The influence of emotional state on risk perception in pedestrians: a psychophysiological approach

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Traffic accidents involving pedestrians represent one of the most relevant causes of death and injury around the world. Several studies have underlined the role of risk perception as a clear predictor of risky behaviour in pedestrians. However, risk perception is an ability susceptible to be altered as a consequence of some circumstances and psychological issues, such as emotional states. The present research aimed to study the influence of two emotions (happiness and sadness) on risk perception in pedestrians. To carry said research out, 53 participants took part in the experiment. They had previously been randomly assigned to one of the three experimental conditions (happiness group, sadness group and control group), by watching a video clip to generate the implied emotion. After this, all of them watched a sequence of 8 video clips involving pedestrian situations, four of which involved a risky situation while the other four involved a non-risky situation. Risk perception was measured by both self-report and psychophysiological arousal. The results showed that the control group got significantly more physiological activation in high risky situations than the other two groups, both in Skin Conductance Level and Skin Conductance Response. Besides, the control group was the only one who got a significant higher activation in high risk situations than in no risky situations, both in SCL and in SCR. These results suggest that pedestrians walking under a relevant emotional state could have their risk perception ability negatively affected, with potential consequences on suffering road accidents

Key words: Risk perception; Pedestrians; Emotion; Psychophysiology; Skin conductance.

Introduction

Traffic accidents involving pedestrians represent an important cause of death and severe injuries in Spain. According to official statistics, during 2017 there were 351 pedestrians killed (19% of the total of people killed in traffic accidents), 1,940 were injured and required hospitalization, and 12,382 were injured and did not require hospitalization (DGT., 2018). Despite the general tendency to reduce the number of pedestrian deaths throughout recent years, research is still needed to improve knowledge of the variables predicting traffic accidents involving pedestrians.

Road safety studies have identified three categories of variables which are involved in any traffic situation: infrastructures (conditions of pavement, road, etc.), vehicles (technical issues related to cars, trucks, bicycles, etc.) and human factors (involving all of the physical and psychological aspects of drivers, cyclists and pedestrians). Of these, the human factor has arisen as the main predictor of road accidents (Karpova, Sigova, Kruglova, & Kelbakh, 2017; Plotnikova, 2018; Sikron, Baron-Epel, & Linn, 2008)., It is, then, necessary to explore the main variables in the human factor which could explain the occurrence of traffic accidents.

Research in Traffic Psychology has highlighted risky behaviours in both drivers (Elander, West, & French, 1993; Herrero-Fernández & Fonseca-Baeza, 2017; Herrero-Fernández, Oliva-Macías, & Parada-Fernández, 2019; Wang & Xu, 2019) and pedestrians (Granié, 2009; Granié, Pannetier, & Guého, 2013; Zhou, Horrey, & Yu, 2009) as one of the best predictors of traffic accidents. At the same time, risky behaviour has been proposed as a direct result of risk perception, so the greater the risk perceived in one specific situation, the less likelihood of conducting a risky behaviour is (Castanier, Paran, & Delhomme, 2012; Elias & Shiftan, 2012; Herrero-Fernández, 2015; Herrero-Fernández, Macía-Guerrero, Silvano-Chaparro, Merino, & Jenchura, 2016; Wilde, 1982, 1988). Moreover, literature has pointed out a negative correlation between age and risky behaviours on the road, i.e., younger pedestrians would perceive less risk, therefore, taking more risks, and having a higher probability of being run over in an accident than older pedestrians (Alonso, Esteban, Useche, & Colomer, 2018; Brosseau, Zangenehpour, Saunier, & Miranda-Moreno, 2013; Lichenstein, Smith, Ambrose, & Moody, 2012; Ojo, Adetona, Agyemang, & Afukaar, 2019). More specifically, young adult pedestrians (aged 18 – 35) have been identified as the highest risk group, as they are associated, more strongly than other age groups, with both dangerous crossing and dangerous violations (Brosseau et al., 2013).

Risk perception, as defined in the information processing theory (Kahneman & Frederick, 2002), is processed in two separate ways: risk as analysis and risk as affect or feeling. The differences found between subjective (self-reported) and objective (physiological arousal) risk perception support the idea that physiological arousal could reflect automatic processes of risk assessment (Crundall, Chapman, Phelps, & Underwood, 2003; Kinnear, Stradling, & McVey, 2008), which could be unrelated to the conscious analysis of risk (Slovic, Finucane, Peters, & MacGregor, 2002, 2004). Therefore, these two ways should be assessed in risk perception research, as they are proposed as an orthogonal model.

