DRIVING SAFETY AND SAFETY ENGINEERING: EXPLORING RISK COMPENSATION

by

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Dissertation submitted to the Faculty of the

Virginia Polytechnic Institute and State University

in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

in

Psychology

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December 3, 1986

Blacksburg, Virginia

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(ABSTRACT)

This study examined the parameters under which risk compensation in driving can occur due to the use of safety belts. Risk compensation theories hypothesize that if individuals wear safety belts, they will drive in a more risky manner than if they do not wear safety belts due to the increased perception of safety they provide. Although much of the current literature has debated the existance of risk compensation in driving for many years, until the current study an experimental analysis of the effect has not yet been conducted that permits a controlled examination of both between-subject and within-subject effects.

Risk compensation was not found in the between-subject analyses of the present research, however the within-subject analyses demonstrated the risk compensation effect. Subjects drove significantly faster when they switched from not wearing a safety belt to wearing a safety belt than subjects who either did not switch belt use or drivers who switched from safety belt use to safety belt non-use. The study also suggested that the mechanism by which risk compensation occurs is that safety belt use makes drivers feel safer when they can compare the sensations wearing a safety belt vs. those when not wearing a safety belt. The risk compen-

sation effect probably did not manifest itself in the between-subject studies because this comparison did not (and could not) take place.

The implications of this study to driving real automobiles on multi-user roadways is discussed. Suggestions and examples of possible research to further expand the knowledge about how and when risk compensation occurs are also provided.

ACKNOWLEDGEMENTS

There have been many individuals who have helped to shape the student, professional, and most importantly the individual who prepared this document. For their assitance in data collection, I want to thank Jeff Stuart and Cheryl Anderson.

Special thanks have to be extended to the man who has helped more than any other single individual to shape the young psychologist I have become. To the chairman of the committee, and a man I would like to continue to call friend, thanks Scott.

I would also like to acknowledge the mechanical and design efforts of Galen Lehman. Although I finally discovered that the only job Galen has not already mastered is weather control, the work Galen put into rebuilding the go-kart, fitting the go-kart with counters for the pedals, and the design of the ill-fated computer timing system is greatly appreciated.

The support group that gave me the extra-curricular push (as well as an occational curricular push) were great. Thanks Mikey, James R, Goof, Timmy, and the omnipresent New Yorker Walkman.

This dissertation is dedicated to my love my family, and the memory of loved ones passed away.

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INTRODUCTION TO RISK COMPENSATION

The purpose of the following experiment was to determine how changes in the use of safety equipment effect risk taking behaviors within and across individuals. There are currently a variety of theories available, for example, risk/danger compensation (Peltzman, 1975; O'Neill, 1977; Blomquist, 1986), risk homeostasis (Wilde, 1982), 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 results 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 reviewed chronologically.

Taylor (1964) correlated galvanic skin response with risk taking (i.e., vehicle speed), and found GSR to be significantly correlated with vehicle speed. In fact, Taylor used these data to support the notion that drivers were adjusting 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-1960's (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 an accident. 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 as shown by increases in pedestrian death and injury.

Using a time-series regression model, Peltzman related death rates to archival measures of driving speed, alcohol consumption, the extent of driving in youth, per capita income, a price index for medical costs and automobile repairs, and a time trend. Regression coefficients were estimated from the "pre-regulation" period (1947-1965). Annual fatality rates were then calculated for the "post-regulation" period (1966-1972) using the estimated regression coefficients. Differences between the actual and predicted fatality rates for the post-regulation period were then attributed to the safety regulations.

Peltzman concluded from his results that, as predicted by risk compensation theory, auto safety regulation did not affect the highway fatality rate. Data also supported the hypothesis that the safety regulations increased driver risk taking. 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 accidents, 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 proposed research.

O'Neill (1977) developed a "decision theory model of danger compensation." In this model, 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 calls it), no empirical evidence was cited to support the theory or any hypotheses drawn from the theory.

The risk compensation theory which has received the most attention is the Theory of Risk Homeostasis formally proposed by G.J.S. Wilde in 1982 (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 re-establishing 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).

However, Wilde argues 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

4) perceived costs of risky behavior

Items 1 and 2 serve to enhance one's target level of risk and items 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 the spot on the doctor's appointment calendar or losing the 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 an accident).

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 interindividual differences including their target level of risk. It may well 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). It is the purpose of the proposed research to investigate the risk compensation effect in both between- and within-subject comparisons.

Since Wilde formalized his risk homeostasis theory in Risk Analysis in 1982, many articles, pro and con, have been published (e.g., Evans, 1985a, 1985b, 1986a,; Mackay, 1985; McCarthy, 1986; McKenna, 1985a, 1985b; O'Neill, Lund, Zador, & Ashton1985; Wilde, 1982a, 1982b, 1985, 1986; Wilde, Claxton-Oldfield, & Platenius, 1985). With the exception of Wilde, Claxton-Oldfield, and Platenius (1985), each of these studies used a population of road users as the unit of analysis rather than individual drivers. For example, Evans (1986a) provided a summary of data he compiled to refute Wilde's risk homeostasis theory.

In this study, Evans (1986a) examined the hypothesis from risk homeostasis theory that fatalities per unit time in a given population will remain constant. In order to examine this hypothesis, Evans examined the following seven dependent variables:

1) Long-term trends in traffic accident rates.
2) Short-term trends in traffic accident rates following a one time perturbation (1970's energy crunch and 55 MPH speed law).
3) Long-term trends of traffic accident rates after a major perturbation (1970's energy crunch and 55 MPH speed law).
4) Traffic accident rates on different types of roads.
5) Response of traffic accident rates to changes in laws mandating the use of safety equipment.
6) The traffic accident rate of individuals over time.

7) Long-term trends in overall accident rates (all causes).

Using these seven different DV's, Evans (1986a) demonstrated that each of the quantities considered varied in ways inconsistent with risk homeostasis theory as stated by Wilde (1982a,b). For example, Evans found that in 1972, the last year unaffected by uncertain energy supplies and prior to the 55 MPH law, the fatality rate per unit time was 19.1 fatalities per billion hours of driving on the rural interstate system. In 1974, the first full year following the energy crunch the fatality rate dropped to 10.3 fatalities per billion hours of travel. The prediction from risk homeostasis theory is that the fatality rate should return to the pre-energy crunch rate of 1972 once drivers became aware of the change in risk taking among the driving population. However, Evans found that the fatality rate following 1974 did not return to the rate of 1972 (pre-energy crunch), disconfirming the risk homeostasis hypothesis.

