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Defining risk in the Risk Homeostasis Theory

Does risk perception, risk acceptance and gender influence risk behavior?

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Abstract

In this risk homeostasis study participants (*N*= 168) performed on a videogame in which they had to fly a spaceship through a field of comets, while they could adjust its speed. Subsequently, participants filled in the DOSPERT scale which recorded their levels of risk perception and risk acceptance. This study did not find support for risk homeostasis theory, but results showed significant differences in risk behavior for high and low scores on risk perception and risk acceptance. Participants with a high score on risk perception played the game more risk aversive and participants with a high score on risk acceptance played the game with more risk. Men and women scored significantly different on the DOSPERT scale in which men have a higher risk acceptance and women a higher risk perception. Furthermore, women were significantly more risk-aversive in this study than men.

Keywords: Risk Homeostasis Theory, DOSPERT scale, gender differences, risk perception, risk acceptance

1. Introduction

Every day millions of people take their car to go to work. It is common knowledge that there is a risk in driving a car, but apparently this risk is evaluated as acceptable by the drivers. Even so, there is an ongoing search of decreasing risk in daily activities such as driving, but also in for example railway traffic and safety of workers on a construction site. Because risk-taking is such a common daily activity, and unfortunately leads to accidents on a regular basis, it is important to keep searching for new ways and improving old ways to understand risk behavior. A further understanding of risk behavior will provide the means to improve safety protocols and thereby more successfully decrease risk-taking and improve accident prevention.

In the case of driving a car, risk reduction has been managed by introducing a seat-belt and airbags for instance. Unfortunately these inferences do not seem to be as effective as expected and lethal accidents still occur. The barriers prescribed by government or company protocol, wear a helmet on a construction site for instance, do not result in less serious accidents. Risk Homeostasis Theory, first described by Wilde (1982) offers an explanation for the insufficient proficiency of safety measures.

1.1 Wilde's Risk Homeostasis Theory

Wilde (1982) states that there is a level of risk which people are generally willing to take. This level of risk can be pictured as the thermostat which regulates the temperature of a house.

The level at which the thermostat is set will stimulate the heating to keep the temperature in the house at the target level, the temperature will therefore remain homeostatic. The Risk Homeostasis Theory (RHT) transfers the homeostatic effect of a thermostat to risk behavior. RHT states that like a thermostat has a target temperature, people have a target level of risk. People will change their behavior in order to maintain their target level of risk.

Driving a car for instance has a certain level of risk. When this particular behavior is made less risky by the introduction of a seatbelt, the behavior of the driver will change as a reaction to the new level of safety. The driver could perhaps drive faster, since he feels that the new level of safety allows this more risky behavior. Therefore, after the introduction of a new safety measure, the behavior of in this case drivers will change so that the level of risk is the same as before the safety measure was introduced; the risk remains in homeostasis. According to Wilde (1998) the introduction of the seatbelt will only result in less risk until the moment drivers notice the decreased risk and start behaving riskier. From this theory the question derives why people, and in this case drivers, would change their behavior to be more risky to compensate the safety measures.

Wilde (1998) states that the level of risk which people are willing to take depends on four different factors:

1. The expected benefits of risky behavior alternatives
2. The expected costs of risky behavior alternatives
3. The expected benefits of safe behavior alternatives
4. The expected costs of safe behavior alternatives

The first factor can already explain why a driver would be willing to behave more risky. Speeding, which increases risk, also has some expected benefits. The driver would probably be home sooner and has to spend less time in the car. Factor 4 (the expected costs of safe behavior alternatives) is similar to factor 1 (the expected costs of safe behavior) in this case not speeding would mean that the driver has to spend more time in the car. Factors 2 (the expected costs of risky behavior alternatives) and 3 (the expected benefits of safe behavior) are also somewhat similar to each other.

The expected costs of risky behavior could be a speeding ticket, whereas an expected benefit of safe behavior could be not receiving a speeding ticket. The level of risk which people are willing to take will be higher when factors 1 and 4 are higher and when factors 2 and 3 are lower (Wilde, 1988).

Throughout literature RHT proves to be a highly controversial topic with several proponents and opponents, which will both be discussed in this thesis. Consequently, the possibilities of RHT as well as other risk-related theories will be discussed.

1.2 Support for Risk Homeostasis Theory

Jackson and Blackman (1994) found support for RHT in a driving simulation test. In their experiment they introduced varying levels of monetary accident costs as a motivational factor for safe behavior and a speed limit and speeding fines as non-motivational factors. Jackson and Blackman (1994) predicted that an increase in the costs of an accident should result in less accidents in total. Also, since speed limit and increased speeding fines do not influence the target level of risk, they should not influence the total accident loss. The results of the study provided support for the two predictions. The increase of the accident cost influenced the accident rate by reducing it significantly and the accident rate was not influenced by varying in the speed limit and speeding fine (Jackson & Blackman, 1994). In another driving simulation study by Hoyes, Stanton and Taylor (1996) participants had to drive in simulated high risk and low risk environments. Hoyes, Stanton and Taylor (1996) found that there were less collisions in the high environmental risk condition. Furthermore their participants responded within ten minutes to a change of environmental risk, thereby opposing RHT which originally argues that a change of risk causes behavior to change within months. Hoyes, Stanton and Taylor (1996) argue that the difference in time span in RHT is due to delayed feedback and that the feedback in a simulated environment gives an immediate feedback of errors.

A more recent study by Baniela and Rios (2010) found support for RHT in a more practical field. In their study Baniela and Rios (2010) analyzed ship accidents while trying to explain their occurrence by RHT. The researchers came to their study subject when they noticed that the number of serious maritime accidents had increased since the 1990s. To their surprise this increase happened during the same time when new technical safety standards were introduced. In their analysis Baniela and Rios (2010) found that safer ships suffer overall the same amount of accidents as ships that are by definition less safe. RHT could explain this finding; the target level of risk on both the safe and unsafe ships remains the same. Therefore the crew on the safe ship will behave less safe and the crew on the unsafe ship will behave safer. Baniela and Rios (2010) consider their analysis of maritime accidents not to be proof that the safety measures taken on ships are failing, but that the industry should also look to other ways and measures to increase safety such as RHT.

Trimpop (1998) describes RHT when it was not yet described by Wilde, but studied by Taylor as early as 1964. Taylor found in his study that drivers adjust their behavior while driving at a location where accidents have happened prior to the driving. He argued that the participants sensed danger at the location of the prior accident and adjusted their behavior as a response (Trimpop, 1998). The galvanic skin response, which was also measured in Taylors study, stayed the same during the tour. This suggests that it is possible to adjust behavior on basis of perception of danger, a risky situation without conscious knowledge. Also, it suggests that behavior is adjusted when there is an undesired level of perceived risk.

The article is concluded by Trimpop (1998) stating that there is strong empirical support that behavior is adjusted through perception of risk, but that there is less support for the idea of a full homeostatic process. RHT should therefore be investigated with new ideas, for instance with multiple levels of target risk.

1.3 Opponents to RHT

The fact that RHT implies that safety measures are not effective in reducing risk (and as a consequence in reducing accidents), already makes it controversial on itself. But not only the impact of RHT, were it to be accepted, makes it controversial. The theory has many opponents which will be discussed in this section.

Hoyes and Glendon (1993) discuss in their article whether RHT can be falsified. They argue that it is not possible to measure accident loss as it is defined in RHT. When accident loss stays equal to a previous level or changes in the predicted direction RHT cannot be falsified. Furthermore, the introduction of safety measures is usually accompanied by advertising which encourages motivational changes. Therefore it is not clear whether accident loss is due to the safety measure or the accompanied motivational change (Hoyes & Glendon, 1993). To falsify RHT motivational changes and accident loss should me more objectively defined (Hoyes & Glendon, 1993).

