameters irrespective of the nature of the affect priming, t-tests with Bonferroni correction for multiple comparisons were conducted. No significant differences were found between men and women on any of the parameters measured on the simulator. As a result of this finding, as well as the small number of participants of each gender in each cell of the analysis (n=10), gender was not entered into the analyses examining the effect of emotion priming.

Personal Variables and Risky Driving

In order to test whether the four study groups differed in the dependent variables before the onset of the study, a one-way MANOVA was conducted on the five pre-manipulation dependent variables with affect condition (relaxing positive affect; arousing positive affect; negative affect; neutral affect) as

independent variable. The analysis revealed a multivariate affect conditions effect, F (15, 199.16) = 4.43, $p < 0.001$. The univariate results appear in Table 1. As all the dependent variables were significantly different among the affect conditions, the analyses examining the effect of affect condition were conducted with the pre-manipulation scores as covariates.

In order to test whether the four study groups differed in the two main personality variables relevant to risky driving, a one-way MANOVA was conducted on sensation seeking and driving as relevant to self-esteem with affect condition (relaxing positive affect; arousing positive affect; negative affect; neutral affect) as independent variable. The analysis revealed a non-significant multivariate affect conditions effect, F (6, 148) = 1.32, $p = 0.25$. The univariate results were also non-significant: F (3, 75) = 1.47, $p = 0.23$ for sensation seeking and $F < 1$ for driving as relevant to self-esteem. Therefore, the personality variables were not included in the main analyses.

Table 1 Means and Standard Deviations for Headway, Speed Measures, and Lane Change Measures by Induction Group and Time of Measurement

	Induction Group									
	Relaxing positive affect (N =20)		Stimulating positive affect (N = 20)		Negative affect (N =20)		Neutral affect (N = 20)		F	p
	M	SD	M	SD	M	SD	M	SD		
Headway	10.43	3.40	12.79	3.52	13.53	4.64	17.07	11.69	3.31	0.024
Average speed	27.10	3.32	22.87	3.85	21.38	2.74	26.01	4.05	12.26	<0.001
Time exceeding speed limit	78.55	15.73	46.85	37.86	40.40	35.12	76.68	45.01	6.36	0.001
Crossing white line	2.3	0.97	2.00	1.41	1.5	0.76	3.00	1.86	4.49	0.006
Travel in opposite lane	11.32	5.56	13.17	6.77	8.55	4.82	17.57	7.61	7.26	<0.001

Personal Variables and risky driving

To test the first hypothesis, predicting more risky driving among participants indicating higher relevance of driving to self-esteem and higher sensation seeking, Pearson correlations were conducted

between these variables. For the purposes of this analysis, only driving parameters observed before affect priming were employed in order to preclude the effect of emotional state. The results appear in Table 2.

Table 2 Pearson Correlations between Personal Variables and Driving Measures

	Headway (seconds)	Average speed (meters per second)	Time exceeding speed limit (seconds)	Crossing a dashed white line	Travel in opposite lane (seconds)
Relevance of driving to self-esteem	0.21** -	0.159	0.301**	0.211	0.224*
Sensation seeking	0.04	0.17	0.33**	0.26*	0.28*

*$p < .05$, ** $p < .01$

As Table 2 shows, results provide evidence in favor of the hypothesis. Significant correlations were found between higher relevance of driving to self-esteem and less headway, more time exceeding the speed limit, and more travel in the opposite lane. Higher sensation seeking yielded significant correlations with more time exceeding the speed limit, more movements across a dashed white line, and more travel in the opposite lane.

Effect of Emotion Priming on Risky Driving

In order to examine the effect of emotion priming on the parameters of risky driving, a series of 5 one-way ANCOVAs were conducted on the post-manipulation scores of the five risky driving variables with affect condition (relaxing positive affect; arousing positive affect; negative affect; neutral affect) as independent variable. The pre-manipulation scores of each risky driving variable were entered as covariates. Descriptive statistics appear in Table 3.

Table 3 Means and standard deviations for headway, speed measures, and lane change measures by induction group and time of measurement.