Evans (1986a) also took issue with terms such as "partial homeostasis" which have been used to describe situations where the hypothesized compensation effect is observed without the hypothesized <u>complete</u> homeostasis effect predicted by Wilde's model. Evans compared the use of the term "partial homeostasis" to the equally fallacious term "partial conservation of mass" which, if true, would suggest experiments in which half of the original material always disappears. Evans contended that this semantic awkwardness has needlessly prolonged and confused the discussion of risk compensation effects. Evans' argument is not that changes in the safety or risk taking environment do not produce behavior change, but rather that environmental change does not elicit a perfect one-to-one behavior change to offset the change in the environment as a homeostatic model would predict.

In his response to the critique by Evans (1986a), Wilde (1986) attacked the conclusions drawn by Evans primarily on statistical grounds. As stated earlier, the seminal article by Peltzman (1975) was also criticized because the conclusions were based on correlated data which lead to spurious and biased regression coefficients (Joksch, 1975). Wilde (1986) summarized the current arguments for and against his and 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). This study addressed the issues of experimental control and the individual as the unit of analysis by creating a situation in which 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 wearing it or was worn by subjects who previously did not wear it). Dependent measures included latency for each lap driven, number of deviations from the prescribed lane in one of the turns, and the number of times the accelerator and brake pedal were pressed and released. Hypotheses tested in this experiment are detailed below.

HYPOTHESES

1) Groups of subjects who do not wear 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 wear the safety belt.
2) The risk compensation effect will be detected in two directions. Subjects who are unbelted in the first phase and are required to buckle up for the second phase will drive in a more risky manner during the second phase. Similarly, subjects who wear a safety belt during the first driving phase and are then required to remove it will drive more cautiously in the second phase.
3) Subjects observed not wearing their safety belt on the trip to the go-kart track will drive in a more risky manner in the go-kart than subjects who were observed wearing their belts on the trip. This hypothesis is derived from a study by Evans (1986c) in which unbelted drivers were found to be over-represented among drivers involved in traffic accidents, suggesting greater risk taking among drivers who choose not to wear safety belts.

4) Control groups in which no switch in safety conditions occur (i.e., drivers unbuckled during the first phase remain unbuckled for the second driving phase and vice versa) will not demonstrate the risk compensation effect.

METHODS

The methods described below were designed to manipulate the perceived safety of a driving situation. The actual safety of the subject was protected by these methods and procedures, which were approved by Virginia Tech's Human Subjects Review Board.

SUBJECTS

Subjects were undergraduate psychology students from a large southeastern university who received extra credit in a course for their voluntary participation.

APPARATUS

Subjects were required to drive a 5-hp. go-kart equipped with a 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. Each pedal was equipped with a counter. The counter tallied the number of times each pedal was depressed.

Subjects completed multiple circuits of the oval clay track approximately 330 feet 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.

Originally, speed measures of the go-kart were to be obtained from four pressure hoses set on the track that triggered switches connected to a small computer. The computer would have measured and stored four speed measures per each circuit of the track. Unfortunately, the weather turned unseasonably chilly and the pressure hoses for timing became too rigid to contract when run over by the go-kart. For this reason, 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 observation stand and the accuracy measure hoses.

Driving accuracy was measured at 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.

Blood pressure and pulse measures were taken used an automatic, digital blood pressure/pulse measuring device (Berke-Line, Inc.). In addition, pulse measures were also taken using a 3-M Littman stethoscope.

QUESTIONNAIRES

Following each 15 circuits of the track (i.e., each phase), subjects were asked to complete a brief questionnaire. This survey served as part of the cover story, but also asked questions pertaining to the comfort and handling of the vehicle, and the subject's perceived safety. A copy of this questionnaire is given in Appendix A.

Subjects were asked to complete a second questionnaire following the completion of the comfort, handling, and safety questionnaire after the second phase. This questionnaire investigated the subject's motives for the way they drove. A copy of this questionnaire is given in Appendix B.

PROCEDURE

Subjects were randomly assigned to one of four different safety belt conditions, as defined below:

1) Subject belted during the first 15 trials and unbuckled during the second 15 trials,
2) Subject belted during the first and second 15 trials,
3) Subject unbuckled during the first 15 trials and buckled during the second 15 trials,
4) Subject unbuckled during the first and second 15 trials.

Subjects were greeted by an experimenter in Derring Hall, and given the consent form to sign (see Appendix C for a copy of the consent form). Once the consent form was signed, the subject was given driving directions to the track site in Newport (approx. 10 min. away). Subjects were asked to turn their headlights on so they could be easily identified when they arrived in Newport. The experimenter then escorted the subject to the exit for the highway to Newport (Rt. 460). Subjects did not need to leave this highway until they reached the track site in Newport. The experimenter noted 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 in Newport.

Once a subject arrived in Newport, the experimenter recorded the time the subject entered the parking lot just outside of the go-kart 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, the 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. Please 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 (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., trials). Each set of trials was followed by a break that allowed subjects to have their blood pressure and pulse taken and complete a brief questionnaire. The blood pressure/pulse measures were obtained four times; that is, before and after each driving trial, including the pre-trial warm-up laps. The driving comfort and handling questionnaire was administered following the first and second phases, immediately after completing the physiological measures. The motivational questionnaire was administered following the driving comfort and handling questionnaire after the completion of the second phase. Drivers were notified when the specified number of laps were completed when the experimenter sounded a freon air-horn after subjects 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 or after the experiment.

RESULTS

LAP LATENCIES

Figure 1 on the following page 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 quickly. Phase 1 latencies continued to decline slightly with successive trials, but Phase 2 trial latencies were quite constant across trials. It also appears from this figure that subjects in the "Not Buckled Phase 1-Buckled Phase 2" group travelled more slowly than the other three groups, although this group difference appears to be larger during the first phase than during the second phase.