Janssen and Tenkink (1988) criticize RHT from a utility perspective. They argue that a decision-maker (a driver) might behave in a way which follows RHT, but that his motive is not to control or manage risk. It would not be rational for the driver to maintain a constant level of risk, but to maximize the utility of driving. Therefore RHT is a by-product of maximizing utility, which is according to Janssen and Tenkink (1988) a more reasonable purpose for a driver to be motivated by.

Hoyes (1994) concludes that RHT has a self-evident and base construct in a transportational field, but that RHT does not always have a base in the non-transportational field. In his article Hoyes (1994) uses employees in a nuclear plant as an example for a field where RHT cannot be applied.

He argues that in a nuclear plant only employees with a target level of risk which fits with the danger of a nuclear plant will seek employment there. Workers who do not find the risk acceptable will simply seek employment elsewhere. Therefore, Hoyes (1994) states that there is in this case only a change in target risk and no change in intrinsic risk.

Hoyes, Dorn, Desmond and Taylor (1996) refute RHT in a simulation study. They state that in RHT a utility is needed for compensation to take place after a change in safety. Therefore utility and intrinsic risk should show a statistical connection. However, this was not what the data of Hoyes et al. (1996) showed. The participants in the simulation study took more risk when there was more to be gained, which Hoyes et al. (1996) offer as a proof for utility factors to play a role.

There was also proof of behavioral compensation where the different intrinsic safety conditions were concerned. But, the factors of intrinsic safety and utility behaved independently. This, according to Hoyes et al. (1996) is refuting evidence to RHT, because RHT states that there can be no behavioral change when there is no utility to be gained.

1.4 Risk perception and risk acceptance

One of the important features of RHT is the perception of risk. For homeostasis to occur, the driver or decision-maker should perceive a level of risk belonging to a situation or a change of situation. When a situation is perceived as being risky to some extent, the driver or decision-maker can decide whether the risk is acceptable or not and from that decision alter his behavior. Science has not only covered the topic of risk perception and risk acceptance on the field of RHT, but also on basis of other theories and practical analyses. This section will cover some of the literature on risk perception and risk acceptance outside the field of RHT.

Rundmo (1996) discusses the risk perception and risk behavior of employees in offshore oil industries. In his article Rundmo (1996) links risk perception and risk behavior. He states that accidents can cause risk perception; an employee who was involved in or witnessed an accident might be more perceptive of the risk in the future.

Furthermore, risk perception may cause accidents; feeling unsafe may cause the employee extra workload and strain, causing an increase in the probability of accidents (Rundmo, 1996). Risk perception and risk behavior were significantly correlated in the study, but both variables were found to be independent from each other; risk perception did not predict risk behavior. Rundmo (1996) therefore argues that changing individual risk perception will not improve safety. A study by Rundmo and Iversen (2004) showed, though in another field, more promising results for reducing risk behavior.

In this research Rundmo and Iversen (2004) compared two groups of Norwegian adolescents of which the experimental group took part in a traffic safety campaign. The traffic safety campaign changed the risk perception of the adolescents in relation to speeding and recognition of traffic hazards. The participants reported less speeding accidents and less risk behavior in traffic after the traffic safety campaign (Rundmo & Iversen, 2004). The fact that other traffic safety campaigns were found to be less successful is explained by the researchers that this specific campaign focused on risk perception, whereas other campaigns mainly focused on attitudes towards traffic safety (Rundmo & Iversen, 2004).

Arezes and Miguel (2006) also studied risk perception in the working field conducting research in the field of hearing protection devices. They found that the perception of risk (hearing damage) resulted into different attitudes and behaviors of workers in relation to hearing protection.

The analysis of Arezes and Miguel (2006) shows that workers use their hearing protection based on the level of risk they perceived, which was not necessarily and most often not corresponding to the objective level of risk. This shows that, albeit in a specific field, while there can be an objective level of risk, risk perception can influence behavior. This is supported by Perlman, Sacks and Barak (2014) who did research into the ability of construction superintendents to perceive risk situations. The experienced construction superintendents did not perform significantly better at recognizing risk situations in a simulated environment than students. Also, the superintendents were more prone to recognize accidents which would have more severe effects than accidents with higher probabilities of occurring. Perlman, Sacks and Barak (2014) state in their conclusion that the hours of risk training do not result in better risk perception.

Morrongielo and Major (2002) conducted a research into risk compensation in relation to safety gear for children. They examined the judgments of parents about their children's safety in different play situations, for instance biking. In this research, parents allowed their children more dangerous play situations when the children wore safety gear, or when the children had experience with the activity (Morrongielo & Major, 2002). They conclude with the assumption that safety gear is thought to be an absolute protection while it is in fact a relative protection.

Although the research of Morrongielo and Major (2002) has some limitations, for instance that the interviews are conducted by telephone and therefore do not assess real behavior but only said behavior, it does show that behavior (allowing children to play with different level of risks) can be altered by the introduction of a safety measure.

1.5 Risk behavior and gender

In the domain of RHT the field of gender differences is as good as untouched, but the domain of risk behavior certainly does not lack of gender research. Because gender differences are such a prominent feature of research into risk perception and risk acceptance this section will cover some literature about gender differences as to investigate whether RHT can be affected by gender.

Oltedal and Rundmo (2006) investigated gender differences through a questionnaire about personality traits and accident involvement among young Norwegian adults. Gender was found as a predictor for risky behavior, where men behaved more risky than women (Oltedal & Rundmo, 2006). Also, men scored higher on all personality traits which were associated with risky driving behavior. Male drivers who scored high on normlessness accounted for most risk behavior, where normlessness is described as having low respect for traffic rules and regulations.

These findings are supported by Rhodes and Pivik (2011) who also conducted research into risk perception and driving behavior. They found that male drivers report more frequent risky driving behavior than female drivers.

Furthermore, Rhodes and Pivik (2011) found that affect, meaning how much the driver likes to engage in risky driving behavior, predicts the actual risk behavior. Risk perception was also found to be a predictor of risk behavior. It should be noted that the positive affect was most influential for male drivers to engage in risky behavior in comparison to female drivers (Rhodes & Pivik, 2011). Risk perception diminished risky behavior both for female and male drivers, but was more decisive for the risk behavior of female drivers (Rhodes & Pivik, 2011).

In a study by Wickens et al. (2012), who researched aggressive driving behavior among male and female drivers, no significant effect was found on gender. While male drivers were generally slightly more aggressive, the differences between male and female drivers were not significant.

Harris and Jenkins (2006) researched gender differences in risk behavior in several domains, including health, recreation and gambling. In these domains, women reported it to be less likely to engage in risk behavior. Also, the women rated the probability of negative consequences for the risk behavior as higher than men (Harris & Jenkins, 2006). Furthermore, when disregarding the possibility of negative consequences, women expected less enjoyment of engaging in risky behavior than men.

Harris and Jenkins (2006) therefore found that man are more likely to engage in risky behavior because they expect more enjoyment of the risky behavior and a lower probability of negative consequences. These findings are supported by Ronay and Kim (2006) who researched attitudes towards hypothetical risk decisions. In their study men and women individually did not differ in their attitude towards hypothetical risk deceptions but as a group men where more tolerant than women. Ronay and Kim (2006) interpreted this finding as a notion that risk has a stronger social value for men. In addition, Ronay and Kim (2006) found that men where more positive about the concept of risk on itself and also about risk activities.

2. Methods

2.1 Participants

For the experiment the participants were obtained through the networks of the researchers, for example their friends and family. In total 181 participants took part in the experiment, of which 13 participants were excluded from the analysis due to technical issues.