Self-report methods to assess risk perception have been measured in previous research through Likert scales (Groot, Steg, & Poortinga, 2013; Kuttschreuter & Hilverda, 2019; Ma, Yang, Zhou, Feng, & Yuan, 2019), visual-analogic scales (Gallo et al., 2014) and qualitative interviews (Khan & Chreim, 2019). Regarding the objective measurement of risk perception, physiological correlates of risk perception have been well-established. Research in different areas including pedestrians (Herrero-Fernández et al., 2016) has shown that electrodermal activity (EDA) covariates with risk perception (Choi, Jebelli, & Lee, 2019; Kinnear, Kelly, Stradling, & Thomson, 2013; Wickramasekera, Pope, & Kolm, 1996). Moreover, studies on the distinguishing features of emotions have shown that fear, an emotion associated with perceived risk, has a specific and unique pattern of EDA that is different to other emotions like anger or dislike (Williams et al., 2005). This could be due to the biological characteristics of EDA, which is a direct measure of sympathetic nervous system, as sweat glands are innervated only by the sympathetic nervous system. Given that the parasympathetic nervous system does not affect it, the balance between them (activation system vs. calm down system) is not considered, and, therefore, very short stimulus – response time lapses are observed. Besides, EDA is commonly measured through both tonic and phasic activity. Whereas the first one refers to a general level of activation, the second one does so to a certain increase in respect to the level.

Otherwise, more commonly used physiological indices [e.g. respiration rate (RR), heart rate (HR)] have shown smaller relationships with risk perception, which could be due to the dual innervation of both cardiovascular and respiratory systems (sympathetic and parasympathetic nervous systems). Only one study on drivers found that self-reported perceived risk correlated with HR (Mesken, Hagenzieker, Rothengatter, & de Waard, 2007).

On the other hand, risk perception could be influenced by some psychological variables, such as emotions (Waters, 2008). Research has focused mainly on the study of personality traits, especially anger, establishing strong correlations between this personality trait and risky behaviours in both drivers (Deffenbacher, 2008; Escanes & Poo, 2018; Ferrer, Maclay, Litvak, & Lerner, 2017; Peng, Wang, & Chen, 2019) and pedestrians (Herrero-Fernández, Oliva-Macías, & Parada-Fernández, 2019). However, less attention has been paid to other emotions like sadness (Jeon, 2016; Jeon & Zhang,

2013) or happiness (Nisa'Minhad, Ali, Khai, & Ahmad, 2016) in spite of their negative influence on the quality of driving. Even less amount of research has been dedicated to analyzing emotional states. Previous studies have shown that negative and even positive emotional states (Hogarth, Portell, & Cuxart, 2007) could affect risk perception negatively (Bhandari, Hallowell, Van Boven, Gruber, & Welker, 2016b; Liu, Xie, She, Chen, & Li, 2013; Rajesh, Srinath, Sasikumar, & Subin, 2017), with the subsequent increase in risky behaviours.

The aim of the current study is, then, to analyze how emotional states affect risk perception in young pedestrians. More specifically, two opposite emotional states (happiness and sadness) will be compared with a control condition (neutral emotion) in their influence on risk perception in both high and low risky situations. The hypothesis of the research is that both positive (happiness) and negative (sadness) emotions will similarly reduce the risk perception ability, in comparison with the control condition.

Method

Participants

Seventy participants (Psychology ungraduate students) were recruited and randomly assigned to one of the three experimental conditions. All of them were Spanish. After watching the video (in both happiness and sadness groups) or waiting (in the control group), those participants who reported feeling the emotion corresponding to the assigned group (happiness in the happiness group, sadness in the sadness group, and "neutral emotion" in the control group) were selected to take part in the study, so the criterion to accept or reject a participant was based on their declaring to feel (qualitatively) the corresponding emotion. The intensity of emotion was measured (see *Self-reports* sub-section) but not taken into account in the selection of participants.

However, given that initially there were only 8 participants in the control group reporting feeling "neutral emotion", 14 additional participants were recruited and non-randomly assigned to the control group in order to increase the sample size of this control group. These last participants were also Psychology undergraduate students f. This way, there were finally 19 participants in the happiness group (14 females, 73.68%; Age: M = 19.47, SD = 0.62), 16 in the sadness group (11 females, 68.80%; Age: M = 19.44, SD = 0.73), and 18 in the control group (13 females, 72.20%; Age: M = 19.93, SD = 0.56). The groups were equivalent both by gender, $\chi^2(2) = 1.19$, $p = .552$, and by age, $F(2, 52) = 0.07$, $p = .931$. Finally, all of the participants signed the informed consent, which notified that the participants could withdraw the experimental task at any moment and that the information would be confidential. They volunteered and did not receive any compensation for the participation. After completing the data gathering, the participant was explained the aims and psychophysiological rationale of the research.

Stimuli

The first step of the study consisted of an emotion induction task. Emotion induction lends itself to varied methods (Lench, Flores, & Bench, 2011; Salas, Radovic, & Turnbull, 2012; Westermann, Spies, Stahl, & Hesse, 1996), such as music (Västfjäll, 2002), verbal or written stimuli (Velten, 1968), pictures (Lang, Bradley, & Cuthbert, 2005), or films (Gross & Levenson, 1995). In the present research, the emotion induction process was carried out through films.