There are three acceptable analysis strategies for studying the risk compensation effect in this experiment (Cook & Campbell, 1979). One analysis applies a repeated-measures analysis of variance (ANOVA) to determine if an Experimental Condition by Phase interaction occurred indicating the predicted differences in mean latency change between phase one and phase two between experimental conditions. Another possible analysis strategy involves using ANOVA to determine if predicted mean differences on the posttest (Phase 2) occurred between experimental conditions. A significant interaction in this 2 X 2 ANOVA, 2 Belt Use Phase 1 (yes vs. no) X 2 Belt Use Phase 2 (yes vs. no), would indicate that the belt use

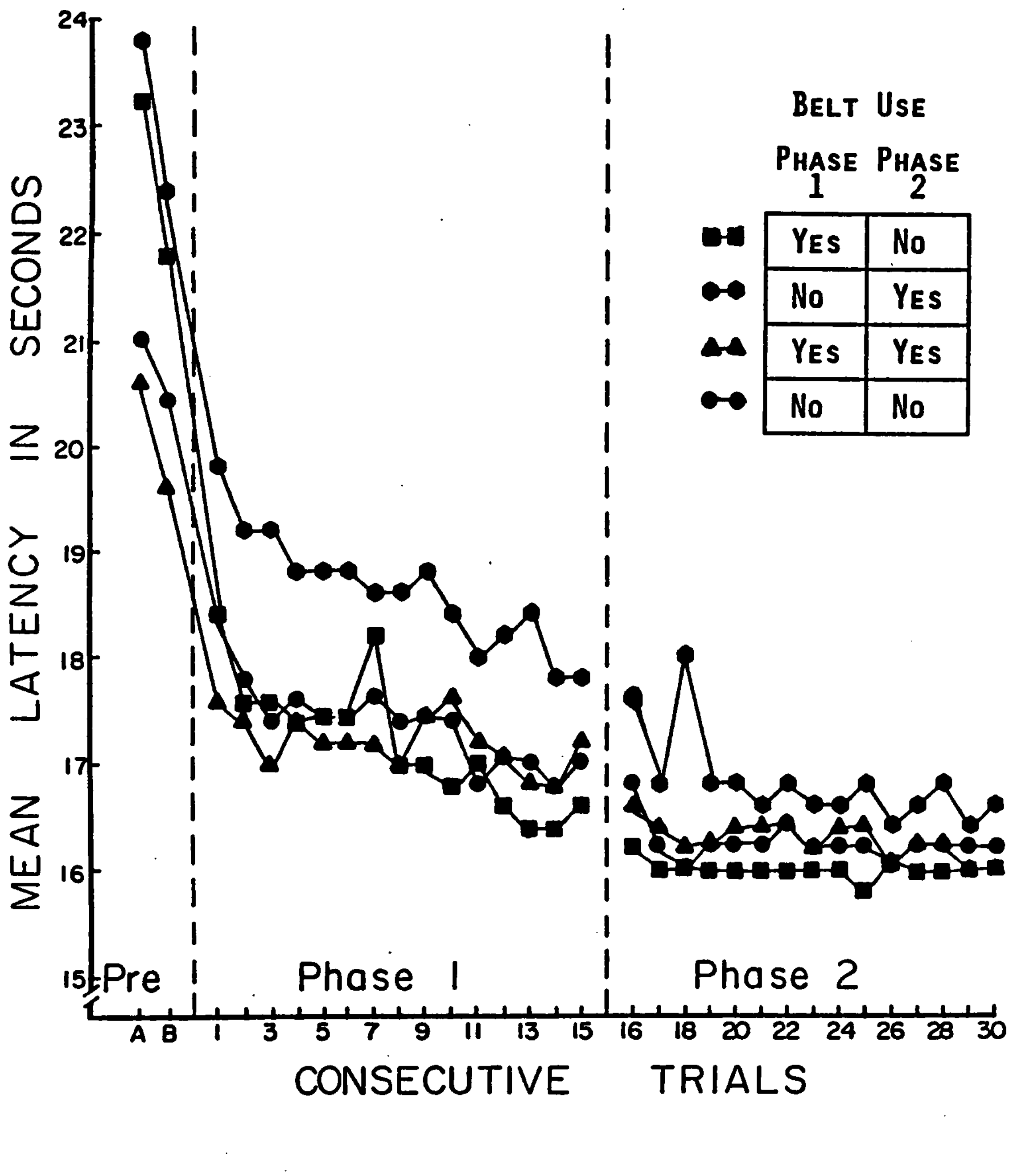

FIGURE 1. MEAN LATENCY IN SECONDS BY EXPERIMENTAL CONDITION

condition in Phase 1 differentially influenced the impact of the Phase 2 condition on lap times. The third strategy is to create difference scores between Phase 1 and Phase 2, and use ANOVA to determine if these difference scores differed significantly across experimental conditions in the directions predicted by risk compensation theory. Each of these strategies was used to examine the latency data.

For the repeated-measures (within-subjects) ANOVA, lap latency (measured in seconds) was analyzed using two between-subject factors (4 Conditions X 2 Genders) and two within-subject factors (2 Phases X 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 effects were detected, i.e., for Phase, $F(1,48)=140.09$, $p<.0001$ (latencies from the second phase were slower than latencies from the first phase), and Trial, $F(14,672)=11.65$, $p<.0001$ (latencies decreased with each successive trial). A significant Phase X Trial interaction was also found $F(14,672)=3.11$, $p<.0001$. This interaction is probably due to the fact that latencies decreased slightly but steadily during the first phase but were relatively stable during the second phase (see Figure 1).

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

The second strategy used to determine if the risk compensation effect was present applied ANOVA to determine if there were mean differences on the posttest (Phase 2) between experimental conditions. A significant interaction effect in this 2 X 2 ANOVA (2 Belt Use Phase 1 (yes vs. no) X 2 Belt Use Phase 2) would indicate that groups that did not change their belt use from phase 1 to phase 2 differed from groups that did change their belt use with respect to latency in phase 2. The interaction term of this ANOVA did not approach statistical significance ($F<1$), indicating that subjects' Phase 2 latencies did differ between the two groups which changed their belt use from Phase 1 to Phase 2 and those who did not.

The final method used to determine if the risk compensation effect occurred was based on difference scores between Phase 1 and Phase 2 latencies. Due to the 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 overall 2 Belt Use Phase 1 (yes vs. no) X 2 Belt Use Phase 2 (yes vs. no) ANOVA for the difference scores was statistically significant ($F(3,52)=2.61$, $p=.06$). The interaction was also significant $F(1,52)=4.09$, $p<.05$. Table 1 on the following page shows the 2 X 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

Table 1
Percent Change Scores for Lap Latency

Belt Use Phase 2	Belt Use Phase 1: Yes	Belt Use Phase 1: No
Yes	.05	.09
No	.07	.07

between the Yes-Yes and the No-Yes groups. Tukey's (HSD) studentized range tests for simple effects (which protects for experimentwise error rate) showed that subjects who did not wear the safety belt for the first set of trials then wore it for the second set of trials (No-Yes) had significantly larger percent change scores than subjects who wore the safety belt for both trials (Yes-Yes) ($p<.01$). The scores of these two groups did not 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 Unbelted Phase 1-Belted Phase 2 condition decreased their latencies more than subjects who wore the safety belt during both phases, as predicted by risk compensation theory. However, the risk compenation theory prediction that subjects in the Belted Phase 1-Unbelted Phase 2 condition should actually drive slower in the second phase (and have negative change scores) was not confirmed.