2.2 Equipment and measurements

In this study, risk behavior is measured with a video game. In the video game the participants drive a space-ship through a field of comets to a destination.

It is possible to vary in speed, which will increase points, but also increase the risk of losing a shield while bumping in to a comet. The extent to which participants increase their speed and their proximity to the comets (time to collision) is seen as risk taking.

Also, the availability of more shields is seen as a low-risk situation and the availability of lesser shields as a high risk situation. Before starting the actual video game participants run a trial. Thereafter all participants play the game in a 1, 3, 5 and unknown shield condition.

2.3 DOSPERT scale

The association between Risk Homeostasis and Risk Perception will be tested by the DOSPERT scale by Blais and Weber (2006). This questionnaire assesses the likelihood and the intentions of the participants in which they might engage in risky behaviors. The 30 items are originated from five domains: ethical, financial, health/safety, social and recreational risk. The DOSPERT uses a 7-point rating scale ranging from 1 (extremely unlikely) to 7 (extremely likely) to assess whether participants would engage in the behavior and to assess whether the participants rate the 30 items as risky behavior ranging from 1 (Not at all) to 7 (Extremely risky). In addition to the DOSPERT the respondents will receive some questions about how likely they think it is that their spaceship would hit a comet.

The results in this study missed one item of the DOSPERT scale, namely "passing off somebody else's work as your own", leaving the DOSPERT scale with 29 items in this study.

2.4 Hypothesis

In this thesis three prior predictions are made about the behavior of the participants in relation to their performance in the game and their attitude towards risk perception and risk acceptance.

I. Participants who score high on risk acceptance and participants who score low on risk perception on the DOSPERT scale will play the game with more risk; participants who score high on risk perception and low on risk acceptance will play the game more carefully.
II. Participants who score high on risk perception will alter their behavior more radical (slow down) than participants who score low on risk perception when bumping into a comet.
III. The results will significantly differ for men and women, in which women are more risk-aversive and will therefore score higher on risk perception and lower on risk acceptance on the DOSPERT scale and show more risk-aversive behavior in the videogame.

Besides these hypotheses the data will be analyzed to make a global overview of the behavior of participants during the videogame, for instance the moment after they hit a comet, their behavior during their last shield and their behavior in the unknown shields condition. Also, the answers about the number of shields the participants thought they had will be compared to their scores on the DOSPERT scale.

3. Results

In total, the data of 168 participants was used for the analysis, of which 42 participants are men and 126 participants are women. The minimum age was 18 years and the maximum age 57 years. Before analyzing the data, the assumptions of parametric data were checked. The sample is large enough to assume a normal distribution and to assume homogeneity of variance (N = 168). Also, the data are measured at least at interval level. The assumption of independence cannot be tested, but will be assumed for the sample. The measures were not repeated, nor is there reason to belief that the participants were influenced by each other.

3.1 Risk Homeostasis

To find out whether a risk homeostasis effect occurred during the experiment a paired samples t-test was executed for the mean time to collision and the mean speed of all shields per condition. Risk homeostasis occurs when participants would either slow down after they hit a comet (compensating for the lost shield by slowing down to avoid risk) or when their time to collision gets larger (compensating for the lost shield by more carefully avoiding comets in front of the spaceship).

3.1.1 One shield condition

In the one shield condition the mean speed was lower with one shield (M= 430.55, SE= 8.30) than with zero shields left (M= 519.69, SE = 13.29). This difference was significant $t(163) = -10.23$, $p < .001$. This represents a large effect size (r = .63). The time to collision (TTC) in the one shield condition was higher with one shield (M= 1.26, SE=.02) than with zero shields left (M= .98, SE= .03). This difference was significant $t(163) = 12.66$, $p < .001$. This represents a large effect size (r= .70). A visual display of these means can be found in Figure 1 and Figure 2.

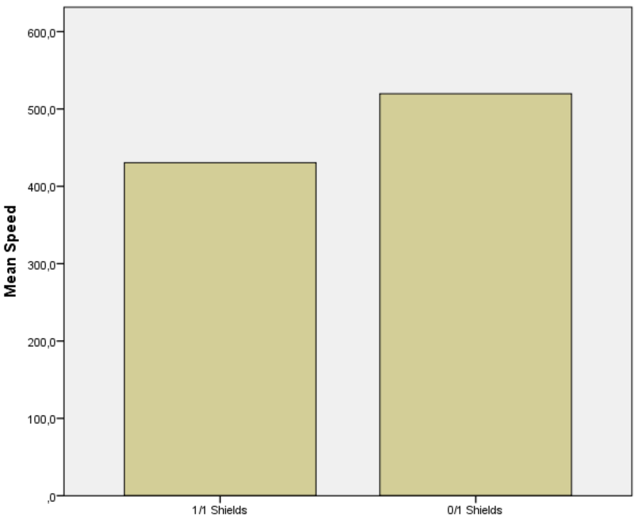


Figure 1: Bar chart of mean speed in one shield condition

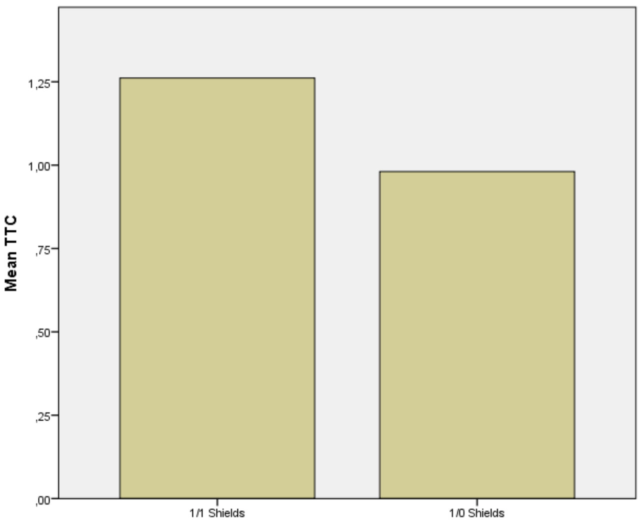


Figure 2: Bar chart of TTC in one shield condition

3.1.2 Three shield condition

The mean speed in the three shield condition was lower with three shields left (*M*= 433.78, *SE*= 8.01) than with two shields left (*M*= 527.09, *SE*= 13.30). This difference was significant $t(164) = -11.72$, $p <.001$. This represents a large effect size ($r= .68$). The TTC in the three shield condition was higher with three shields left (*M*= 1.25, *SE*= .02) than with two shields left (*M*= .96, *SE*= .03). This difference was significant $t(164) = 13.72$, $p <.001$. This represents a large effect size ($r= .73$).

The mean speed in the three shield condition was lower with two shields left (*M*= 534.38, *SE*= 13.66) than with one shield left (*M*= 540.87, *SE*= 13.72). This difference was not significant $t(156) = -1.15$, $p> .05$. This represents a very small effect size ($r= .09$). The TTC in the three shield condition with two shields left was slightly lower (*M*= .94, *SE*= .03) than with one shield left (*M*= .91, *SE*= .03). This difference was not significant $t(156) = 1.16$, $p >.05$. This represents a very small effect size ($r= .09$).

The mean speed in the three shield condition was lower with one shield left (*M*= 550.28, *SE*= 14.24) than with zero shields left (*M*= 553.77, *SE*= 13.95). This difference was not significant $t(146) = -.63$, $p > .05$. This represents a very small effect size ($r= .05$). The TTC in the three shield condition with one shield left was slightly lower (*M*= .885, *SE*= .03) than with zero shields left (*M*= .893, *SE*=.03). This difference was not significant $t(146) = -.388$, $p < .05$. This represents a very small effect size (r=.03).