Then, in a first step a video clip lasting 3.38 minutes was presented to the participants in the happiness group, displaying the meeting of an immigrant with her family at an airport after several years of zero contact. The video can be watched in the following link (in Spanish): https://www.youtube.com/watch?v=Uv8ou8VukbU. Another video clip lasting 6.30 minutes was presented to the participants in the sadness experimental group. This video was the last scene of the film *The Champ* (Zefferelli, 1979), which represents a boxer who is dying after a fight, and his little son crying beside the bed. This scene has been used in previous research to induce sadness (Krahe et al., 2011). The participants belonging to the control group (neutral emotion) did not watch any video at this stage, and they were waiting with no stimuli for 3 minutes after the physiological base-line gathering process (see Procedure for further details) as an equivalence to the time spent watching the video clip in the other two groups.

The second step involved nine video clips portraying neutral and risky pedestrian behaviours which were used with the participants from the three groups to measure the dependent variables. Each video lasted between 12 and 17 seconds. At least five seconds lapsed before the risky pedestrian behaviour occurred so that the participant could place themselves in the situation. Between each video, a black screen appeared for 50 seconds to ensure that the participants' physiological arousal returned to the basal level. Although an optimal time-lapse between stimuli has not been established, it is important to take into account the influence of both the nature of the testing situation and individual differences (Christie, 1976). Fifty seconds is a much longer time-lapse than has been used in similar studies. For example, in a study where video clips were presented to assess risk perception, only a 10-s time-lapse was used between clips (Crundall et al., 2003). The first video represented a neutral situation in which no vehicle was present. This neutral video was intentionally chosen to negate the orientation response that was expected due to the novelty of the first experimental stimulus (López, Encinas, & Muñoz, 1994; Lynn, 1966; Sokolov, 1990). The remaining eight videos involved pedestrian situations. Although no video included an accident, four of the videos involved risk because a pedestrian was breaking a traffic rule (e.g., crossing a pedestrian crosswalk when the signal was red, jaywalking). A photo of a risky situation clip is represented in Figure 1a, whereas non-risky videos are represented in Figure 1b. In the other four videos, there was no real risk because the pedestrians were obeying the traffic rules (e.g., crossing the road in crosswalks, crossing the road when the signal was green, looking in both directions before crossing). In all eight experimental videos, there were vehicles that were moving according to the traffic signals. The videos were first randomly selected to follow a certain order, and then all participants viewed the videos in this same order. Participants were told that they were going to watch several clips of real interactions between vehicles and pedestrians, and that they should watch each scene from the perspective of the pedestrians.

[Figure 1a]

[Figure 1b]

Self-reports

On the one hand, the participants indicated immediately after watching the experimental video (in the experimental conditions) or waiting time (in the control condition) which emotion they felt, choosing one of the following options: anger, disgust, sadness, surprise, happiness, fear, other emotion, or neutral emotion. They scored also the intensity of the emotion in a visual-analogic scale ranging from 1 (very low) to 6 (very high). These self-reports were designed *ad hoc* by the research team, based on the Paul Ekman´s categorical approach to the six basic emotions (Ekman, Friesen & Ellsworth, 1972). On the other hand, after each of the nine videos, the participant rated the amount of risk perceived in a 5-point visual-analogic scale, ranging from 0 (no risk) to 5 (very high risk). Therefore, the scores of the four videos representing high risk situations were averaged to create the variable "subjective risk perception in high risk situations" (α = .85), and the same was made with the four videos representing low risk situations (α = .60). This last alpha was slightly lower than the common cutoff (.70).

Apparatus

An Intel Celeron computer with a 19-inch Thin Film Transistor (TFT) monitor was used to present the stimuli previously described. Each participant was seated 60 cm away from the monitor. A photoplethysmogramme was used to measure HR in the non-dominant hand (see Procedure for further details). Moreover, two cup electrodes were used to capture skin conductance level (SCL) and response (SCR), which was considered an increase in conductance level greater than 0.05 μSiemens. In order to process these signals, a Biopac MP150 polygraph was used, which sent the signals to an identical computer to the one previously described. The signal was processed and quantified using Acqknowledge 4.0 software.

Procedure and experimental design

First, the sensors were connected to the participant so that they could start getting used to the experimental environment. The photoplethysmogramme was connected in the distal phalange of the forefinger on the non-dominant hand, and the cup electrodes were connected in the distal phalanges of the middle and ring fingers on the same hand. After all sensors had been connected, participants sat for three minutes without exposure to any other environmental stimuli in order to obtain baseline levels of the three indices. Measuring the physiological baseline permits to control the preexperimental arousal which could vary as a consequence of different variables such as moment of the day, consumption of caffeine or other stimulants, and so on. Then, in case of getting significant differences in baseline across the three groups, it should be statistically controlled in order to isolate its effect on the experimental task. Then, the details of the experiment were described to the participant. Those participants assigned to an experimental group were told that, first, a video clip of about 5 minutes was going to be displayed, with the sole requirement of paying attention to it. Otherwise, those participants assigned to the control group were said to try to get relax for 3 minutes, as no stimuli was presented to them at this step. Then, participants from the three groups were told that nine 15-s video clips would be presented with 50 s of black screen in between each video, their only tasks being to pay attention to the displayed videos and to remain completely still while the videos were playing, scoring after each one of them the amount of risk perceived in the situation. Immediately following the video presentations, the sensors were removed. As explained earlier, data related to the first video was dismissed because of orientation response bias. All procedures, including the presentation of the experimental condition video clip, psychophysiological recordings and video presentation, took about twenty minutes to complete.

