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AN EXPERIMENTAL TEST OF RISK COMPENSATION: BETWEEN-SUBJECT VERSUS WITHIN-SUBJECT ANALYSES

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Abstract—This study examined parameters under which risk compensation in driving can occur following the use of safety belts. Risk compensation theories hypothesize that if individuals use safety belts, they will drive in a more risky manner than if they do not use safety belts due to an increased perception of safety. Although the existence of risk compensation in driving has been debated in the literature for many years, the current study was the first experimental analysis of this theory that permitted a controlled examination of both between-subject and within-subject effects. This study required subjects to drive a 5-hp. go-kart around an oval track either buckled or unbuckled in the first of two phases of 15 driving trials. After the first phase the safety condition was switched for half the subjects (i.e., the safety belt was removed from subjects using it or was used by subjects who previously did not use it). Dependent measures included latency for each lap, deviations from the prescribed lane, and perceived safety while driving. The amount of time it took for subjects to travel to the go-kart track and their safety belt use during that trip was also measured. Risk compensation theory was not supported in the between-subject analyses of the research data; however, some within-subject comparisons did demonstrate risk compensation. Subjects who switched from not using the safety belt to using it increased driving speed during the second phase significantly more than subjects who used the safety belt during both driving phases. The study suggested that the occurence of risk compensation is dependent upon individuals being able to compare the sensations using a safety belt with those of not using a safety belt. Risk compensation did not manifest itself in between-subject studies because this comparison could not take place. The implications of this study to driving automobiles on multi-user roadways is discussed. Suggestions for research to further expand the knowledge about how and when risk compensation occurs are also provided.

This study examined how changes in the use of safety equipment, specifically the use or nonuse of safety belts, influences risk-taking perceptions and behaviors within and across individuals. There are currently a variety of theories, for example, risk/danger compensation [Peltzman, 1975; O'Neill, 1977; Blomquist, 1986], risk homeostasis [Wilde, 1982a, 1982b], and human behavior feedback theory [Evans, 1986a], that describe conditions where the addition or removal of some safety factor (e.g., safety belts, road quality, auto size) will result in a behavior change of either more or less risk taking. However, the result of research on hypotheses derived from these theories have been equivocal with respect to the existence of what, for simplicity, will be termed "risk compensation." This research is briefly reviewed chronologically.

Taylor [1964] correlated galvanic skin response (GSR) with risk taking (i.e., vehicle speed), and found GSR to be significantly correlated with vehicle speed. Taylor used these data to support the notion that drivers adjusted their speed to maintain a constant risk per minute. This work essentially stood alone as a demonstration of risk compensation until Peltzman [1975] provided the first evidence of a risk compensation effect in U.S. highway fatality rates.

Peltzman used a time-series model to determine if safety features installed in vehicles in the mid-1960s (e.g., seat belts for vehicle occupants, energy absorbing steering column, dual braking system, padded instrument panel) were as effective as predicted in preventing fatalities. Peltzman hypothesized that drivers make a choice between the probability of death or injury to oneself and what Peltzman termed "driving intensity" (p.

681). According to Peltzman, the effect of making safety devices available is to lower the risk price of driving intensity and lower the probability of death or injury given a crash. This effect was also hypothesized to impact pedestrians. Peltzman predicted that an increase in driving intensity over the population of drivers would produce an increased risk to pedestrians demonstrated by increases in pedestrian death and injury.

Peltzman found that, as predicted by risk compensation theory, auto safety regulation did not affect the highway fatality rate. Perhaps the most convincing evidence of increased driver risk taking was that cars equipped with safety devices were involved in a disproportionately high number of crashes, thus supporting the notion of some kind of risk compensation. Peltzman's article has been criticized on a number of counts, primarily statistical, and these critiques are discussed later in support of the need for the present study.

O'Neill [1977] developed a "decision theory model of danger compensation." O'Neill assumed that drivers are rational, and will maximize the total expected outcome of their inputs. One prediction of this theory is that drivers, motivated to arrive at their destination as soon as possible, will compensate for the increased safety provided by safety belts or any other safety measures by driving faster. Although O'Neill provided a coherent theoretical framework for the study of risk compensation (or "danger compensation" as he called it), no empirical evidence was cited to support the theory nor were any specific hypotheses drawn from the theory.