A visual display of these means can be found in Figure 3 and Figure 4.

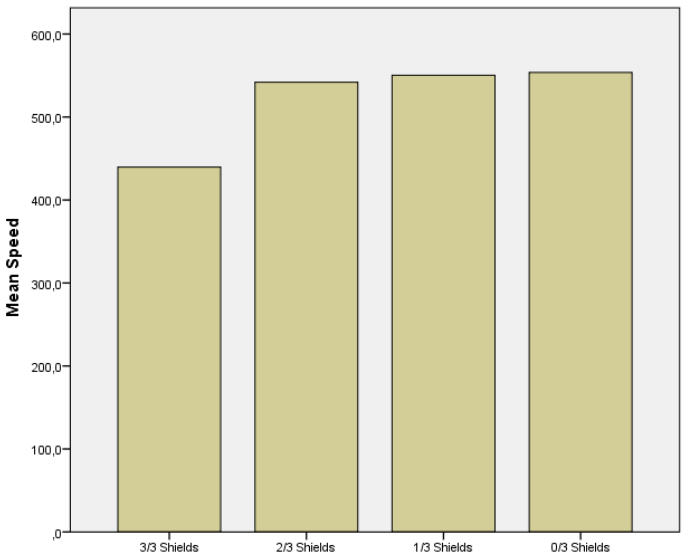


Figure 3: Bar chart of mean speed in three shield condition

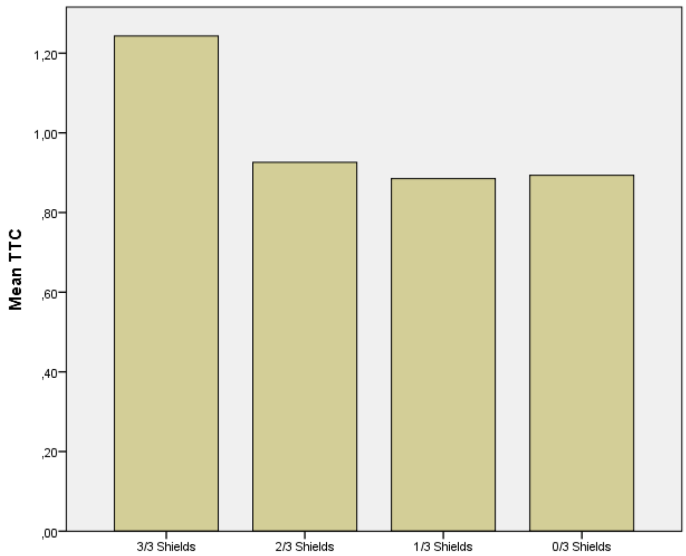


Figure 4: Bar chart of TTC in three shield condition

3.1.3 Five shield condition

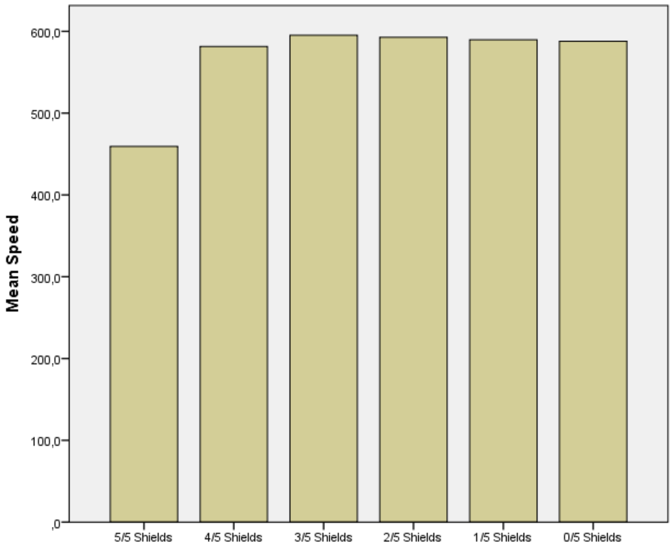
The mean speed in the five-shield condition was lower with five shields left (*M*= 447.76, *SE*= 9.00) than with four shields left (*M*= 551.87, *SE*= 13.65). This difference is significant *t*(164) = -12.17, *p*<.001. This represents a large effect size (*r*= .69). The TTC in the five shield condition with five shields left is higher (*M*= 1.22, *SE*= .02) than the TTC with four shields left (*M*= .92, *SE*= .03). This difference is significant *t*(164) = 15.27, *p* <.001. This represents a large effect size (*r*=.77).

The mean speed in the five shield condition was lower with four shields left (*M*= 556.20, *SE*= 13.80) than with three shields left (*M*= 568.28, *SE*= 13.80). This difference is significant *t*(160) = -2.01, *p* <.05. This represent a small effect size (*r*= .16). The TTC in the five shield condition is higher with four shields left (*M*= .91, *SE*= .03) than with three shields left (*M*= .88, *SE*= .03). This difference was not significant *t*(160) = 1.28, *p* > .05. This represents a small effect size (*r*= .10).

The mean speed in the five shield condition was higher with three shields left (*M*= 578.16, *SE* = 14.35) than when two shields with two shields left (*M*=573.50, *SE*= 13.50). This difference was not significant *t*(149) = .82, *p* > .05. This represents a very small effect size (*r* = .07). The TTC in the five shield condition with three shields left was slightly lower (*M*= .86, *SE*=.03) than with two shields left (*M*= .88, *SE*= .03). This difference was not significant *t*(149) = -1.05, *p* > .05. This represents a very small effect size (*r*= .09).

The mean speed in the five shield condition was higher with two shields left (*M*= 582.14, *SE*= 13.99) than with one shield left (*M*= 579.49, *SE*= 14.39). This difference was not significant *t*(140) = .46, *p* > .05. This represents a very small effect size (*r*= .04). The TTC in the five shield condition with two shields left was higher (*M*= .86, *SE*=.03) than with one shield left (*M*= .85, *SE*=.03). This difference was not significant *t*(140) = .384, *p* > .05. This represents a very small effect size (*r*= .03).

The mean speed in the five shield condition was higher with one shield left (*M*= 589.62, *SE*= 14.87) than with zero shields left (*M*= 587.79, *SE*= 15.07). This difference was not significant *t*(130) = .401, *p*> .05. This represents a very small effect size (*r*= .04). The TTC in the five shield condition with one shield left was higher (*M*= .83, *SE*= .03) than with zero shields left (*M*= .80, *SE*= .03). This difference was not significant *t*(130) = 1.11, *p* > .05. This represents a small effect size (*r*= .10).
A visual display of these means can be found in Figure 5 and Figure 6.



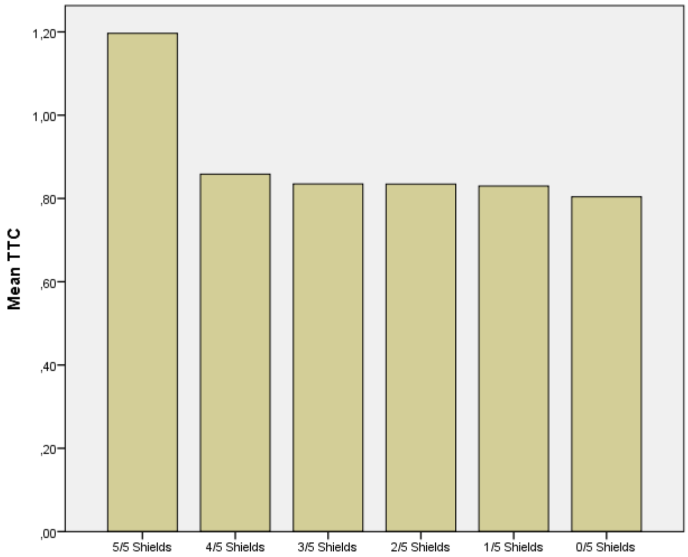


Figure 5: Bar chart of mean speed in five shield condition

Figure 6: Bar chart of TTC in five shield condition

3.1.4 Unknown shield condition

The mean speed in the unknown shields condition, which had three shields, was lower with three shields left (*M*= 423.41, *SE*= 7.58) than with two shields left (*M*= 514.62, *SE*= 12.26). This difference was significant *t*(163) = -11.57, *p* <.001. This represents a large effect size (*r*= .67). The TTC in the unknown shield condition with three shields left was higher (*M*= 1.28, *SE*= .02) than with two shields left (*M*= .99, *SE*= .03). This difference was significant *t*(163) = 13.20, *p* <.01. This represents a large effect size (*r*= .72).