Therefore, the empirical design consisted of a randomized controlled experimental study.

Results

Preliminary analyses

First, the effect of the independent variable (videos in the case of both experimental groups and waiting time with no stimulus in the control group) on the induction of emotion was analyzed through a χ^2-test, so the association between the assigned experimental condition (sadness, happiness, or control) and the reported emotion (sadness, happiness, surprise, disgust, anger, fear, other emotion, or neutral emotion) was tested. The results showed a significant effect with a large effect size (Rea & Parker, 1992) in the induction of emotion, $\chi^2(10) = 97.86$, $p < .001$, Cramer´s $V = .76$. More specifically, the post-hoc results showed that 16 (66.7%) of those participants assigned to the Sadness group reported feeling sadness; 19 (82.6%) of those participants assigned to the Happiness group reported feeling happiness, and 18 (48.6%) of those participants assigned to the Control group reported feeling "neutral emotion". Besides, differences by group in intensity of emotion were found, $F(2, 52) = 6.00$, $p = .005$, $\eta^2 = .19$, concluding that the happiness group ($M = 4.00$, $SD = 1.17$) scored higher than the control group ($M = 2.79$, $SD = 1.08$, $p = .004$). Finally, the score of the sadness group ($M = 3.53$, $SD = 0.96$) did not differ from neither the happiness group ($p = .443$) nor the control group ($p = .156$).

Then, differences in basal activation in HR, SCL, and SCR were tested through three one-way ANOVA. No significant differences were attained in HR, $F(2, 50) = 0.54$, $p = .584$, SCL, $F(2, 50) = 2.61$, $p = .084$, and SCR, $F(2, 52) = 2.27$, $p = .114$. As a result, the statistical control of the base lines in the subsequent analyses was not necessary.

Finally, physiological data showed relative normal distributions except for the case of the SCR according to both skewness (Sk) and kurtosis (K): HR at high risky situations, Sk = -0.28, K = 0.57; HR at low risky situations, Sk = -0.21, K = 0.51; SCL at high risky situations, Sk = 1.10, K = 0.31; SCL at low risky situations, SK = 1.00, K = 0.25; SCR at high risky situations, SK = 1.86, K = 3.23; SCR at low risky situations, Sk = 1.86, K = 2.55. Therefore, SCR scores were transformed, so root squares from the raw data were calculated. It made the distribution more centered: SCR at high risky situations, SK = 0.61, K = -0.48; SCR at low risky situations, Sk = 1.19, K = 0.11.

Multivariate mixed analyses (interaction, within-effects and between-effects)

Second, a mixed MANOVA (Wilks´ γ) was conducted in order to analyze the differences by group in risk perception both in high risky situations and low risky situations through the three psychophysiological indices. Within and between-subject effects as well as their interaction were analyzed, and statistical power ($1 - \beta$), significance and effect sizes (η^2) were reported. This last one was interpreted following Cohen Standards, so values between .01 and .04 were considered small effects, values between .05 and .14 medium, and values above .14 large (Cohen, 1988). Statistical power was calculated with G*Power 3.1.9.4 (Faul, Erdfelder, Lang, & Buchner, 2007). According to Cohen´s criterion, statistical power should be at least .80 (Cohen, 1988; Field, 2005).

The results showed a significant multivariate interaction effect with a large effect size, Wilks´ γ = 0.56, $F(8, 70) = 2.73$, $p = .006$, $\eta^2 = .25$ ($1 - \beta = .99$). Moreover, a significant multivariate within-subject effect with a large effect size was observed, Wilks´ γ = 0.05, $F(4, 35) = 177.03$, $p < .001$, $\eta^2 = .95$ ($1 - \beta = .98$). This implies that a multivariate difference in risk perception in high risky situations with regard to low risky situations was attained. Besides, a significant multivariate between-subject effect with a large effect size was observed, Wilks´ γ = 0.56, $F(8, 70) = 2.98$, $p = .006$, $\eta^2 = .28$ ($1 - \beta = .92$). This implies that a multivariate difference by groups in risk perception was attained. Therefore, univariate statistics were analyzed.

Univariate interaction effect analyses

On considering the variables affecting the interaction effect, significant differences with large effect sizes were found in both SCL, $F(2, 38) = 8.81$, $p = .001$, $\eta^2 = .32$ (1 –

β = 1), and SCR, $F(2, 38) = 3.98$, $p = .027$, $\eta^2 = .17$ (1 – β = 1). These results along with the intragroup comparisons in activation in high risk situations and low risk situations are detailed in Figure 2 (SCL) and Figure 3 (SCR). As can be observed, there were significant differences in both cases solely in the case of the control group. Finally, no significant effect was obtained neither in subjective perception of risk, $F(2, 38) = 0.58$, $p = .564$, nor in HR, $F(2, 38) = 1.13$, $p = .335$.