	Induction group							
	Relaxing positive affect (N = 20)		Stimulating positive affect (N = 20)		Negative affect (N = 20)		Neutral affect (N = 20)	
	M	SD	M	SD	M	SD	M	SD
Headway								
Before	10.43	3.4	12.79	3.52	13.53	4.64	17.07	11.69
After	15.2	5.49	9.56	6.76	6.9	3.78	16.57	15.21
Average speed								
Before	27.1	3.32	22.87	3.85	21.38	2.74	26.01	4.05
After	23.22	1.71	30.78	3.71	29.88	2.58	26.18	4.01
Time exceeding speed limit								
Before	78.55	15.73	46.85	37.86	40.4	35.12	76.68	45.01
After	50.98	26.26	109.23	27.33	113.37	18.87	77.02	45.19
Crossing while line								

Before	2.3	0.97	2	1.41	1.5	0.76	3	1.86
After	0.5	0.88	3.05	2.03	2.55	1.93	1.85	1.84
Travel in opposite lane								
Before	11.32	5.56	13.17	6.77	8.55	4.82	17.57	7.61
After	2.29	4.54	22.12	11.43	21.62	13.45	12.51	10.62

Headway. The analysis revealed a significant main effect for time of measurement, $F(3, 75)=14.01$, $p<.0001$, $\eta^2=0.36$. Importantly, Eta squared (η^2) is a measure of the effect size or the proportion of variance associated with or accounted for by each of the effects in an ANOVA. In the current case, this effect is considered of a large size. Pairwise comparisons with Bonferroni's adjustment to significance level revealed that headway distance was smaller for the negative affect as compared to both the neutral and relaxing positive affects and was smaller for the arousal condition as compared to the relaxing positive condition. All other differences were not significant. Thus, whereas relaxing positive affect led participants to take fewer risks on the road, arousing positive and negative affect led to greater risk-taking.

Lane changes, measured by number of movements across a solid white line and duration of travel in the opposite lane. The ANCOVA conducted on the number of movements across a dashed white line revealed a significant large size effect of affect condition, $F(3, 75) = 12.43$, $p < 0.001$, $\eta^2 = 0.33$. Pairwise comparisons with Bonferroni's adjustment to significance level revealed that number of movements across a dashed white line were higher for the arousal and the negative affect as compared to the positive and neutral affects. All other differences were not significant. The ANCOVA conducted

on the duration of travel in the opposite lane revealed a significant large size effect of affect condition, $F(3, 75) = 18.49$, $p < 0.001$, $\eta^2 = 0.43$. Pairwise comparisons with Bonferroni's adjustment to significance level revealed an identical pattern to the movements across a dashed white line: the duration of travel in opposite lane was longer for the arousal and the negative affect than for the positive and neutral affects. All other differences were not significant. In other words, here too, arousing positive and negative affect led to greater risk-taking than relaxing positive affect.

Speed, measured by average speed and length of time exceeding speed limit. The analysis revealed a significant strong effect of affect condition for average speed, $F(3, 75) = 67.26$, $p < 0.001$, $\eta^2 = 0.73$. Pairwise comparisons with Bonferroni's adjustment to significance level revealed that the driving speed was higher for the positive arousal and negative affects as compared to both the neutral and relaxing positive affects and was smaller for the relaxing positive affect as compared to the neutral affect. All other differences were not significant. As for time exceeding speed limit, the analysis revealed a significant large effect of affect condition, $F(3, 75) = 36.27$, $p < 0.001$, $\eta^2 = 0.59$. Pairwise comparisons with Bonferroni's adjustment to significance level revealed that the duration of time exceeding speed limit was longer for the arousal and negative affects as compared to both the neutral and relaxing positive affects and was smaller for the relaxing positive affect as compared to the neutral affect. All other differences were not significant. That is, once again, exposure to words arousing stimulating positive or negative affect led to more risky driving, while exposure to words arousing relaxing positive affect reduced risk-taking on the road.

DISCUSSION

By observing driving behavior on a simulator, the current study confirms the findings of previous investigations that made use of self-report instruments (Ehrenfreund-Hager & Taubman – Ben-Ari, 2016; Taubman – Ben-Ari, 2012), indicating the significant influence of emotional state on risky

driving. For all three parameters of risk-taking measured, headway, speed, and lane changes, exposure to stimulating positive and negative affect priming led to an increase in risky driving, while relaxing positive affect priming reduced dangerous driving behavior. The findings call into question the dichotomous perception of emotions as either positive or negative, and supports the contention that the use of stimulating positive or negative affect in safe driving campaigns is not only ineffective, but actually encourages risk-taking on the road. In contrast, evoking relaxing positive emotions appears to reduce the tendency of young drivers to take risks behind the wheel (Lewis et al., 2008; Roidl, Frehse, & Hoger, 2014; Sibley & Harre, 2009; Taubman – Ben-Ari, 2012).