The mean speed in the unknown shields condition with two shields left was lower (*M*= 524.24, *SE*=13.04) than with one shield left (*M*= 551.72, *SE*= 13.53). This difference was significant *t*(147) = -4.09, *p* <.001. This represents a medium effect size (*r*= .32). The TTC in the unknown shield condition was higher with two shields left (*M*= .96, *SE*= .03) than with one shield left (*M*= .90, *SE* =.03). This difference was significant *t*(147) = 2.63, *p* < .01. This represents a small effect size (*r*= .21).

The mean speed in the unknown shields condition when one shield is left was lower (*M*=460.43, *SE*= 13.84) than with zero shields left (*M*= 571.62, *SE*= 14.71). This difference was significant *t*(139) = -2.11, *p* < .05. This represents a small effect size (*r*= .18).The TTC in the unknown shield condition was slightly higher with one shield left (*M*= .871, *SE*= .03) than with zero shields left (*M*= .868, *SE*=.03). This difference was not significant *t*(139) = .16, *p* > .05. This represents a very small effect size (*r*= .01).

A visual display of these means can be found in Figure 7 and Figure 8.

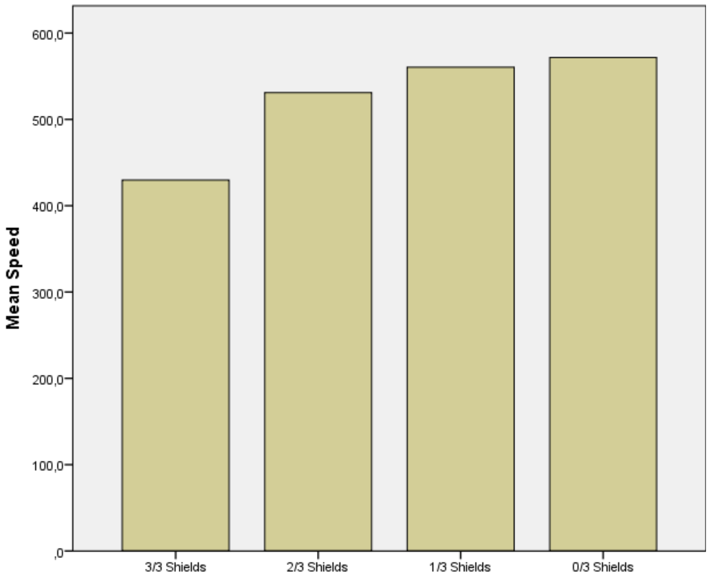


Figure 7: Bar chart of mean speed unknown shield condition

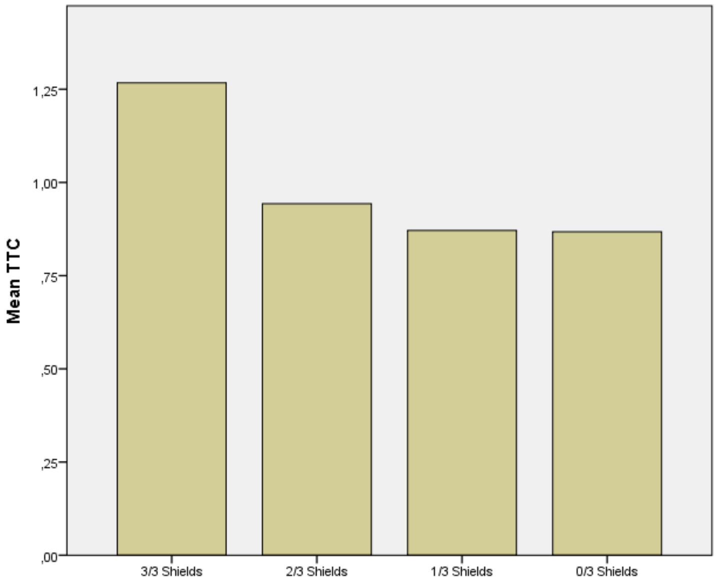


Figure 8: Bar chart of TTC unknown shield condition

3.1.5 Maximum speed and TTC

To find out whether participants might compensate the loss of shields with a lower maximum speed instead of a lower mean speed, a paired samples t-test was executed for the mean speed for all conditions which paired the maximum number of shields and the zero shield.

In the one shield condition the maximum speed was lower with one shield left (*M*= 529.52, *SE*= 13.83) than with zero shields left (*M*= 549.88, *SE*= 15.62). This difference was significant *t*(167) = -2.03, *p* < .05. This represents a small effect size (*r*= .16).

In the three shield condition the maximum speed was higher with three shields left (*M*= 539.64, *SE*= 13.96) than with zero shields left (*M*= 510.06, *SE*= 19.62). This difference was not significant *t*(167) = 1.94, *p* > .05. This represents a small effect size (*r*= .15).

In the five shield condition the maximum speed was higher with five shields left (*M*= 556.61, *SE*= 14.52) than with zero shields left (*M*= 481.07, *SE*= 22.91). This difference was significant *t*(167) = 3.68, *p* < .001. This represents a small effect size (*r*= .27).

In the unknown shield condition the maximum speed was higher with three shields left (*M*= 517.62, *SE*= 12.66) than with zero shields left (*M*= 507.44, *SE*= 21.70). This difference was not significant *t*(167) = .58, *p* > .05. This represents a very small effect size (*r*= .04).

3.1.6 Expected shield loss

Prior to the game

Participants were asked some questions before the game started about how many shields they expected to lose and how likely they think it is to lose a shield during the game on a seven point scale from ‘extremely unlikely’ to ‘extremely likely’.

The most given answer to the statement ‘My spaceship will hit a comet’ was somewhat likely. The average (*M*= 5.34) lays between somewhat likely and moderately likely.

The answers ranged from moderately unlikely to extremely likely. None of the participants thought it was extremely unlikely that their spaceship would hit a comet prior to the game.

The statement ‘My spaceship will not lose shields during the game’ was most often answered with moderately unlikely. The average (*M*= 2.71) lays between moderately unlikely and somewhat unlikely. Answers ranged from extremely unlikely to extremely likely.

The statement ‘The spaceship will lose all shields before reaching the final destination’ was most often answered with moderately likely. The average (*M*= 4.23) lays between the answers undecided and moderately likely. The answer ranged from extremely unlikely to extremely likely.

To investigate if the answers to these questions have a connection to the participants score on risk perception , a histogram was drawn for all three questions which can be seen in Figure 9, Figure 10 and Figure 11.