[Figure 2]

[Figure 3]

Univariate within-group effect analyses

Regarding the within-effect comparisons, the univariate comparisons showed significant differences both in SCR, $F(1, 38) = 15.24$, $p < .001$, $\eta^2 = .29$, [(1 – β = .98), high risky situations: $M = 0.14$, $SD = 0.12$; low risky situations: $M = 0.07$, $SD = 0.10$] and in the subjective perception of risk, $F(1, 38) = 618.72$, $p < .001$, $\eta^2 = .94$ [(1 – β = 1), high risky situations: $M = 4.09$, $SD = 0.84$; low risky situations: $M = 0.51$, $SD = 0.52$]. The results of this last contrast are detailed in Figure 4. As can be seen, the three experimental groups subjectively perceived more amount of risk in high risk situations than in low risk situations. Finally, no significant effect was obtained neither in SCL, $F(1, 38) = 0.78$, $p = .382$, nor in HR, $F(1, 38) = 0.76$, $p = .388$.

[Figure 4]

Univariate between-group effect analyses

Finally, with respect to the between-subject comparisons, univariate contrasts showed significant differences in SCL, $F(2, 38) = 10.94$, $p < .001$, $\eta^2 = .37$ ($1 - \beta = .99$). Bonferroni´s Post Hoc test showed that the control group (M = 3.82, SD = 0.28) had higher SCL than both the happiness group (M = 2.03, SD = 0.29; $p < 001$) and the sadness group (M = 2.10, SD = 0.49; $p = .013$). Besides, significant differences were observed in SCR, $F(2, 38) = 5.96$, $p = .011$, $\eta^2 = .21$ ($1 - \beta = .98$). Bonferroni´s Post Hoc test showed that the control group (M = 0.15, SD = 0.02) had higher SCR than both the happiness group (M = 0.08, SD = 0.02; $p = 024$) and the sadness group (M = 0.03, SD = 0.04; $p = .020$). Otherwise, no significant effect was revealed in subjective perception of risk, $F(2, 38) = 2.01$, $p = .147$, and HR, $F(2, 38) = 0.36$, $p = .698$.

Discussion

The goal of the current research was to analyse the influence of two opposite emotional states (happiness and sadness) on the ability of risk perception in a pedestrian context. With this aim in mind, an experimental task was designed to induce the emotional state and to measure the risk perception in two ways (Kahneman & Frederick, 2002), both objectively (psychophysiological arousal) and subjectively (self-report).

First of all, the preliminary analyses show that the effectiveness of emotion induction task was different in the three groups. Then, the video clip which was presented to induce happiness was more effective than the video used to induce sadness, given the percentage of individuals preassigned to each condition who reported feeling happiness or sadness. Likewise, the procedure followed with the control group (waiting time) was the least effective one, as there were many participants assigned to this condition who indicated feeling other than “neutral emotion”. Despite it being a preliminary part aiming to induce a certain emotion in order to later analyse the effect of these emotions on risk perception, some considerations should be commented for future research. First, scientific literature has shown that the final scene of *The Champ* is one of the most effective video resources to induce sadness (Gross & Levenson, 1995). However, whereas in other similar research the duration of the video used to be about 3-4 minutes (Krahe et al., 2011; Predatu, David, & Maffei, 2020), in the present research, the whole final scene was presented, with a time span of six and a half minutes. This issue could have affected the emotion induction process negatively, as the happiness video lasted three and a half minutes. Finally, the waiting time was the least effective method to induce "neutral emotion". In this case, the presentation of a neutral video clip would be probably more effective.

Regarding the main hypothesis of the study, the results showed that the control group perceived more risk objectively than the other two groups in both high risky situations and low risky situations, as the physiological arousal (SCL) was higher in both cases. However, at the same time, it was observed that the control group was the only one who got more physiological arousal in high risky situations than in low risky situations, as measured by both SCL and SCR, suggesting a better discrimination from actually non-dangerous situations than from actually dangerous ones. Besides, in the case of the SCR, it was observed that the control group attained a higher increase in physiological arousal than both happiness and sadness experimental groups in high risky situations. On the other hand, there were no significant differences in physiological arousal between the happiness group and sadness group. This implies that being under the influence of an emotion could be more relevant to the impairment of risk perception than the specific emotion felt (or the valence of the emotion, positive or negative), considering that only happiness and sadness were studied. Previous research has shown different evidence regarding this issue. Some research has suggested that sadness is associated with more accurate judgments and less susceptibility to common biases than other emotions (Alloy & Abramson, 1979; Bless, Bohner, Schwarz, & Strack, 1990). Then, risk perception in sad people should be more accurate than in both happy people and people under a neutral emotional state, or, at least, they should perceive more risk than the others, behaving less riskily according to the risk homeostasis theory. In this sense, one research on subjective risk perception in different non-driving contexts found that the happiness-induced group was more affected in risk perception than the sadness group (Drace & Ric, 2012).