The risk compensation theory which has received the most recent attention is the "Theory of Risk Homeostasis" formally proposed by G.J.S. Wilde [Wilde, 1982a]. Wilde proposed that while driving a vehicle, a person is:

> "acting in a way that may be understood as a homeostatically controlled self-regulation process. At any moment of time the instantaneously experienced level of risk is compared with the level of risk the individual wishes to take, and decisions to alter ongoing behavior will be made whenever these two are discrepant. Whether the ensuing behavior will have the desired effect of reestablishing equilibrium between the target level and the experienced level of risk, depends upon the individual's perceptual, decisional, and executional skills" [Wilde, 1982a, p. 210].

Wilde argued that an individual's skill, as well as extraneous interventions that provide a greater opportunity but not a greater desire for safety and health, have at most a temporary effect on the level of subjective and objective risk. According to Wilde's theory, the only factor that appears to determine the long-term level of subjective and objective risk is one's target level of risk, which, in turn, is dependent on the individual's evaluation of the costs and benefits of various action alternatives. Although much of Wilde's work focuses on the driving task, Wilde is careful to state that his theory is more general and was "put forward as a hypothesis of the dynamics of human conduct in the face of risk" [Wilde, 1982a, p. 210].

According to the theory, the only factor that acts to determine the long-term level of subjective and objective risk, which in turn affects risk taking behaviors, is the target level of risk. Wilde [1982a] identified four factors which sum to make up one's target level of risk: (1) perceived benefits of risky behavior; (2) perceived costs of cautious behavior; (3) perceived benefits of cautious behavior; and (4) perceived costs of risky behavior. Factors 1 and 2 serve to enhance one's target level of risk, and factors 3 and 4 serve to reduce one's target level of risk. For example, a driver in a hurry to get to a doctor's appointment or job interview will have a relatively high target level of risk if the perceived benefits of risk taking (getting to the appointment on time) and the perceived costs of cautious behavior (losing one's spot on the doctor's appointment calendar or losing one's job) are greater than the perceived benefits of cautious behavior (avoiding a speeding ticket) and the perceived costs of the risky behavior (getting a speeding ticket or being involved in a crash).

As described above, risk homeostasis theory would appear to be based on the behavior of individuals; however, Wilde [1982b] stated, "from this formulation it should be obvious that RHT (risk homeostasis theory) applies to the road-using community as a whole over a prolonged period of time and *not* to each and every individual in that community" (p. 255). Despite this earlier formulation of RHT, Wilde [1985] stated that, "although the primary focus of observation of RHT is the collective, it is obvious that the accidents are the result of perceptions, decisions, and actions of *individuals* with their intra- and inter-individual differences including their target level of risk. It may be that some elementary features of these phenomena can be explored *in vitro*, but there seem to be insurmountable obstacles to fully reconstructing dynamic reality through such efforts" (p. 1532).

Since Wilde formalized his risk homeostasis theory, many articles, pro and con, have been published [e.g., Evans, 1985a, 1985b, 1986a; Mackay, 1985; McCarthy, 1986; McKenna, 1985a, 1985b; O'Neill, Lund, and Zador *et al.*, 1985; Wilde, 1982a, 1982b, 1985, 1986; Wilde, Claxton-Oldfield, and Platenius, 1985]. With the exception of the laboratory simulations of Wilde *et al.* [1985], these studies used between-subject rather than within-subject designs to test the risk compensation hypothesis.

Wilde [1986] responded to Evans' [1986a] critique primarily by finding fault with his statistical methodology. The seminal article by Peltzman [1975] was also criticized on statistical grounds. Joksch [1975] stated that Peltzman's conclusions were based on correlated data which lead to spurious and biased regression coefficients. Wilde [1986] summarized the current arguments for and against his and presumably other risk compensation theories with the following statement, "attempts to address the validity question should preferably take the form of well-controlled field experiments, instead of retrospective analyses of multi-interpretable archival data that can be debated *ad infinitum*" (p. 95). The present study addressed the issues of experimental control and the individual as the unit of analysis by creating a situation where individual drivers were observed in a controlled driving situation in which perceived safety (or risk) was manipulated and reactions to changes in such manipulations were measured within individual subjects.