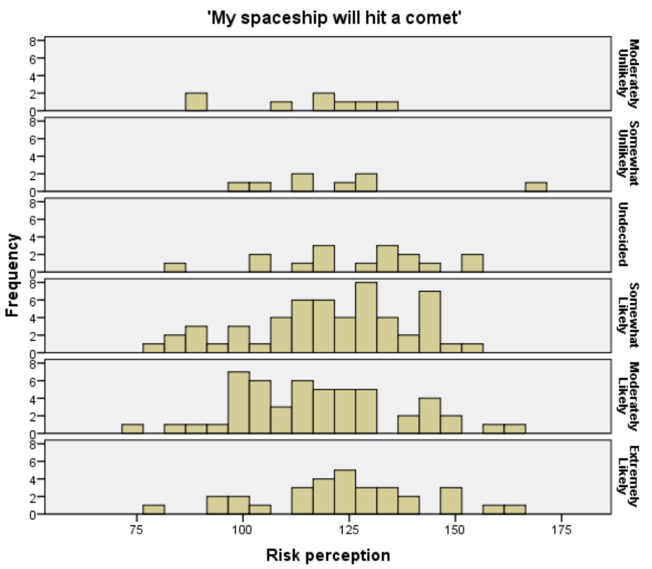


Figure 9: Histogram of risk perception with ‘hit a comet’

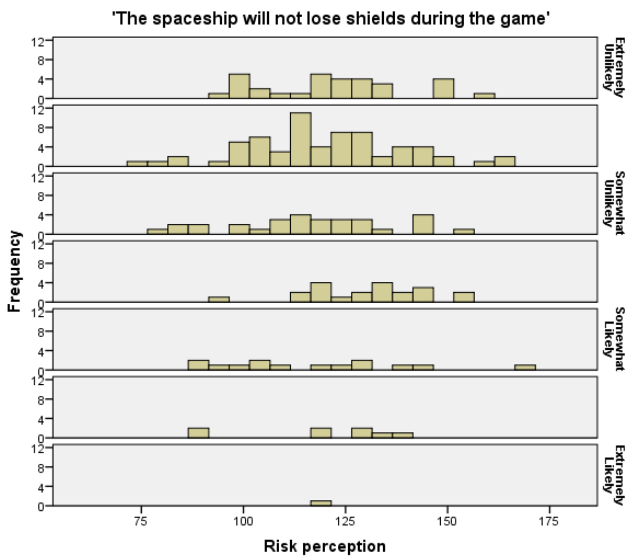


Figure 10: Histogram of risk perception with ‘not lose shields’

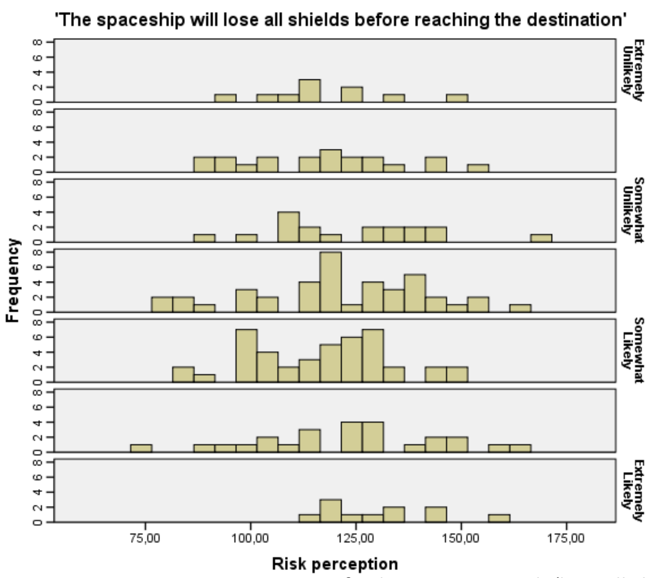


Figure 11: Histogram of risk perception with ‘lose all shields’

3.1.7 After the game

After they finished the game, participants were asked how many shields they had lost in total (excluding the trial) and how many shields they had in the unknown shields condition.

The total shields which participants could possibly lose during all conditions was twelve shields. The most given answer to ‘How many shields do you think you lost in total’ was ten shields. The average (*M*= 12.23) was also around twelve shields. The lowest given answer was zero and the highest answer forty shields lost.

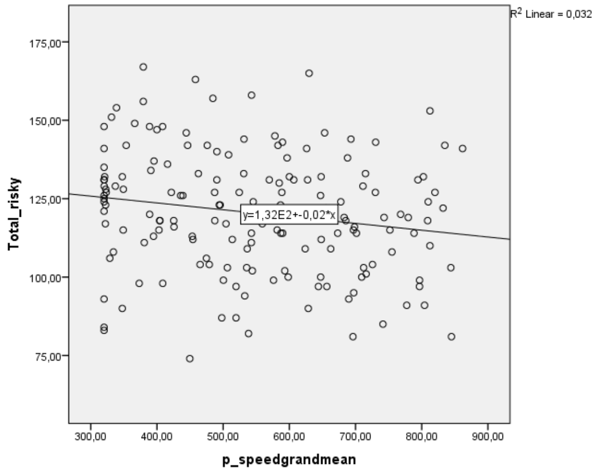
The most given answer about the shields in the unknown condition (with in fact three shields) is three shields. The average answer (*M*= 8.21) is between eight and nine shields in the unknown condition. The lowest answer was zero shields and the highest answer was 250 shields.

3.2 Hypothesis I: Participants who score high on risk acceptance and participants who score low on risk perception on the DOSPERT scale will play the game with more risk; participants who score high on risk perception and low on risk acceptance will play the game more carefully.

The DOSPERT scale measures risk perception and risk acceptance by means of 30 items, of which 29 were used in this study, on a 7-point rating scale. Therefore, the highest possible score on both risk perception and risk acceptance is 203 (if all items are rated as extremely likely) and the lowest possible score 29 (if all items are rated as extremely unlikely). In this study the maximum score on risk perception was measured at 167 points on the DOSPERT scale, and the minimum at 74 points on the DOSPERT scale. For risk acceptance the maximum score is measured at 151 points on the DOSPERT scale in this study and the minimum score at 43 points on the DOSPERT scale.

To investigate the first hypothesis the total score on risk perception and risk acceptance was calculated for all participants. The median and mean of the total scores is used as a cut-off point to divert the sample into low and high scores on the DOSPERT scale. For risk perception the cut-off point is established at a score of 120 (*M =* 120.44, *Me*= 120.50). For risk acceptance the cut-off point is established at a score of 99 (*M*= 98.64, *Me* = 99.00). With these two cut-off points a new variable were computed dividing the participants in high and low risk perception groups and high and low risk acceptance groups.

To get a broad look on the sample a scatterplot was drawn for both risk acceptance and risk perception with mean speed, which can be found in Figure 12 and Figure 13. These scatterplots show that participants with a higher score on risk perception had a lower mean speed than participants with a lower score on risk perception. Participants with a higher score on risk acceptance had a higher mean speed than participants who scored lower on risk acceptance.



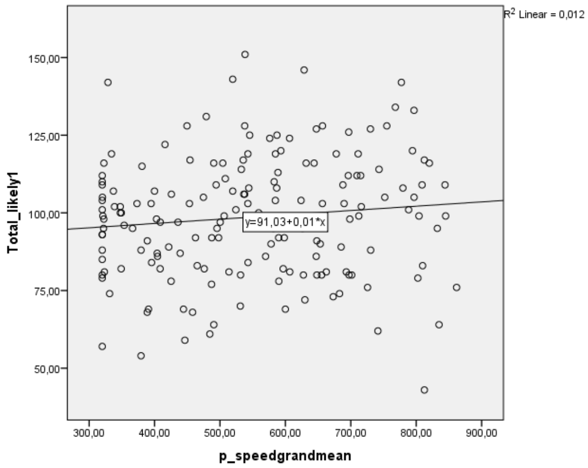


Figure 12: Scatterplot of mean speed with risk perception

Figure 13: Scatterplot of mean speed with risk acceptance

To investigate the effect of risk perception and acceptance on speed and TTC a paired samples t-test was executed. For the high risk acceptance group (*N*= 83) the mean speed (*M*= 529.22, *SE*= 13.68) was higher than the mean speed (*M*=486.05., *SE*= 12.68) of the low risk acceptance group (N= 85). This difference is significant *t* (166) = -2.34, *p* <.05. This represents a small effect size (*r*= .18).The mean TTC of the high risk acceptance group (*M*= .99, *SE*= .02) was lower than the mean TTC (*M*=1.07, *SE*= .03) of the low risk acceptance group. This difference was significant *t*(166)= 2.46, *p*< .05. This difference represents a small effect size (*r*= .19).