In the same line, the affect-as-information model points out that affective states are a source of information regarding the global status of the environment (Schwarz & Clore, 2007). According to this statement, a positive affect informs people that their environment is safe whereas a negative affect signals a problematic environment. Whereas some research based on self-reported risk likelihood estimation has got support for this theoretical approach (Drace & Ric, 2012), the current study has shown no differences neither in the subjective measure nor in the objective ones between happiness and sadness groups. However, most of said research did not control the risk perception in neutral situations. In the current study, both SCL and SCR measures showed within-group differences in risk perception only in the control group, so neither experimental groups differentiated between risky and neutral situations. Then, according to both Figure 1 and Figure 2, this implies that emotional states affect the risk perception in high risky situations, making it similar to non-risky situations. Finally, there were no significant differences in HR. Several studies have suggested that HR could not covariate with risk perception (Herrero-Fernández, 2016; Herrero-Fernández et al., 2016; Jones, Chapman, & Bailey, 2014).

With regard to the subjective way of risk perception, the three groups perceived more risk in high risky situations than in low risky situations, so emotional state has no significant influence in the conscious analysis of the situations. Consistently with these results and with the Kahneman and Frederick´s information processing theory, other studies have found differences in the objective way in which risk perception is assessed but not in the subjective one, demonstrating the independence of these two ways (Crundall et al., 2003; Fuller, McHugh, & Pender, 2008; Kinnear et al., 2008; Peters, Västfjäll, Gärling, & Slovic, 2006). Furthermore, it has been proposed that the objective way in which risk perception is assessed could reflect automatic processes of risk assessment, which may be non-related to rational evaluation of such risk (Slovic et al., 2002, 2004). In this sense, behaviour in unexpected situations involving risk at some degree (emergency situations) could be more dependent on those automatic processes of risk assessment than on rational evaluations. This explanation would be related to research on positive and negative urgency, showing that both positive and negative mood states could lead to behave rashly (Cyders & Smith, 2007; Cyders et al., 2007).

These results have several implications in different areas. As far as the experimental area is concerned, the current results indicate that research about risk perception should consider both the objective and the subjective ways of risk perception, as they can be unrelated. Regarding the practical implications for road safety, on the one hand, commercial advertisements are usually placed in streets in order for both pedestrians and drivers to be exposed to them. In the case of advertisements with a strong emotional content, this could imply a risk for road users exposed to them. Likewise, the risk of crossing a crosswalk while watching the mobile phone has been pointed out. While this assertion is true, the present research goes further and could imply that a pedestrian walking on the sidewalk and watching an emotional video clip could get an emotional state which could affect him / her as far as the ability of risk perception for a certain time lapse is concerned. On the other hand, traffic safety campaigns should focus also on emotional regulation strategies, so that road users can be capable of dealing with their emotional states and, therefore, ofbehaving more safely. The same can be said of psychological interventions oriented to risky drivers and pedestrians, which should consider this issue, too.

Finally, the present research has some limitations. First, the samples of study comprised only young people, so the results can be extrapolated only to this age population. Further studies should be conducted to replicate the current results in older and younger people. Second, this study analysed risk perception as one of the main predictors of risky behaviour. While there is research supporting this idea, there are some other variables influencing unsafe behaviour, such as internalization of rules (Granié, 2009) or crosswalk design (Larsen, Buliung, & Faulkner, 2013). Moreover, risk-taking was not measured in the current study. While the main aim was to analyse the relationship between emotional states and risk perception, future research should verify the link between emotional states, risk perception and risky behaviour. For example, following the current experimental paradigm, after watching each clip and providing a perceived risk rating, the participants could be easily asked about how likely it is that he/she would engage in that pedestrian behaviour. Third, only two emotions were assessed. Future research should analyse the effect of other basic emotions on risk perception or directly on risky behaviour. Some research has been conducted aiming this in other (traffic non-related) contexts, such as working environments (Bhandari, Hallowell, Van Boven, Gruber, & Welker, 2016a; Cafagna & Barattucci, 2019; Tixier, Hallowell, Albert, van Boven, & Kleiner, 2014). Likewise, other technologies, such as virtual reality and eye tracking, should be implemented in this kind of research fields in order to improve the ecological validity of the studies. Finally, the last limitation is related to the gender composition of the three groups. Despite the male / female ratio being equivalent in the three groups, there were many more female than male participants in the three cases. Future research should analyse differences by gender in the effect of emotional state on risk perception. Literature has shown that male perceive less risk than women and take more risks as pedestrians (Herrero-Fernández, 2015; Herrero-Fernández et al., 2016), in consequence, it is a relevant variable to consider in future research.