Briefly, this study required that subjects drive a 5-hp. go-kart around an oval clay track. Subjects were either buckled or unbuckled in the first of two phases of 15 driving trials. After the first phase the safety condition was switched for half the subjects (i.e., the safety belt was removed from subjects using it or was used by subjects who previously did not use it). Dependent measures included latency for each lap driven, number of deviations from the prescribed lane in one of the turns, and perceived safety while driving. The amount of time it took for subjects to travel to the go-kart track and their safety belt use during that trip were also measured.

Hypotheses

1. If risk compensation can be exhibited between subjects, one would predict that groups of subjects who do not use the safety belt while operating the go-kart will drive in a less risky manner (e.g., slower and more accurately) than groups of subjects who use the safety belt. It would also be expected that the travel time to the go-kart track would be shorter for subjects who used a safety belt during that trip.

2. Within-subjects, the risk compensation effect may be detected in two directions. Subjects who are unbelted in the first phase and are required to buckle up for the second phase are predicted to drive in a more risky manner during the second phase. Similarly, subjects who use a safety belt during the first driving phase and are then required to remove it will drive more cautiously in the second phase.

METHODS

Subjects

Subjects were 56 undergraduate psychology students from a large southeastern university who received extra credit in a course for their voluntary participation. The 28 male and 28 female subjects were balanced across groups.

Apparatus

Subjects were required to drive a 5-hp. go-kart equipped with an inertia reel type combination shoulder-lap safety harness. This go-kart was driven with a small steering wheel like a standard automobile and two pedals, one operating the throttle and one operating the brakes.

Subjects completed multiple circuits of the oval clay track which measured approximately 100 meters in circumference. This track was smoothed and rolled to provide as flat and level a surface as possible, and was surrounded by an oak fence with rails that would have prevented the go-kart from leaving the outside of the track had the need arisen. In addition, the go-kart was equipped with a safety rail that would protect the occupant and go-kart in the event that contact with the outside rail occurred. The track was sloped to the inside and bordered by raised clay edges to mark the lane in which drivers were requested to remain.

Lap timing was accomplished by using a hand-held digital stopwatch with lap timing (split) capability. The stopwatch was stopped when the subject crossed a landmark (fence post) on the opposite end of the track from the experimenter's observation stand. Driving accuracy was measured in one turn by pressure hoses which extended from the outer track edge toward the track center. When compressed, these hoses activated switches which lit LED's when each hose was run over, indicating inaccurate driving.

Questionnaires

Following each set of 15 circuits of the track (i.e., each phase), subjects were asked to complete a brief questionnaire. This survey asked questions pertaining to the comfort and handling of the vehicle, and the subject's perceived safety while driving the go-kart.

Procedure

Subjects were randomly assigned to one of four different safety belt conditions: (1) buckled during the first 15 trials and unbuckled during the second 15 trials; (2) buckled during the first and second 15 trials; (3) unbuckled during the first 15 trials and buckled during the second 15 trials; (4) unbuckled during the first and second 15 trials.

Subjects were first greeted by an experimenter at the university's psychology department, and given a consent form to sign. Once the consent form was signed, the subject was given driving directions to the track site 10 miles away. Subjects were asked to turn their headlights on so they could be easily identified by the second experimenter when they arrived at the track. The first experimenter then escorted the subject to the exit for the highway to the track. Subjects did not need to leave this 4-lane divided highway until they reached the track site. The first experimenter recorded the subject's safety belt use and the time the subject got onto the exit from a watch that was synchronized with an identical watch held by the experimenter at the go-kart track.