DRIVING ACCURACY

Very few subjects drove inaccurately enough to trip the accuracy counters in the corner (n=8). In fact, subjects strayed from the track only 28 times in 1680 laps driven In other words, subjects strayed from the center of the track on only .02% of the laps. 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) X 3 Car Size (large vs. medium vs. small) ANOVA was conducted on the time it took subjects to drive from Derring Hall to Newport. 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 non-users driving large cars (mean=8.97 min.) vs. non-users driving medium sized cars (mean=10.65 min.), $p<.05$. Table 2 on the following page shows the 2 X 3 matrix of means and cell sizes for Belt Use X Car Size.

Correlations were calculated between subject's latency from Derring Hall to Newport 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 $r=.12$ $p>.39$). T-tests on latencies in phase 1 and 2 and their sum were performed by belt use on the way to the track in Newport (yes vs. no). None of these tests proved to be statistically significant ($p>.34$). These tests indicate that there may be little similarity between the driving task on paved roads and the driving task on the clay go-kart track.

TABLE 2
TRAVEL TIME (MINUTES) FROM DERRING HALL TO NEWPORT BY CAR SIZE AND BELT USE

WEARING BELT TO TRIP	CAR SIZE: LARGE	MEDIUM	SMALL
YES	9.93	9.28	9.38
NO	8.97	10.64	9.36

BRAKE AND ACCELERATOR PEDAL PRESSING

Brake and accelerator pedal pressing were not correlated in either the first or second phase. However, brake pedal pressing during Phase 1 was highly correlated with brake pedal pressing in Phase 2 ($r=.76$, $p<.0001$), and accelerator pressing in Phase 1 was highly correlated with accelerator pressing in Phase 2 ($r=.56$, $p<.003$). Brake and accelerator pedal presses were used to predict latency in each phase. The resulting regression equations were statistically significant:

Phase 1 Latency = 243.22 - 1.48(Brake Presses) + .7942(Accel. Presses)
$R^2=.51$, $F(2,26)=12.50$, $p<.001$
Phase 2 Latency = 233.84 - 1.19(Brake Presses) + .5774(Accel. Presses)
$R^2=.29$, $F(2,26)=4.83$ $p<.02$.

These equations indicate that subjects drove fastest when they used the brake pedal, and used a steady accelerator pedal (i.e., did not continually push it all the way down then let it all the way off often).

PHYSIOLOGICAL MEASURES

Pulse rate taken from the blood pressure machine was analyzed using a 2 between (4 Conditions X 2 Genders) X 1 within (4 Measurement Trials, physiological measures taken before and after the pre-phase warm-up, and after both Phase 1 and Phase 2) ANOVA. A significant main effect for Measurement Trials was detected ($F(3,144)=5.42$, $p<.002$), with pulse generally rising until the measurement following Phase 2. A marginally significant Measurement Trial X Condition interaction ($F(9,144)=1.77$, $p=.08$) was also detected.

In order to determine if pulse rate differed between the two experimental phases, a second ANOVA was conducted using only the final two of the four pulse measures taken (i.e., measurements taken following Phase 1 and Phase 2). The Measurement Trial main effect effect was significant ($F(1,48)=4.16$, $p=.05$), and the Measurement Trial X Condition interaction was marginally significant ($F(3,48)=2.70$, $p=.06$). This interaction was primarily due to the fact that pulse declined between the final two measurement trials in all the conditions except for the Unbelted Phase 1-Belted Phase 2 condition in which pulse rate increased, indicating that the arousal levels of all subjects except those in the Unbelted Phase 1-Belted Phase 2 group dropped from the measurement following Phase 1 to the measurement following Phase 2. On the following page, Table 3 provides the mean pulse rates for all four experimental conditions by each of the four measurement trials. Pulse rate was not correlated with latency in Phase 1, ($r=-.21$, $p>.10$), or Phase 2, ($r=-.03$, $p>.75$).

Stethoscope heart rate followed the same pattern of results as pulse rate, however, the effects were generally weaker than those found using the machine pulse measure. The same effects were significant when all four measurement trials were included in the analysis, but no significant

TABLE 3
MACHINE MEASURED PULSE BY MEASUREMENT PHASE AND EXPERIMENTAL CONDITION

Experimental Condition	Measurement Phase: Pre-trial	Warm-up	Phase 1	Phase 2
Yes-No	72.86	82.93	84.00	77.86
No-Yes	78.57	80.93	81.79	85.57
Yes-Yes	74.43	76.86	84.14	81.29
No-No	82.50	77.07	86.93	79.79

effects were detected when the first two measurements were eliminated from the analysis.

Using the same 2 between X 1 within ANOVA model as used for the pulse analysis, only a main effect of Gender was detected for diastolic blood pressure ($F(1,48)=10.02$, $p=.003$), with females having lower diastolic BP than males. The same model was applied to systolic blood pressure with different results. Females had significantly lower systolic BP than males, $F(1,48)=53.25$, $p<.0001$). In addition, a significant measurement trial main effect was found ($F(1,48)=53.25$, $p<.0001$). Table 4 shows the means of systolic blood pressure by measurement trial. A second ANOVA using only the final two blood pressure readings (taken after Phase 1 and Phase 2) detected only a main effect of Gender $F(1,48)=56.70$, $p<.0001$), with females showing lower systolic BP than males.

MOTIVATIONAL QUESTIONNAIRE

The items of the motivational questionnaire (taken following Phase 2 driving) were correlated with each other and total latency per phase. How fast a subject wanted to go correlated positively with the number of benefits subjects reported they perceived for going fast ($r=.25$, $p=.06$), but did not correlate with how accurately they wanted to drive ($r=.18$, $p>.15$), or the number of benefits perceived for driving accurately ($r=-.05$, $p>.70$). Similarly, how accurately a subject wanted to drive correlated significantly with the number of benefits subjects

Table 4
Systolic Blood Pressure by Measurement Phase

Measurement Phase			
Pre-trial	Warm-up	Phase 1	Phase 2
128.16	134.95	135.41	134.11

reported they perceived for driving accurately, $r=-.34$, $p=.01$ (the negative correlation is due to the reverse wording of the accuracy/benefit question). How accurately a subject wanted to drive did not correlate how fast they wanted to drive ($r=.18$, $p>.15$), nor the benefits perceived for driving fast ($r=-.05$, $p>.65$).