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Fig. 1a. A photogram taken from a clip representing a risky situation

Fig. 1b. A photogram taken from a clip representing a non-risky situation

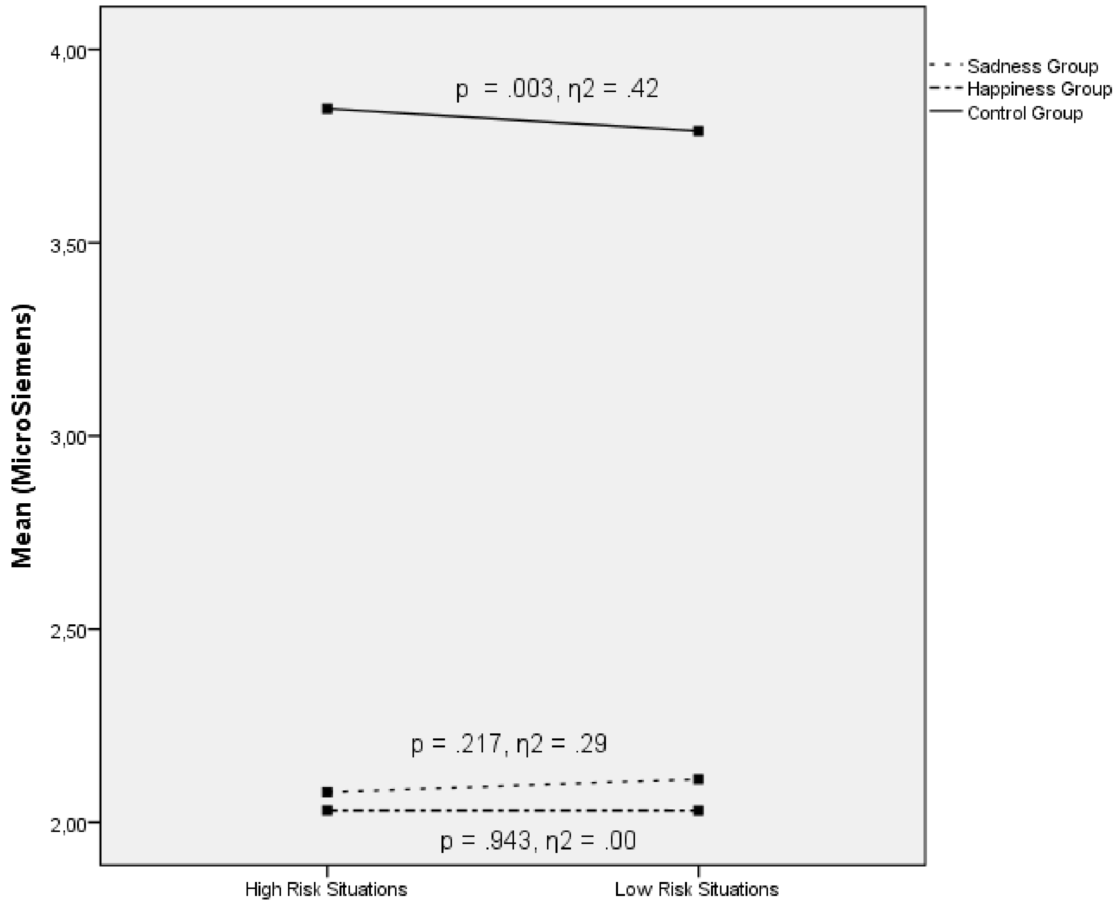

Fig. 2. Interaction effect of group (type of emotion) and level of risk situations on SCL. Significance (p-values) are referred to the intragroup differences in activation in high risk situation and low risk situations.