Beyond its value for the design of safety interventions, the current study demonstrates the correlation between the results obtained through self-reports and actual observed driving behavior on a simulator. Studies using questionnaires to examine behavioral intentions have been criticized on the grounds that they may not reflect what an individual will actually do in real time (Boufous et al., 2010). Our findings, however, suggest that this is not the case, as the data collected for risky driving on a simulator revealed the same patterns as did self-report questionnaires tapping the willingness to drive recklessly. Furthermore, the results indicate that self-reports of driving behavior do not suffer from a social desirability bias (Sullman & Taylor, 2010). Though we used a simulator, and not real driving due to ethical considerations (we could not let individuals drive in a car, while leading them to drive recklessly following the emotional manipulations), the results are compelling and important.

Although the affect inductions employed in the study were relatively brief and simple, the results showed them to have significant and distinctive effects. This is in line with the contemporary view that emotional state plays a major role in a variety of behavioral processes (Geuens, De Pelsmacker, & Faseur, 2011). It would therefore be of particular value to more thoroughly examine the influence of the use of affect, and especially positive affect, in safe driving campaigns.

It is worthy of note that no differences were found here in the observed risky driving of males and females. This finding may reflect a misapprehension in regard to gender differences. Due to the high level of involvement in car crashes among young male drivers, many investigations have focused on this population, with less research attention being paid to females. However, the number of women drivers is growing steadily, meaning that they are increasingly exposed to danger and recklessness on the road. As a result, we are liable to see an increase in risky driving and involvement in traffic accidents among women (Welsh & Lenard, 2001). Moreover, several previous studies have also reported no gender differences in risky driving behavior (Hennessy & Wiesenthal, 2001; Lawton & Nutter, 2002). Nevertheless, the lack of a difference between males and females in the current study could also derive from the small sample size. In order to determine the true meaning of this finding, future studies would be advised to employ a larger sample to examine observed driving behavior on a simulator.

In respect to the personal variables, the results indicate that a higher level of relevance of driving to self-esteem is associated with less headway, more time exceeding the speed limit, and more travel in the opposite lane. This lends support to the contention that risk-taking among young drivers is not merely a product of inexperience, lack of skill, or random circumstances, but may be deliberate behavior that fulfills certain needs (Taubman – Ben-Ari, 2008). Similarly, sensation seeking was found to be associated with more time exceeding the speed limit, more movements across a solid white line, and more travel in the opposite lane. This finding provides further confirmation of the strong link between sensation seeking and risk-taking (Zuckerman, 2009). Furthermore, sensation seeking has been shown to be linked to sensitivity to monotonous road conditions, leading to driver fatigue and more frequent steering wheel movement (Thiffault & Bergeron, 2003). This effect of sensation seeking on driving might have come to bear in the parameters measured in the current study, that is,

sensitivity to monotony may have resulted in more steering wheel movement reflected in more movements into the opposite lane.

The correlations found here between the personal variables and observed driving behavior confirm the results of previous studies employing self-report questionnaires (Desrichard & Denarie, 2005; Ehrenfreund-Hager & Taubman – Ben-Ari, 2016; Taubman – Ben-Ari et al., 1999). Moreover, previous studies have yielded strong correlations between behaviors observed on a simulator and actual driving on the road (Boyle & Lee, 2010; Wang et al., 2010). Taken together, these findings provide support for the use of a simulator as a reliable indicator of an individual's normal driving behavior in real life.

While the current study is innovative in nature and produced findings of significance to both theory and practice, it must be noted that the sample was relatively small and therefore cannot be considered fully representative. Future studies might attempt to replicate the findings using a larger and more diverse sample. In addition, the study focused on young drivers as this group displays the highest involvement in car crashes. However, it is also important to examine the influence of emotional state on risky driving among other populations and age groups. Furthermore, although a previous study demonstrated the differential effect of the various affect inductions on the willingness of young males and young females to drive recklessly, the small sample size precluded the possibility of examining this issue in the current study. Future investigations employing a larger sample to measure risky driving on a simulator may also be able to examine gender differences in the response to the priming of different emotions. They may also explore how long do such influences last.

Our study indicates that emotions have a significant effect on young drivers' risky road behavior. Moreover, it suggests that the conventional use of negative affect in safety campaigns not only fails to reduce risky driving, but may actually encourage it. Thus, the findings argue for abandoning fear

appeals in favor of the use of relaxing positive affect, shown here to lead to a lower level of risk-taking behind the wheel. This conclusion, previously reached in studies using self-report questionnaires to tap the willingness to drive recklessly, is confirmed in the current study by observed behavior on a simulator, reflecting actual driving habits on the road. It is our hope that this increased understanding of the motives for risk-taking among young drivers will aid in the design of effective, theoretically sound, interventions aimed at enhancing road safety and modifying driving behavior.

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