The four items from the motivational questionnaire were then used as predictors for the total time to complete each driving phase. The results of a stepwise regression procedure showed that only how fast a subject reported they wanted to drive significantly predicted the subjects' actual speed on the track:

Phase 1 Latency: $R^2=.20$, $F(1,54)=13.18$, $p<.001$

Phase 2 Latency: $R^2=.26$, $F(1,54)=18.52$, $p<.0001$.

An ANOVA on how fast subjects reported wanting to drive was conducted across experimental conditions. This ANOVA showed that subjects did not differ with respect to their desire to drive fast across experimental condition ($F(3,52)=1.32$, $p>.25$, overall mean=2.96, 1=as fast as possible).

The written responses to the question, why did you want to go as fast as you reported wanting to go, were also examined. Sixty-six percent of the subjects (37/56) replied they wanted to go fast for the "excitement", "fun", or because they "liked to do it." Other responses included: "try to test limits of control" (n=5), "didn't want to crash" (n=5), "won't (can't) really get hurt" (n=3), no reason given (n=2), and finally, "did what I was told to" (n=1).

DRIVING COMFORT AND HANDLING QUESTIONNAIRE

The five items from the "Driving Comfort and Handling Questionnaire" (taken after both the first and second phase) were correlated with each other. The only non-significant correlations was between amount of effort required during the first phase with ease of control and comfort of driving during the first phase. All the other items within each questionnaire were correlated at the $p<.05$ level, with many at the $p<.01$ level of significance.

Stepwise regression procedures using the five questionnaire items from each phase to predict latencies of Phase 1 and Phase 2 were conducted. Comfort of driving, amount of effort required, and perceived safety were included in the regression equation for latency of Phase 1, $R^2=.22$, $F(3,52)=4.95$, $p<.01$. The equation was:

$$\text{Latency Phase 1} = 285.55 - 6.97(\text{Comfort}) + 6.84(\text{Effort}) - 3.0(\text{Safe}).$$

No linear combination of items from the second phase was found that would produce a statistically significant regression equation to predict latency in Phase 2.

Only how fast the subject reported he/she wanted to go predicted Phase 2 latency significantly. However, Phase 1 latency was predicted by how fast subjects reported they wanted to go, how comfortable subjects felt, how much effort was required for control, and how safe the subject felt. A stepwise regression was performed using how fast subjects reported wanting to go in addition to the comfort, effort, and safety measures. The regression equation that resulted did not include safety:

Phase 1 Latency= 254.59 + 7.44(How Fast) - 6.22(Comfort) + 4.17(Effort) R^2=.30, $F(3,52)$=7.50, p<.001.

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 on the means of the responses to the three items by whether the subject was wearing the safety belt or not. Only comfort differed significantly as a function of belt use. Belt wearers reported feeling more comfortable (mean=5.29) than non-wearers (mean=4.43), $t(54)$=-2.30, p<.03. Belt wearers also reported feeling safer than non-wearers (5.68 vs. 5.21 respectively); however, this difference was not statistically significant, $t(54)$=-1.34, p=.19. Belt use did not have an effect on amount of perceived effort required, $t(54)$=.09, p>.90.

In order to determine if changes in safety belt use produced changes in perceived comfort, effort required, and safety, 2 Belt Use Phase 1 (yes vs. no) X 2 Belt Use Phase 2 (yes vs. no) ANOVAs were performed on the comfort, effort, and safety scores from the second phase. The only statistically significant finding from these three ANOVAs was that belt wearers felt safer than non-wearers (6.00 vs. 5.01 respectively,

$F(3,52)=9.07$, $p<.01$). None of the remaining main effects nor interaction terms was statistically significant.

Difference scores were also calculated for subjects reported safety using the equation:

Difference = Safe rating Phase 2 - Safe rating Phase 1.

The ANOVA on difference scores between the four experimental conditions was significant ($F=6.10$, $p<.001$). Tukey's (HSD) tests for simple effects showed that subjects in the Belted Phase 1 - Unbelted 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 was significantly different from zero in the Belted Phase - Unbelted Phase 2 condition in which subjects felt less safe not wearing the belt than they felt wearing it ($t(14)=-2.80$, $p<.05$). This difference was marginally significant for subjects in the Unbelted Phase 1 - Belted 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, Belted Phase 1 and Phase 2, $t(14)=1.38$, $p>.20$; Unbelted Phase 1 and Phase 2, $t(14)=0.43$, $p>.80$. Table 5 shows the mean safety perception difference scores for the four experimental conditions.

TABLE 5
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

Correlations were calculated between the items on this questionnaire following Phases 1 and 2 and machine measured pulse rate following Phases 1 and 2 respectively. None of the correlations was statistically significant, all *p*'s>.35.

DISCUSSION

The purpose of this experiment was to examine risk compensation in the driving task. Theories of risk compensation in driving hypothesize that safety belt users should drive in a more risky manner than safety belt non-users due to the increase in perceived safety provided by the wearing of the safety belt, and consequently design changes in automobile and road engineering which were intended to increase safety and decrease injuries are not 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, Lund, Zador, and Ashton (1985) concluded that risk compensation did 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 Derring Hall to the track site in Newport between subjects who wore safety belts and those who did not. There was also no difference in Phase 1 latencies between subjects that wore their safety belt for that phase of laps vs. subjects who did not. However, within-subject analyses did show that there is a compensation effect.

The risk compensation effect was detected when examining the difference between the way individuals drove when not is wearing a safety belt vs. how those individuals drove when buckled up. Specifically, the data showed that subjects who did not wear the safety belt during the first phase of laps and then switched to wearing the safety belt for the second phase increased their speed (or decreased the lap latency) during the second phase more than subjects who wore the safety belt for both phases. This finding clearly supports the hypothesis from risk compensation theories that an individual who switches from not wearing a safety belt to wearing 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 wearing a safety belt makes people feel safer than not wearing a safety belt. The results from the "Driving Comfort and Handling Questionnaire" supported the hypothesis of risk compensation as examined within subjects, and also sheds some light on why risk compensation is not generally found in between-subject studies.