Once a subject arrived at the go-kart track, the experimenter recorded the time the subject entered the parking lot adjacent to the track. The subject was then randomly assigned to one of the safety belt conditions on the basis of a computer generated list. Before beginning to drive the go-kart, each subject was read the following instructions:

> "You will notice that there are three air hoses on the track. The white covered hoses that go across the whole track will be used to measure your time around the track. The yellow hoses in each of the corners are there to mark the center of the track in the corners. Try to keep the go-kart straddling these hoses whenever you are driving in the corners. The short hoses in this corner that stick out two feet are used to measure the number of times that you stray from the center of the track in this corner. Please remember that this *is not a competition*. Drive quickly, but at a speed that is comfortable for you. I will sound the air horn (sample horn blast) when you have completed the final lap. Please stop the go-kart back here after you hear the horn."

Following the task instructions, subjects were given two practice laps to acquaint themselves with the course and the go-kart. After these warm-up laps, subjects completed two phases of 15 laps of the track (i.e., a total of 30 trials). Each phase and the two warm-up laps were followed by a break during which subjects completed a brief questionnaire. The driving comfort and handling questionnaire was administered following the first and second phases. Drivers were notified when the specified number of laps were completed by the experimenter sounding a freon air-horn after the subject completed the final lap of each driving phase. In order to avoid any effects of feedback on driving behavior, subjects were not provided with their performance scores at any time during the experiment.

RESULTS

Lap latencies

Figure 1 shows mean latency per lap (i.e., trial) for each experimental condition. This graph indicates that subjects drove relatively slowly during the first two practice laps, but speeded up in succeeding laps. Phase 1 latencies continued to decline slightly with successive trials, but Phase 2 trial latencies were quite constant across trials. Although it appears from this figure that subjects in the Unbuckled Phase 1–Buckled Phase 2 group consistently traveled more slowly than the other three groups, a series of *t*-tests found these differences to be nonsignificant.

Two analysis strategies were used to study the risk compensation effect. One analysis applied a repeated-measures analysis of variance (ANOVA) on lap latencies to determine if an Experimental Condition by Phase interaction occurred indicating the predicted within-subject differences in mean latency change between Phase 1 and Phase 2 between experimental conditions. This analysis included between-subject factors to test the hypothesis that risk compensation can be detected in between-subject comparisons. In the second strategy, percent change scores between Phase 1 and Phase 2 latencies were calculated, and ANOVA used to determine if these difference scores differed significantly across experimental conditions in the directions predicted by risk compensation theory.

For the repeated-measures (within-subjects) ANOVA, lap latency (measured in seconds) was analyzed using two between-subject factors (4 Conditions × 2 Genders) and two within-subject factors (2 Phases × 15 Trials within each phase). There were no between-subject differences in lap latencies as a function of group assignment; however, males drove significantly faster than females, $F(1,48) = 7.52, p < .01$. Two other main