The high risk perception group (*N*= 87) had a lower mean speed (*M*= 488.71, *SE*= 13.65) than the mean speed (*M*= 527.88, *SE*= 12.69) of the low risk perception group (*N*= 81). This difference is significant *t* (166)= -2.09, *p*< .05. This represents a small effect size (*r*= .16).

The TTC of the high risk perception group (*M*= 1.07, *SE*= .03) was higher than the TTC of the low risk perception group (*M*= .99, *SE*= .02). This difference is significant *t*(166)= 2.17, *p*< .05. This represents a small effect size (*r*= .17).

Risk perception (for the whole sample) had a significant negative correlation with mean speed (*r*= -.245, *p*< .01). Risk perception had a significant positive correlation with TTC (*r*= .239, *p*< .01). This means that when risk perception is higher the mean speed tends to be lower and the TTC tends to be higher with increasing risk perception.

The variable total risk acceptance (for the whole sample) had a significant positive correlation with mean speed (*r*= .184, *p*< .05). Risk acceptance had a significant negative correlation with mean TTC (*r*= -.168, *p*< .05). This means that when risk acceptance is higher the mean speed also increases and that the TTC tends to decrease with higher risk acceptance.

3.3 HII: Participants who score high on risk perception will alter their behavior more radical (slow down) than participants who score low on risk perception when bumping into a comet.

To investigate the second hypothesis the sample is again split at the cut-off point for risk perception 120 (*M* = 120.44, *ME*= 120.50). In Table 1 the mean speed and TTC for each shield in the different conditions is compared for the high risk perception and the low risk perception group. The mean speed and TTC for the three shield condition can be found in Table 2, for the five shield condition in Table 3 and for the unknown shield condition in Table 4.

Table 1: Mean speed and mean TTC for high and low risk perception in the one shield condition.

	Mean speed high risk perception	Mean TTC high risk perception	Mean speed low risk perception	Mean TTC low risk perception
1/1 shields	*M*= 419.73	*M*= 1.29	*M*= 439.03	*M*= 1.24
	Sd= 109.68	*Sd*= .25	*Sd*= 102.99	*Sd*= .25
0/1 shields	*M*= 505.97	*M*= 1.00	*M*= 531.45	*M*= .96
	Sd= 185.39	*Sd*= .38	*Sd*= 151.08	*Sd*= .35

Table 2: Mean speed and mean TTC for high and low risk perception in the three shield condition.

	Mean speed high risk perception	Mean TTC high risk perception	Mean speed low risk perception	Mean TTC low risk perception
3/3 shields	*M*= 424.98	*M*= 1.28	*M*= 439.17	*M*= 1.24
	Sd= 104.49	*Sd*= .25	*Sd*= 101.43	*Sd*= .24
2/3 shields	*M*= 496.59	*M*= 1.00	*M*= 556.07	*M*= .92
	Sd= 165.29	*Sd*= .37	*Sd*= 172.58	*Sd*= .33
1/3 shields	*M*= 500.25	*M*= .97	*M*= 584.05	*M*= .85
	Sd= 163.79	*Sd*= .35	*Sd*= 173.77	*Sd*= .33
0/3 shields	*M*= 520.25	*M*= .94	*M*= 582.52	*M*= .85
	Sd= 172.45	*Sd*= .38	*Sd*= 160.44	*Sd*= .33

Table 3: Mean speed and mean TTC for high and low risk perception in the five shield condition.

	Mean speed high risk perception	Mean TTC high risk perception	Mean speed low risk perception	Mean TTC low risk perception
5/5 shields	*M*= 423.16	*M*=1.27	*M*= 471.38	*M*= 1.17
	Sd= 108.34	*Sd*= .24	*Sd*= 118.87	*Sd*= .24
4/5 shields	*M*= 521.05	*M*= 1.00	*M*= 581.46	*M*= .84
	Sd= 183.45	*Sd*= .36	*Sd*= 160.11	*Sd*= .31
3/5 shields	*M*= 542.68	*M*= .95	*M*= 590.89	*M*= .82
	Sd= 185.60	*Sd*= .38	*Sd*= 161.55	*Sd*= .29
2/5 shields	*M*= 547.89	*M*= .94	*M*= 599.13	*M*= .82
	Sd= 172.58	*Sd*= .37	*Sd*= 154.64	*Sd*= .27
1/5 shields	*M*= 553.70	*M*= .90	*M*= 602.80	*M*= .82
	Sd= 177.88	*Sd*=.36	*Sd*= 160.97	*Sd=.28*
0/5 shields	*M*= 570.75	*M*= .82	*M*= 598.30	*M*= .80
	Sd= 189.58	*Sd*= .39	*Sd*= 155.59	*Sd*= .27

Table 4: Mean speed and mean TTC for high and low risk perception in the unknown shield condition.

	Mean speed high risk perception	Mean TTC high risk perception	Mean speed low risk perception	Mean TTC low risk perception
3/3 shields	*M*= 409.72	*M*= 1.31	*M*= 432.40	*M*= 1.26
	Sd= 96.59	*Sd*= .22	*Sd*= 97.38	*Sd*= .23
2/3 shields	*M*= 508.17	*M*= 1.01	*M*= 520.73	*M*= .97
	Sd= 167.68	*Sd*= .35	*Sd*= 144.94	*Sd*= .34
1/3 shields	*M*= 535.24	*M*= .93	*M*= 565.53	*M*= .87
	Sd= 175.81	*Sd*= .37	*Sd*= 150.12	*Sd*= .31
0/3 shields	*M*= 549.92	*M*= .93	*M*= 593.01	*M*= .82
	Sd= 183.18	*Sd*= .31	*Sd*= 160.47	*Sd*= .29

As can be seen in Tables 1 to 4, the mean speed in all conditions and shields is lower for the high risk perception group in comparison with the low risk perception group. Also, the TTC is higher for the high risk perception group in comparison with the TTC of the low risk perception group for all conditions and shields. The Tables 1 to 4 also show that the high risk perception group as well as the low risk perception group do not decrease their speed or increase the TTC after bumping into a comet.

3.4 HIII: The results will differ significantly for men and women, in which women are more risk-aversive and will therefore score higher on risk perception and lower on risk acceptance on the DOSPERT scale and show more risk-aversive behavior in the videogame.

To investigate whether men and women score differently on risk acceptance and risk perception an independent samples t-test was executed for the variables risk acceptance and risk perception.

On average, men had a higher risk acceptance (*M*= 108.31, *SE*= 3.06) than women (*M*= 95.40, *SE*= 1.67). This difference was significant *t*(166)= 3.80, *p* < .001. This represents a small effect size (*r* = .28). Men scored lower on risk perception (*M*= 110.07, *SE*= 2.60) than women (*M*= 123.90, *SE*= 1.64). This difference was significant *t*(166)= -4.29, *p* < .001. This represents a medium effect size (*r*= .32).

To investigate whether women show more risk-aversive behavior in the game an independent samples t-test was executed for the mean TTC and the mean speed.