The results of the questionnaire found that subjects who wore the safety belt in Phase 1 did not report feeling safer than subjects who did not wear their safety belt. However, during the second phase, subjects who switched from wearing the safety belt to not wearing the safety belt reported feeling significantly less safe the second phase. Similarly subjects who did not wear the safety belt the first phase and switched to wearing the belt reported feeling significantly safer during the second phase. Subjects who did not switch belt wearing 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/non-use itself does not create a difference in perceived safety, rather this difference is detected when a driver can compare the perceptions of driving safety while wearing a safety belt to those perceptions when not wearing 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 wearing the safety belt.

The preceding discussion primarily describes the situation where an individual switches from not wearing a safety belt to wearing one. If risk compensation is a bidirectional effect, then subjects who wore the belt for the first phase then switched to not wearing the second phase (Yes-No) should have felt less safe during the second phase and consequently these subjects should have driven slower. Although these subjects did report feeling 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 perceived 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.

The physiological measures were taken to study potential relationships between safety belt use, perceived safety, and latency. Analyses showed no significant relationship between pulse rate (as measured by the blood pressure machine) and either safety belt use or perceived safety. However, pulse rate did change differently between Phases 1 and 2 for subjects in the Not wearing Phase 1 - Wearing Phase 2 (No-Yes) group compared to the pulse rates of subjects in the other three experimental conditions. The pulse rate for subjects in the No-Yes condition increased between its measurement following Phase 1 and its measurement following Phase 2, whereas the pulse rate for subjects in the other three groups dropped. One explanation for this difference may be that subjects in the No-Yes condition were reacting to the continuing novel stimulation of increasing speed, while subjects in the other three groups had adapted to their speed by the time the second phase pulse measure was taken and were subsequently less aroused.

The hypothesis that the excitement of speed contributed most to the pulse measures is supported by subjects' responses to the motivational and driving comfort and handling questionnaires. Two-thirds of the subjects reported that the reason they wanted to go as fast as they did was for the "excitement" or "fun" of it. In fact, one subject reported that he drove fast to "get the adrenaline pumping." It is also supported by the general trend that pulse rate increased with each successive measurement along with speed, until the drop from the measurement following Phase 1 to the measurement following Phase 2. It may be the case that subjects in all but the Not Buckled Phase 1 - Buckled Phase 2 (No-Yes) group did not perceive the speed (latency) change between Phase 1 and Phase 2 to be sufficiently stimulating to increase their arousal level and pulse. This argument is weakened by the fact that latency change scores were significantly different only between the No-Yes and Yes-Yes groups, although subjects in the No-Yes group had the highest mean latency change scores of all four groups.

The two questionnaires provided information about what motivated subjects to drive at the speeds they did. During the first phase, the regression analysis showed that how fast a subject reported wanting to drive predicted their actual speed the best, and that how comfortable the subject felt and how much effort was perceived to be necessary to control the vehicle also contributed to predicting Phase 1 latency. However, the regression analysis from data collected during and following Phase 2 showed that only how fast subjects reported wanting to drive significantly predicted latency for this phase. Subjects did not differ with respect to how fast they reported wanting to drive between experimental conditions.

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 wore the safety belt both phases to those who only wore it during Phase 2, it still may not be powerful enough to make an impact on accidents, injuries, or property damage as proposed by compensation theory proponents. Also, the nature of the automobile driving task and design differ significantly from that of the go-kart. 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 (it was taken from a standard car), however, the uneven clay track made it very obvious to the driver that the belt was holding him/her securely in the go-kart seat. In a standard car driving on an average 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 accidents. 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 cues to 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.

Automobile drivers switching from the non-use of safety belts to using safety belts may not have the same opportunity to compare the few perceptible benefits of safety belt use demonstrated on paved roadways as easily and readily as subjects in this experiment had. For example, it is unlikely that under non-experimental conditions a driver would drive around a cobblestone street unbuckled, stop the car, wait two minutes, buckle up, then drive off again. The results from the questionnaire safety item indicated that it was the switch from belted to unbelted and vise versa that produced the difference in perceived safety, and travel speed. The difference in perceived safety between wearing a safety belt and not wearing one may be reduced if the time between driving the first buckled or unbuckled phase and the second switch phase was increased, thus reducing the information available for making a comparison. An experiment to test this hypothesis can be easily performed. One would only have to schedule subjects for two driving sessions on successive days, rather than both in one day, or systematically vary the interval between driving sessions. It may also be instructive to examine the effects of extending the driving sessions beyond the 15 laps used in this study.

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 would 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. This experiment would help to determine the extent to which the compensation effect was demonstrated in this experiment 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 the risk compensation effect. 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 this increase in traction will motivate the subject to try to drive faster 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 switch, 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 clearly demonstrated that there is a risk compensation effect produced when subjects switch from the non-use of safety belts to using safety belts. More generally, the results would 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 one's perception that he/she will experience the negative outcome of unsuccessful risk taking. At this point, however, also seems unlikely that this effect is sufficiently robust to manifest itself in the "real world" of multi-user paved roads and comfort oriented automobiles. The studies proposed above would contribute to the investigation of an interesting phenomenon and would assist to further delimit the motivational and situational components of risk compensation.

REFERENCES

Adams J.G.U. (1982). The efficacy of seat belt legislation. (SAE Paper No. 820819). Warrendale, PA. Society of Automotive Engineers.

Blomquist, G (1986). A utility maximization model of driver traffic safety behavior. Accident Analysis and Prevention, 18, 371-375.

Cook, T.D., & Campbell, D.T. (1979). Quasi-Experimentation. Houghton-Mifflin Company.

Evans, L. (1985a). Human behavior feedback and traffic safety. Human Factors, 27(5), 555-576.

Evans, L. (1985b). Factors controlling traffic crashes. Warren, MI: General Motors Research Laboratories.

Evans, L. (1986a). Risk homeostasis theory and traffic accident data. Risk Analysis, 6, 1, 81-94.

Evans, L. (1986b). Comments on Wilde's Notes on "Risk Homeostasis Theory and Traffic Accident Data". Risk Analysis, 6, 1, 103-107.

Evans, L. (1986c). Belted and Unbelted Drivers Accident Involvement Rates Compared. Warren, MI: General Motors Research Laboratories.

Evans, L., Wasielewski, P., & von Buseck., C.R. (1982). Compulsory seat belt usage and driver risk-taking behavior. Human Factors, 24(1), 41-48.

Haight, F.A. (1986). Risk, especially risk of traffic accident. Accident Analysis and Prevention, 18, 359- 366.

Joksch, H.C. (1975). Critique of Sam Peltzman's study. Accident Analysis and Prevention, 8, 129-137.

Lund, A.K., & O'Neill, B. (1986). Perceived risks and driving behavior. Accident Analysis and Prevention, 18, 367-370.