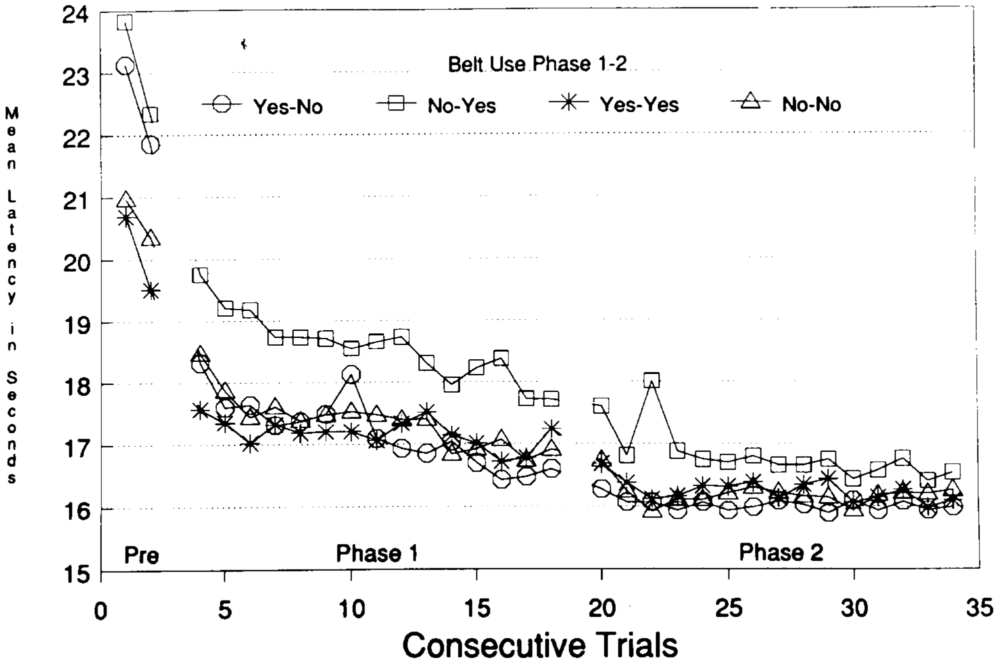

Fig. 1. Mean latency in seconds by experimental condition.

effects were detected, i.e., for Phase, $F(1,48) = 140.09$, $p < .0001$ (latencies from the second phase were lower than latencies from the first phase), and Trial, $F(14,672) = 11.65$, $p < .0001$ (latencies decreased with each successive trial). A significant Phase × Trial interaction was also found $F(14,672) = 3.11$, $p < .0001$. This interaction was probably due to the fact that latencies decreased slightly but steadily during the first phase but were relatively stable during the second phase (see Fig. 1).

The predicted Phase × Condition interaction was statistically significant, $F(3,48) = 2.75$, $p = .05$, indicating that as predicted by risk compensation theories, groups differed with respect to the within-subject latency change between Phase 1 and Phase 2. The Trial × Condition interaction, $F(42,672) = 1.47$, $p = .03$ was also significant.

The second method used to determine if the risk compensation effect occurred was based on difference scores between Phase 1 and Phase 2 latencies. Due to differences in group lap times during the first phase, difference scores were transformed into percent change scores using the formula: Percent Change = [(Latency Phase 1) − (Latency Phase 2)]/Latency Phase 1.

The predicted interaction was statistically significant, $F(1,52) = 4.09$, $p < .05$. Table 1 shows the 2 × 2 matrix of means for the percent change score tested by the ANOVA described above. As shown in Table 1, this interaction was primarily due to the difference between the "Buckled Both Phases" and the "Unbuckled Phase 1–Buckled Phase 2" groups. Tukey's (HSD) studentized range tests for simple effects (which protects for experimentwise error rate) showed that subjects who did not use the safety belt for the first set of trials then used it for the second set of trials (No–Yes) had significantly larger percent change scores than subjects who used the safety belt for both trials (Yes–Yes) ($p < .01$). The scores of these two groups did not differ significantly from the other groups, and no other differences were significant (p's $> .05$). These results indicate that although all subjects decreased their lap latencies from Phase 1 to Phase 2, subjects in the "Unbuckled Phase 1–Buckled Phase 2" condition decreased their latencies more than subjects who used the safety belt during both phases, as predicted by risk compensation theory. However, the risk compensation theory prediction that subjects in the "Buckled Phase 1–Unbuckled Phase 2" condition should actually drive slower in the second phase (and thus have negative change scores) was not confirmed.

Driving comfort and handling questionnaire

In order to determine what effect (if any) safety belt use had on perceptions of comfort, effort, and safety in Phase 1, t-tests were performed comparing the mean responses to the three items for subjects who used the safety belt versus subjects who did not. Only comfort differed significantly as a function of belt use. Belt users reported feeling more comfortable than nonusers, $t(54) = -2.30$, $p < .03$. Belt users did not report feeling safer than nonusers (5.68 vs. 5.21 respectively; $t(54) = -1.34$, $p = .19$). Belt use did not have an effect on amount of perceived effort required to control the go-kart, $t(54) = .09$, $p > .90$.