On average, men had a lower TTC (*M*= .94, *SE*= .04) than women (*M*= .06, *SE*= .02). This difference is significant *t*(166)= -3.25, *p* < .01. This represents a small effect size (*r*= .24). Men had a higher mean speed (*M*= 571.71, *SE*= 19.32) than women (*M*= 514.14, *SE*= 10.17). This difference is significant *t*(166)= 4.10, *p* < .001. This represents a medium effect size (*r*= .30).

4. Discussion

The purpose of this study was to investigate risk homeostasis theory on itself as well as to link risk homeostasis to risk perception and risk acceptance. Also, the differences between men and women on risk homeostasis, risk acceptance and risk perception were investigated.

4.1 Risk homeostasis

The data from this study does not fully support RHT. A risk homeostasis effect would be assumed if participants slow down their speed or increase their time to collision (TTC) when they lose a shield. The data showed that in all conditions the mean speed was lower when all shields were intact than when shields were lost; the mean speed increased with loss of shields. Although the increase in speed and decrease in TTC is not significant for all comparisons it is still noteworthy, because an opposite effect would be expected.

The difference in speed and TTC between the condition with all shields left and the condition with one less shield is bigger than all other differences in speed and TTC. This can be explained by the fact that the videogame starts at the lowest possible speed. It is therefore logical that the speed during the time in which all shields are intact is lower and the TTC higher.

The participants can only start speeding when the game has started. Still, there are other factors which might have contributed to this effect.

It could be possible that participants are somewhat careful until they lose their first shield because they do not yet know how the game exactly works, regardless of the explanation and the trial. But since the videogame starts with the lowest possible speed, it is more likely that the lower speed and higher TTC during the time in which all shields are intact, is for the biggest part due to the low speed at the start of the game.

This does not explain why the mean speed keeps, not significantly, increasing after the loss of shields and the TTC keeps decreasing. At least, for risk homeostasis to occur the mean speed should decrease and the TTC should increase in all conditions when there are zero shields left.

Next to the mean TTC and the mean speed, the maximum speed was also analyzed in order to investigate risk homeostasis. The maximum speed did not decrease with the loss of a shield in the one shield condition, but did significantly decrease in the three- and five shield condition when comparing the maximum speed with the full amount of shields with the maximum speed with zero shields left.

The maximum speed did not significantly decrease in the unknown shields condition between the full amount of shields and zero shields, but of course in the unknown shields condition participants were not aware that they had zero shields left.

It is remarkable that the maximum speed decreases with the loss of shields while mean speed increases. It is possible that while participants who start with a slow speed increase their speed during the game, participants who start with a relatively higher speed slow down instead, thereby increasing average speed and decreasing maximum speed.

The participants were instructed to reach a destination with their spaceship, but also to gain as much points as possible. Another explanation for the increasing mean speed could therefore be that when starting off slow, participants thought they had gained too few points and would therefore increase their speed while having less shields left. In this case, participants were perhaps too much focused on gaining points.

This possibility brings yet another explanation to mind. What if the risk in this experiment is in fact not determined by the conventional idea of losing shields, but the risk factor is not reaching the final destination? The chances of reaching the final destination obviously increase during the game, simply because the spaceship always moves towards the destination. Correspondingly, one could argue that as the spaceship comes closer to the final destination the risk of not reaching this destination decreases. Therefore, when participants move closer to the final destination the risk decreases and as to pursue homeostasis they speed up and decrease TTC, with the incentive of gaining more points.

This is of course no proof for or against RHT, especially because the increase in speed was mainly insignificant, but an alternative explanation of not finding the RHT effect in this study.

4.2 Expected loss of shields

The data showed that participants who scored higher on risk perception also thought it more likely to hit a comet during the game. Also, participants who scored high on risk perception thought it less likely to not lose shields at all and more likely to lose all shields than participants who scored low on risk perception. But, as can be seen in Figure 9, Figure, 10 and Figure 11, the expectation on performance on the game with risk perception does not follow a clear pattern.

Still, it is not impossible that participants would adjust their behavior to their expectation and would therefore play the game more carefully when risk perception is high. This is further elaborated on in the section about hypothesis risk acceptance and risk perception.

Participants had a moderately accurate notion of the total shields they lost and the amount of shields during the unknown shields condition. While this is not of interest for RHT on itself, it does give a notion that the participants were not just playing the game and biding their time but were actually aware of what they were doing.

4.3 Risk acceptance and risk perception

The first hypothesis states that participants who score high on risk acceptance and low on risk perception will play the game with more risk and participants who score high on risk perception and low on risk acceptance will play the game more carefully. The results of this study have shown that this is in fact the case. Participants who scored high on risk perception had a significantly lower mean speed and a significantly higher TTC than participants with a low risk perception score. Also, participants who scored higher on risk acceptance had a significantly higher mean speed and a significantly higher TTC than participants who scored low on risk acceptance. Overall, risk perception was correlated with a lower mean speed and a higher TTC whereas risk acceptance was correlated with a higher mean speed and a lower TTC.

The effects of risk acceptance and risk perception could also be an explanation of the lacking of risk homeostasis in this study. For risk homeostasis to occur, one should at least be aware or perceptive of risk at all. For, if not aware of risk at all why would one change behavior to pursue homeostasis. This study showed that risk perception differs between participants and affects their behavior in the game.

The second hypothesis states that participants who score high on risk perception will alter their behavior more radical than participants who score low on risk perception when bumping in to a comet. This hypothesis, if found to be true, could be a factor in uniting RHT with risk perception. All participants would for instance alter their behavior following a risk homeostasis pattern to some extent, but participants with high risk perception would do so more radical.

This was not what the results showed in this study. Participants actually did not alter their behavior following a risk homeostasis pattern at all during the game. At least not if losing shields is determined as risk.

However, participants with high risk perception did have a lower mean speed and a higher TTC during all condition from the full amount of shields to zero shields. Although risk perception does not seem to affect a risk homeostasis pattern in this study, it does affect the behavior of the participants.

4.4 Gender differences

The third hypothesis states that results will significantly differ for men and women, in which women are more risk-aversive and will therefore score higher on risk perception and lower on risk acceptance and show more risk-aversive behavior in the game.

The results showed that men and women did differ in risk perception and risk acceptance and also behaved differently during the game.

Men had a significantly higher mean speed and lower TTC than women and women scored significantly higher on risk perception and lower on risk acceptance than men. It should therefore be noted from this study that men and women differ not only in the perception and acceptance of risk, but also in risk behavior.

5. Conclusion

Although this study did not find support for risk homeostasis, many other studies have already discussed it and found support for and against RHT. Therefore, this study should by no means be interpreted as a reason to disregard or not to disregard RHT. It is after all only one among many. What this study does show is that risk perception and risk acceptance are of significant influence to behavior in this case and that also gender is on its turn an influence to risk perception and risk acceptance.

These findings imply that risk behavior can be affected by the risk perception and risk acceptance. Safety measures of a company for instance, could benefit from this knowledge to make employees more aware of risk or to better perceive risk in order to reduce risk behavior.

Furthermore, it could be beneficial to measure the risk acceptance of employees to assess how much risk behavior can be expected in general. Of course, these findings should be replicated before introducing new safety policies.

Future research, especially if replicating something similar to the game used in this study, could look beyond the risk in risk homeostasis determined as the amount of shields. Also, other studies could benefit from broadening their ‘risk scope’ by determining what is perceived as the risk factor according to participants. Is risk the conventional accident in RHT literature, or is risk dependent on the goal which is in mind, for instance arriving at time on work. This study might have found a RHT pattern if risk would have been otherwise defined.

This study probably does not put an end to the risk homeostasis discussion, nor is it meant to do so, but it might offer new ideas to keep practicing risk homeostasis.

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