McCarthy, P.S. (1986). Seat belt usage rates: A test of Peltzman's hypothesis. Accident Analysis and Prevention, 18, 425-438

Mackay, M. (1985). Seat belt use under voluntary and mandatory conditions and its effect on casualties. In L. Evans & R. Schwing (Eds.), Human Behavior and Traffic Safety (pp. 259-278). New York: Plenum Press.

Mc Kenna, F.P. (1985a). Do safety measures really work? An examination of risk homeostasis theory. Ergonomics, 28(2), 489-498.

Mc Kenna, F.P. (1985b). Evidence and assumptions relevant to risk homeostasis. Ergonomics, 28(11), 1539-1541.

O'Neill, B. (1977). A decision theory model of danger compensation. Accident Analysis and Prevention, 9, 157-165.

O'Neill, B., Lund, A.K., Zador, P., & Ashton, S. (1985). Mandatory belt use and driver risk taking: An empirical evaluation of the risk compensation hypothesis. In L. Evans & R. Schwing (Eds.), Human Behavior and Traffic Safety (pp. 93-107). New York: Plenum Press.

Peltzman, S. (1975). The effects of automobile safety regulation. Journal of Political Economy, 83, 677-725.

Robertson, L.S. (1977). State and federal new-car safety regulation: Effects on fatality rates. Accident Analysis and Prevention, 9, 151-156.

Taylor, D.M. (1964). Driver's galvanic skin response and risk of accident, Ergonomics, 7, 439-451.

von Buseck, C.R., Evans, L., Schmidt, D.E., & Wasielewski, P. (1979). Seat belt usage and risk taking in driving behavior. Warren, MI: General Motors Research Laboratories.

Wilde, G.J.S. (1982a). The theory of risk homeostasis: Implications for safety and health. Risk Analysis, 2(4), 209-225.

Wilde, G.J.S. (1982b). Critical issues in risk homeostasis theory. Risk Analysis, 2(4), 249-258.

Wilde, G.J.S. (1985). Assumptions necessary and unnecessary to risk homeostasis. Ergonomics, 28(11), 1531-1538.

Wilde, G.J.S. (1986). Notes on the interpretation of traffic accident data and of risk homeostasis theory: A reply to L. Evans. Risk Analysis, 6(1), 95-101.

Wilde, G.J.S., Claxton-Oldfield, S.P., & Platenius, P.H. (1985). Risk homeostasis in an experimental context. In L. Evans & R. Schwing (Eds.), Human Behavior and Traffic Safety (pp. 119-149). New York: Plenum Press.

Appendix A

Driving Comfort and Handling Questionnaire

Driving Comfort and Handling Questionnaire

Trial: phase-1 phase-2 Last four digits of ID Number________________

Please complete the following questions by circling the number which best represents your impressions.

1. I felt _________ while driving the go-kart.

   Uncomfortable — Comfortable

   1 ----- 2 ----- 3 ----- 4 ----- 5 ----- 6 ----- 7

2. I found it __________ to control and manouever the go-kart.

   Difficult — Simple

   1 ----- 2 ----- 3 ----- 4 ----- 5 ----- 6 ----- 7

3. I found completing the last 15 laps to be ___________.

   Fatiguing — Restful

   1 ----- 2 ----- 3 ----- 4 ----- 5 ----- 6 ----- 7

4. Over the last 15 laps, I felt I had to _________ to control the go-kart.

   Exert much effort — Exert little effort

   1 ----- 2 ----- 3 ----- 4 ----- 5 ----- 6 ----- 7

5. During the last 15 laps of the track I felt _________.

   Unsafe — Safe

   1 ----- 2 ----- 3 ----- 4 ----- 5 ----- 6 ----- 7

Appendix B

Motivation Questionnaire

Final Questionnaire

Last four digits of student ID ______________

Please complete the following questions by circling the number that best represents your impressions, or by writing in the space provided.

1) How fast did you want to go while driving the go-kart?

1	2	3	4	5	6	7
As fast as possible			Fast but safe			A comfortable speed

2) Why? ____

____

3) Did you perceive any benefits to driving quickly?

1	2	3	4	5	6	7
I perceived many benefits			I perceived some benefits			I perceived no benefits

4) What benefits (if any) did you perceive? ____________

____

5) How accurately did you want to drive?

1	2	3	4	5	6	7
I was not concerned about staying in the center of the track.			I tried to stay in the center, but didn't mind straying.			I always tried to stay in the center of the track.

6) Why? ____

____

7) Did you perceive any benefits to driving accurately?

1	2	3	4	5	6	7
I perceived many benefits			I perceived some benefits			I perceived no benefits

8) What benefits (if any) did you perceive? ____________

____

Appendix C

Informed Consent Form

Study on
Driving Comfort and Performance

INFORMED CONSENT

This study involves research on driving comfort and performance. You will be required to complete two driving phases consisting of 15 circuits of the track. Preceding and following these phases your blood pressure and pulse will be measured, and you will be asked to complete a brief questionnaire. This is not a contest. You are asked to drive quickly, but at a speed that is comfortable for you.

Your identity and any record of your performance will remain strictly confidential. Your participation is voluntary, and you may discontinue participation at any time without penalty.

Please complete the following:

I accept responsibilty and release the researchers from liability for any injury I may incur as the result of my participation in this study. To the best of my knowledge I have no physical or medical condition which would disallow my participation in this study. I am also covered under a medical insurance plan (either through the university or a private organization). Under the conditions set forth above I voluntarily agree to participate in this study. Please include an address that we may use to send you a copy of the abstract that will result from this research.