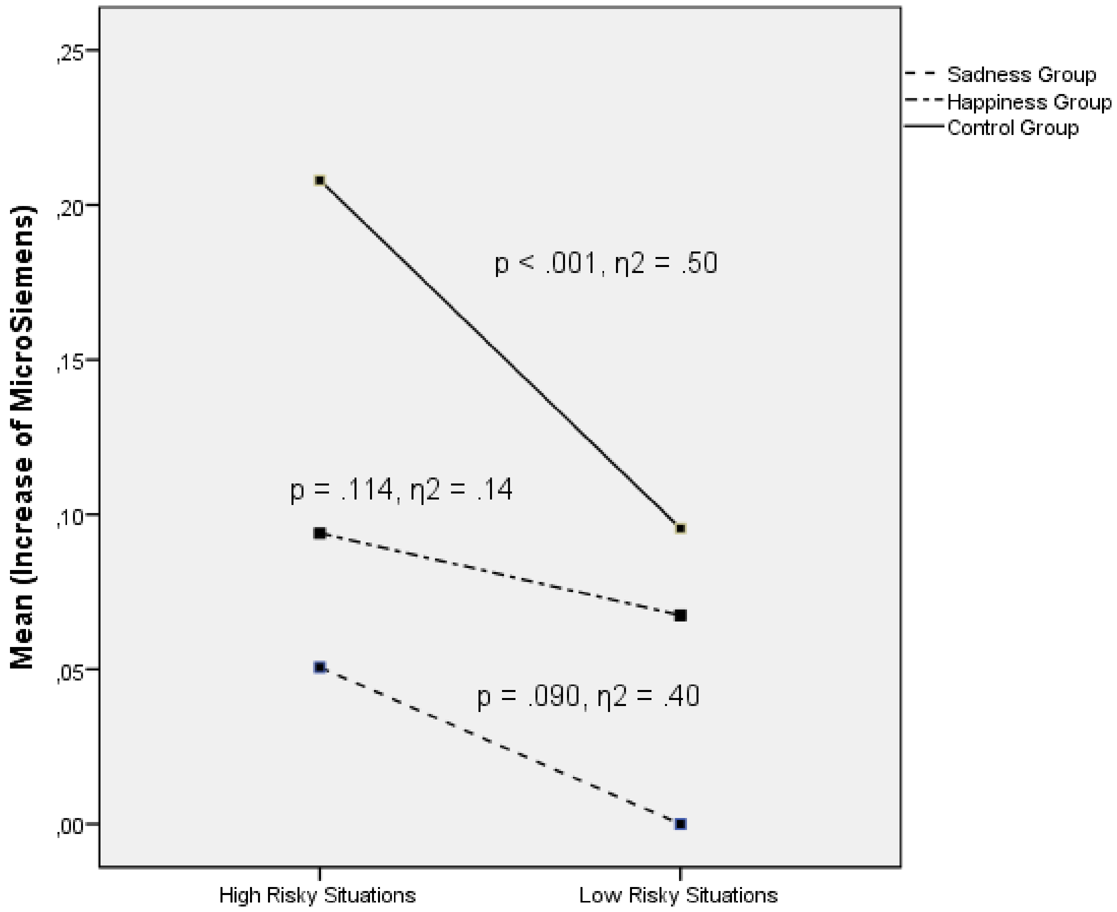

Fig. 3. Interaction effect of group (type of emotion) and level of risk situations on SCR. Significance (p-values) are referred to the intragroup differences in activation in high risk situation and low risk situations.

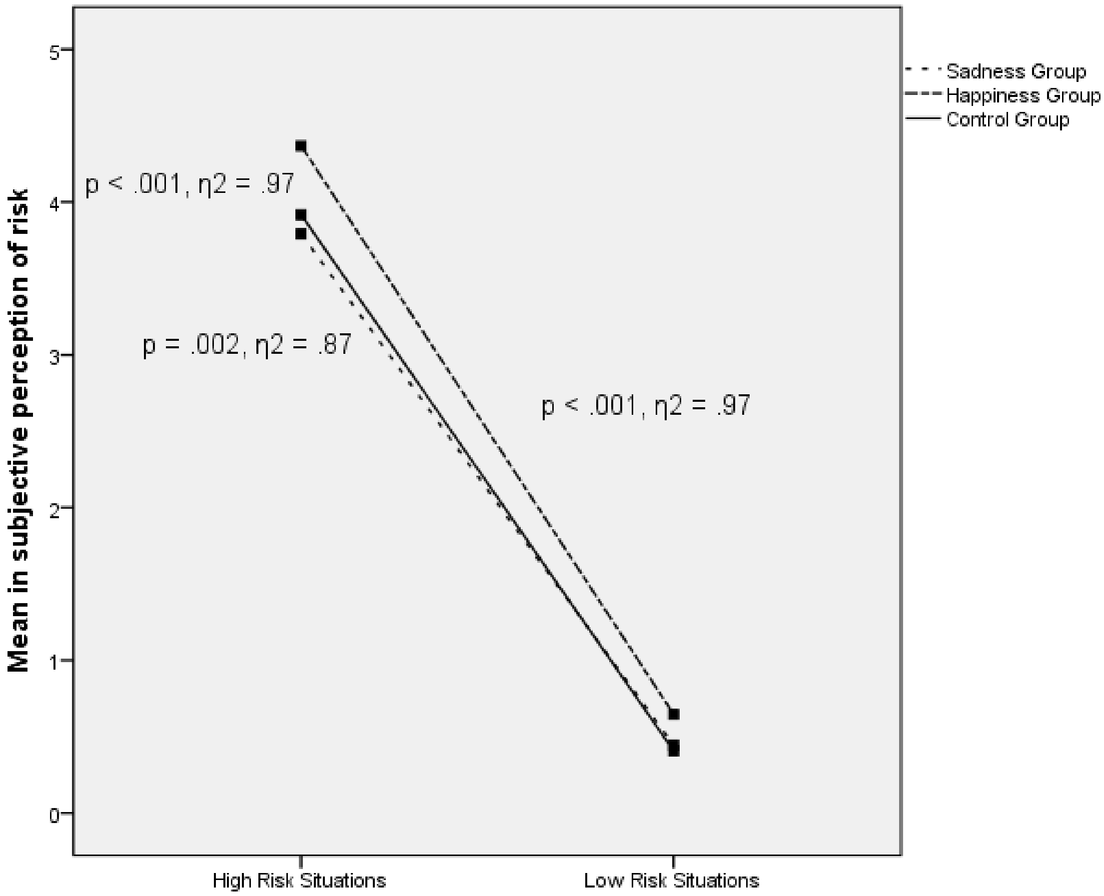

Fig. 4. Interaction effect of group (type of emotion) and level of risk situations on subjectively perceived risk. Significance (p-values) are referred to the intragroup differences in activation in high risk situation and low risk situations.