Table 1. Percent change scores for lap latency

		Belt Use Phase 1	
		Yes	No
Belt Use Phase 2	Yes	4.9%	9.2%
	No	6.6%	6.5%

In order to determine if changes in safety belt use produced changes in perceived safety, difference scores were calculated using the equation:

$$\text{Difference} = \text{Safety Rating Phase 2} - \text{Safety Rating Phase 1}.$$

The ANOVA on difference scores between the four experimental conditions was significant ($F(3,52) = 6.10, p < .001$). Tukey's (HSD) tests for simple effects showed that subjects in the Buckled Phase 1–Unbuckled Phase 2 group felt significantly less safe in the second phase than subjects in each of the other three conditions. No other simple effect differences were significant at the $p < .05$ level.

Student's *t*'s were calculated on each of the difference scores to determine if they differed significantly from zero. The difference in safety perception from Phase 1 to Phase 2 was significantly different from zero in the Buckled Phase 1–Unbuckled Phase 2 condition in which subjects felt *less* safe not using the belt than they felt using it [$t(14) = -2.80, p < .05$]. This difference was marginally significant for subjects in the Unbuckled Phase 1–Buckled Phase 2 condition which subjects felt safer driving buckled in the second phase after driving unbuckled during the first phase [$t(14) = 1.98, p < .10$]. The difference scores for the other two groups were not statistically significant from zero, Buckled Both Phases, $t(14) = 1.38, p > .20$; Unbuckled Both Phases, $t(14) = 0.43, p > .80$. Table 2 shows the mean safety perception difference scores for the four experimental conditions.

Driving accuracy

Very few subjects ($n = 8$) drove inaccurately enough to trigger the accuracy indicator lights in the corner. In fact, subjects strayed from the track only 28 times in 1,680 laps driven (i.e., .02%). The mean lap latency for subjects who strayed from the center of the track did not differ from the mean latency of subjects who did not stray from the center.

Time to the track

A 2 Belt Use (yes vs. no) × 3 Car Size (large vs. medium vs. small) ANOVA was conducted on the time it took subjects to drive to the track site. The only significant effect was the interaction between Car Size and Belt Use, $F(1,45) = 3.91, p < .05$. Tukey's (HSD) Studentized range test for simple effects found this interaction to be due to significantly faster travel for safety belt nonusers driving large cars (mean = 8.97 min) vs. nonusers driving medium sized cars (mean = 10.65 min), $p < .05$. Table 3 shows the 2 × 3 matrix of means and cell sizes for Belt Use by Car Size.

Correlations were calculated between subject's latency from the initial greeting site to the track and their total latencies for each of the two phases. Neither of the two correlations was significant (Phase 1: $r = .05, p > .85$; Phase 2: $r = .12, p > .39$) suggesting there may be little similarity between the driving a standard vehicle on paved roads and driving a go-kart on a clay track.

Table 2. Difference in safety perceptions from Phase 1 to Phase 2 by experimental condition

		Belt Use Phase 1	
		Yes	No
Belt Use Phase 2	Yes	.21	.64
	No	-.79	.07

Table 3. Travel time (minutes) from Derring Hall to Newport by car size and belt use

		Car Size		
		Large	Medium	Small
Wearing Belt on Trip	Yes	9.93 n=4	9.28 n=3	9.38 n=14
	No	8.97 n=6	10.64 n=4	9.36 n=18

DISCUSSION

The purpose of this experiment was to examine risk compensation in a driving task. Theories of risk compensation in driving hypothesize that safety belt users should drive in a more risky manner than safety belt nonusers due to the increase in perceived safety provided by using the safety belt, and consequently design changes in automobile and road engineering which were intended to increase safety and decrease injuries may not be as effective as projected. Using a series of quasi-experimental, between-subject designs and studying a number of different driving behaviors as risk-taking measures (e.g., speed, following distance), O'Neill *et al.* [1985] concluded that risk compensation does not occur in response to safety belt use. The results of the current experiment confirm the lack of support for a risk compensation effect *between* subjects. There were no differences between the time it took for subjects to drive from the initial greeting site to the track site between subjects who used safety belts and those who did not. There were also no between-subject differences in go-kart speeds as a function of safety belt use. However, within-subject comparisons did provide some evidence for risk compensation.