Name________________________ Signature___________________________

ID #________________________ Date_____________ Phone____________

Address ____

For more information, or if you have any questions, please call

Fritz Streff or Dr. E. Scott Geller at 961-6223, or

Dr. Stephen Zaccaro (Chairman, Human Subjects Committee) at 961-7916

APPENDIX D:

ANOVA TABLES

ANOVA Source Table

Dependent variable: Lap Latency

4 Experimental Conditions X 2 Genders X 2 Phases X 15 Trials

Source	df	SS	MS	F
<u>Between</u>				
Condition	3	314.43	104.81	1.30
Gender	1	604.33	604.33	7.52*
Condition X Gender	3	115.18	38.39	0.48
error	48	3857.61	80.37	——
<u>Within</u>				
Phase	1	662.14	662.14	140.09*
Phase X Condition	3	39.05	13.02	2.75*
Phase X Gender	1	2.21	2.21	0.47
Phase X Cond. X Gender	3	7.26	2.42	0.51
error	48	226.88	4.73	——
Trial	14	123.14	8.80	11.65*
Trial X Condition	42	46.61	1.11	1.47*
Trial X Gender	14	9.21	0.66	0.87
Trial X Cond. X Gender	42	22.82	0.54	0.72
error	672	507.26	0.75	——
Trial X Phase	14	30.66	2.19	3.11*
Trial X Phase X Cond.	42	25.77	0.61	0.87
Trial X Phase X Gend.	14	5.36	0.38	0.54
Trial X Ph. X Co. X G.	42	26.16	0.62	0.88
error	672	473.17	0.70	——

* $p < .05$

ANOVA Source Table

Dependent variable: Time (latency) Difference

2 Belt Use Phase 1 X 2 Belt Use Phase 2

Source	df	SS	MS	F
Between				
Belt Use Phase 1	1	0.0053	0.0053	3.43
Belt Use Phase 2	1	0.0005	0.0005	0.32
Phase 1 X Phase 2	1	0.0063	0.0063	4.09*
error	52	0.0799	0.0015	——

* $p < .05$

ANOVA Source Table

Dependent variable: Time (latency) Phase 2

2 Belt Use Phase 1 X 2 Belt Use Phase 2

Source	df	SS	MS	F
Between				
Belt Use Phase 1	1	434.07	434.07	0.77
Belt Use Phase 2	1	572.10	572.10	1.01
Phase 1 X Phase 2	1	118.18	118.18	0.21
error	52	29448.60	566.32	——

* $p<.05$

ANOVA Source Table

Dependent variable: Time to Newport (track)

2 Belt Use to Track X 3 Car Size (large, med., small)

Source	df	SS	MS	F
Between				
Belt Use to Track	1	0.00	0.00	0.00
Car Size	2	2.91	1.44	2.11
Belt Use X Car Size	2	5.40	2.70	3.91*
error	43	29.68	0.69	——

* $p < .05$

ANOVA Source Table

Dependent variable: Diastolic Blood Pressure

4 Experimental Conditions X 2 Genders X 4 Physiological Measurement Trials

Source	df	SS	MS	F
Between				
Condition	3	1092.49	364.16	0.33
Gender	1	10909.85	10909.85	10.02*
Condition X Gender	3	1186.11	395.37	0.36
error	48	52276.98	1089.10	——
Within				
Phase	3	118.86	39.61	0.15
Phase X Condition	9	2921.15	324.57	1.23
Phase X Gender	3	160.52	53.50	0.20
Phase X Cond. X Gender	9	2422.35	269.15	1.02
error	144	38117.77	264.71	——

* $p<.05$

ANOVA Source Table

Dependent variable: Systolic Blood Pressure

4 Experimental Conditions X 2 Genders X 4 Physiological Measurement Trials

Source	df	SS	MS	F
Between				
Condition	3	181.10	60.37	0.05
Gender	1	69030.23	69030.23	53.25*
Condition X Gender	3	701.21	233.74	0.18
error	48	62226.88	1296.39	——
Within				
Phase	3	2014.17	671.39	5.30*
Phase X Condition	9	131.205	145.91	1.15
Phase X Gender	3	840.40	280.13	2.21
Phase X Cond. X Gender	9	2223.21	247.02	1.95*
error	144	18251.64	126.75	——

* $p<.05$

ANOVA Source Table

Dependent variable: Machine Measured Pulse

4 Experimental Conditions X 2 Genders X 4 Physiological Measurement Trials

Source	df	SS	MS	F
<u>Between</u>				
Condition	3	394.96	131.65	0.12
Gender	1	1991.90	1991.90	1.75
Condition X Gender	3	1597.69	532.56	0.47
error	48	54601.14	1137.53	——
<u>Within</u>				
Phase	3	1394.26	464.75	5.42*
Phase X Condition	9	1366.63	151.85	1.77
Phase X Gender	3	1052.29	350.76	4.09*
Phase X Cond. X Gender	9	718.14	79.79	0.93
error	144	12349.28	85.76	——

* $p<.05$

ANOVA Source Table

Dependent variable: Stethescope Measured Pulse

4 Experimental Conditions X 2 Genders X 4 Physiological Measurement Trials

Source	df	SS	MS	F
Between				
Condition	3	12.32	4.11	0.12
Gender	1	108.25	108.25	3.08
Condition X Gender	3	100.881	33.63	0.96
error	48	1686.27	35.13	——
Within				
Phase	3	49.45	16.48	13.66*
Phase X Condition	9	24.57	2.72	2.26*
Phase X Gender	3	15.13	5.04	4.18*
Phase X Cond. X Gender	9	22.01	2.44	2.03*
error	144	173.77	1.21	——

* $p < .05$

ANOVA Source Table

Dependent variable: Safety Perception Phase 2

2 Belt Use Phase 1 X 2 Belt Use Phase 2

Source	df	SS	MS	F
Between				
Belt Use Phase 1	1	0.45	0.45	0.27
Belt Use Phase 2	1	15.02	15.02	9.07*
Phase 1 X Phase 2	1	0.45	0.45	0.27
error	52	86.07	1.66	——

* $p < .05$

ANOVA Source Table

Dependent variable: Effort Perception Phase 2

2 Belt Use Phase 1 X 2 Belt Use Phase 2

Source	df	SS	MS	F
Between				
Belt Use Phase 1	1	3.02	3.02	1.50
Belt Use Phase 2	1	4.02	4.02	2.00
Phase 1 X Phase 2	1	0.02	0.02	0.00
error	52	104.76	2.01	——

* $p<.05$

ANOVA Source Table

Dependent variable: Comfort Perception Phase 2

2 Belt Use Phase 1 X 2 Belt Use Phase 2

Source	df	SS	MS	F
<u>Between</u>				
Belt Use Phase 1	1	0.29	0.29	0.16
Belt Use Phase 2	1	1.79	1.79	1.00
Phase 1 X Phase 2	1	1.79	1.79	1.00
error	52	93.40	1.80	——

* $p<.05$

ANOVA Source Table

Dependent variable: Safety Perception Difference

2 Belt Use Phase 1 X 2 Belt Use Phase 2

Source	df	SS	MS	F
<u>Between</u>				
Belt Use Phase 1	1	5.79	5.79	7.02*
Belt Use Phase 2	1	8.64	8.64	10.49*
Phase 1 X Phase 2	1	0.64	0.64	0.78
error	52	42.86	0.82	——

* $p < .05$

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