A risk compensation effect was detected when examining the difference between the speed individuals drove when not using a safety belt and how those same individuals drove when buckled up. Specifically, the data showed that subjects who did not use the safety belt during the first phase of laps and then switched to using the safety belt for the second phase increased their speed (or decreased the lap latency) during the second phase more than subjects who used the safety belt for both phases. This finding supports the hypothesis from risk compensation theories that an individual who switches from not using a safety belt to using one (as happens to large numbers of people when new safety belt use laws are enacted or other safety belt promotion projects are implemented) will take greater risks when driving while buckled up. This study also investigated some of the possible mechanisms by which risk compensation operates.

The most obvious hypothesis for the mechanism through which safety belt use will increase speed is that using a safety belt makes people feel safer than not using a safety belt. The results from the "Driving Comfort and Handling Questionnaire" supported the hypothesis of risk compensation as examined within subjects, and also suggested reasons for the absence of risk compensation in between-subject studies.

The results of the questionnaire found that subjects who used the safety belt in Phase 1 did not report feeling safer than subjects who did not use their safety belt. However, subjects who switched from using the safety belt to not using the safety belt reported feeling significantly less safe during the second phase. Similarly, subjects who did not use the safety belt the first phase and switched to using the belt reported feeling safer ($p < .10$) during the second phase. Subjects who did not switch belt use conditions between the two phases did not report any differences in perceived safety between the two phases.

Thus, it appears that risk compensation may be best viewed as a contrast effect. That is, safety belt use/nonuse itself does not create a difference in perceived safety; rather this difference is detected only when a driver can compare the perceptions of driving safety while using a safety belt to those perceptions when not using a safety belt. If the contrast between the safety perceptions is sufficient, behavior change can be expected to take advantage of increases in perceived safety (i.e., increase risk taking) or compensate for decreases in perceived safety (i.e., decrease risk taking). Therefore, one would not expect a risk compensation effect to manifest itself in between-subject studies, since subjects do not have the opportunity to compare the safety perceptions of the driving situation before and after experiencing the added safety of an environmental change.

The preceding discussion primarily describes the situation where an individual switches from not using a safety belt to using one. If risk compensation is a bidirectional effect, then subjects who used the belt for the first phase and then unbuckled for the second phase should have felt less safe during the second phase and consequently these subjects should have driven slower. Although these subjects did report feeling significantly less safe after removing the safety belt, they did not drive slower. Such a speed change may not have been demonstrated because subjects who completed the first phase without incident (or even the threat of incident) did not perceive a need to slow down for the second phase, even though they reported the second phase as being less safe than the first phase. Compounding this effect, subjects may not have felt they would be allowed to be put at "real" risk in a controlled, university sanctioned experiment.

It is instructive to consider how these results can be applied to driving real automobiles on multi-user roadways with or without a safety belt. Although the risk compensation effect was sufficiently robust to be statistically significant when comparing subjects who used the safety belt both during phases to those who only used it during Phase 2, it still may not be powerful enough to make an impact on crash rates, injuries, or property damage as proposed by compensation theory proponents. When the difference in percent change scores between subjects who drove buckled during both phases and subjects who were unbuckled in Phase 1 and buckled in Phase 2 (a difference score is used to estimate the speed change produced by risk compensation alone, independent of the observed practice effect) is applied to the current highway speed limit (88 kilometers per hour), the risk compensation effect would amount to a 3.8 kph increase in speed for drivers who normally drive unbuckled and begin to use their belts. This may not seem to be a large enough difference to affect crash and fatality rates on the highway, however research has indicated that it is speed variance, not absolute speed, which contributes most to the crash rate on highways [Deen and Godwin, 1985]. Although the effect of raising average speed by 3.8 kph on the highway across all drivers might be minimal, an increase in speed variance on highways could have adverse consequences.

However, it must also be considered that the nature of the automobile driving task and design differs significantly from that of the go-kart. This statement is supported by the nonsignificant Pearson's *r* found between the time it took subjects to drive to the track and their time on the go-kart track. In addition, subjects in this study reported that they were primarily motivated to drive at the speed they did by thrill seeking. Clearly, most automobile users have motives other than thrill seeking for driving their automobile the way they do (e.g., to get from point *a* to point *b* in one piece).

The safety belt in the go-kart fit like one from a standard car. However, the uneven clay track made the inertia reel lock up the shoulder belt frequently, making it obvious to drivers that the belt was holding them securely in the go-kart seat. In a standard car driving on a paved roadway, one almost never notices that the safety belt is capable of restraining you. In fact, the safety belts in newer cars are designed specifically not to restrain the occupant's movement within the automobile until the car's momentum changes enough to lock the belt tight, as occurs in crashes. On the go-kart track, the bumpy driving surface kept the safety belt locked for much of the time it was being driven, thus providing the go-kart driver with continuous cues regarding the efficacy of safety belts for providing safety that are not available to the drivers of standard automobiles driven on paved roadways.

The lack of "safety feedback" from using standard vehicular safety belts was considered by Lund and O'Neill [1986] to criticize the concept of risk compensation in situations where auto and road design has been changed to reduce the likelihood of injury. Lund and O'Neill proposed that design changes intended to reduce the likelihood of a crash where feedback mechanisms are present may very well produce a compensation effect. This study supports their hypothesis that behavior change may occur if design changes alter perceptions of safety.

Hopefully this research has helped to answer the call of Haight [1986] to perform research aimed at "discovering precisely the circumstances in which perverse compensation exists, and the extent of such compensation" (p. 364). Additional research should focus on the extent to which the driver's motivation contributes or detracts from the risk compensation effect. One useful study could provide subjects with rewards for different driving behaviors or outcomes. For example, rather than telling subjects that they are not participating in a contest, as was done in this experiment, subjects could be told that they are competing to drive the most laps in a given amount of time, drive a prescribed number of laps the fastest, to remain within a prescribed set of boundaries, or even to drive in such a way as to burn the least amount of fuel. Such an experiment would help to determine the extent to which the compensation effect shown in this experiment occurred because of the subjects' emphasis on maximizing speed for thrills.

A second research question that should be addressed involves investigating the long-term implications of risk compensation. Wilde's risk homeostasis model predicts that increases in safety will be completely compensated for, and consequently injury/fatality rates will not change in the long run. Since the outcomes of excessive risk taking in this case are too severe to be manipulated in a controlled experiment, future studies in the field may wish to design an experiment in which risk taking may be operationalized in terms that would permit the outcome of increased risk taking to be expressed and measured without loss of life. For example, risk taking could be operationalized as straying a set distance from the center of the track. As an outcome for unsuccessful risk taking, a fine could be assessed from a pool of money the subject can receive if the center is not crossed. This pool of money to be awarded could be dependent upon speed (i.e., the faster you go the more cash you get as long as you don't stray from the center of the track). This would provide subjects with a motivation to drive more quickly (and take more risks). The track should be designed so that it is sufficiently curved and slick so that increased speed will result in traction loss and less accurate driving (more straying from the center). If risk homeostasis theory is correct, subjects will find an acceptable level of risk taking (chance of monetary loss produced by driving too fast to stay in the center of the track) and continue to drive at that level until something in the risk environment changes, like tires that allow you to track through the corners more accurately. The theory then predicts that this increase in traction will motivate the subject to try to drive faster in order to get more money, but the number of errors that the subject commits and the subsequent financial penalty (the outcome of increased risk taking, the experimental equivalent to injury/fatality rates on the highway) should be the same as before the tires were switched, provided that the subject can accurately perceive the additional traction provided by the tires.

The parameters under which the risk compensation effect and its correlates (e.g., risk homeostasis theory) operate have been further explored and identified in this experiment. It has been demonstrated that there is a risk compensation effect produced when subjects switch from the nonuse of safety belts to using safety belts. More generally, the results suggest that risk compensation may occur in any situation where there is a benefit to taking an increased risk, and something changes in the risk environment to decrease the perception that drivers will experience the negative outcome of increased risk taking. Many questions still remain unanswered with respect to the risk compensation effect and the studies proposed above would contribute much to the investigation of an important phenomenon and would assist to further delimit the motivational and situational components of risk compensation.

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