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The *Transportation Research Record: Journal of the Transportation Research Board* publishes approximately 25% of the more than 3,000 papers that are peer reviewed each year. The mission of the Transportation Research Board (TRB) is to disseminate research results to the transportation community. The Record series contains applied and theoretical research results as well as papers on research implementation.

The TRB peer review process for the publication of papers allows a minimum of 30 days for initial review and 60 days for rereview, to ensure that only the highest-quality papers are published. At least three reviews must support a committee's recommendation for publication. The process also allows for scholarly discussion of any paper scheduled for publication, along with an author-prepared closure.

The basic elements of the rigorous peer review of papers submitted to TRB for publication are described below.

Paper Submittal: June 1–August 1

Papers may be submitted to TRB at any time. However, most authors use the TRB web-based electronic submission process available between June 1 and August 1, for publication in the following year's Record series.

Initial Review: August 15–November 15

TRB staff assigns each paper by technical content to a committee that administers the peer review. The committee chair assigns at least three knowledgeable reviewers to each paper. The initial review is completed by mid-September.

By October 1, committee chairs make a preliminary recommendation, placing each paper in one of the following categories:

1. Publish as submitted or with minor revisions,
2. Publish pending author changes and rereview, or
3. Reject for publication.

By late October, TRB communicates the results of the initial review to the corresponding author indicated on the paper submission form. Corresponding authors communicate the information to coauthors. Authors of papers in Category 2 (above) must submit a revised version addressing all reviewer comments and must include a cover letter explaining how the concerns have been addressed.

Rereview: November 20–January 25

The committee chair reviews revised papers in Category 1 (above) to ensure that the changes are made and sends the Category 2 revised papers to the initial reviewers for rereview. After rereview, the chairs make the final recommendation on papers in Categories 1 and 2. If the paper has been revised to the committee's satisfaction, the chair will recommend publication. The chair communicates the results of the rereview to the authors.

Discussion: February 1–May 1

Discussions may be submitted for papers that will be published. TRB policy is to publish the paper, the discussion, and the author's closure in the same Record.

Many papers considered for publication in the *Transportation Research Record* are also considered for presentation at TRB meetings. Individuals interested in submitting a discussion of any paper presented at a TRB meeting must notify TRB no later than February 1. If the paper has been recommended for publication in the *Transportation Research Record*, the discussion must be submitted to TRB no later than May 1. A copy of this communication is sent to the author and the committee chair.

The committee chair reviews the discussion for appropriateness and asks the author to prepare a closure to be submitted to TRB by June 1. The committee chair reviews the closure for appropriateness. After the committee chair approves both discussion and closure, the paper, the discussion, and the closure are included for publication together in the same Record.

Final Manuscript Submittal: April 1

In early February, TRB requests a final manuscript for publication—to be submitted by April 1—or informs the author that the paper has not been accepted for publication. All accepted papers are published by December 31.

Paper Awards: April to January

The TRB Executive Committee has authorized annual awards sponsored by Groups in the Technical Activities Division for outstanding published papers:

- Charley V. Wootan Award (Policy and Organization Group);
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 - Patricia F. Waller Award (Safety and System Users Group);
 - D. Grant Mickle Award (Operations and Maintenance Group);
- and
- John C. Vance Award (Legal Resources Group).

Other Groups also may nominate published papers for any of the awards above. In addition, each Group may present a Fred Burggraf Award to authors 35 years of age or younger.

Peer reviewers are asked to identify papers worthy of award consideration. Each Group reviews all papers nominated for awards and makes a recommendation to TRB by September 1. TRB notifies winners of the awards, which are presented at the following TRB Annual Meeting.

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In-Vehicle Glance Duration

Distributions, Tails, and Model of Crash Risk

William J. Horrey and Christopher D. Wickens

In general, the unsafe conditions that are likely to produce a motor vehicle crash reside not at the mean of a given distribution (in other words, under typical conditions), but rather in the tails of the distribution. For example, an unusually slow response to a traffic obstacle, rather than an average response, may result in a collision. Although that situation means that crashes are the exception and not the norm, it has implications for how safety-critical data are approached and handled. In this current paper, experimental data collected in a driving simulator are used to demonstrate how an analysis of the average glance durations to an in-vehicle display might lead to different conclusions about safety compared with an alternative analysis of the tail end of the distribution. In addition, a model of crash risk based on the distribution of in-vehicle glances is described, as well as several characteristics of the traffic environment.

Given the high number of vehicles on the road, crashes are fortunately a rare occurrence. However, with the recent growth of new in-vehicle technologies (IVTs) and telematic devices there is increasing visual distraction for drivers (1). To the extent that driving performance is degraded as a result of these devices, there are concerns for safety. Complex, demanding, or compelling in-vehicle tasks may inadvertently draw the driver's gaze into the vehicle and away from the important traffic environment, thereby increasing the likelihood that critical traffic and hazard events may be missed. As demonstrated by Wierwille and Tijerina (2), an increase in in-vehicle glance duration is associated with increased crash risk [see also work by Dingus et al. (3)].

In recognition of these risks, design standards have been proposed to mitigate the amount of time that drivers spend interacting with these devices [e.g., Green (4) and McGehee (5)]. For example, the Alliance of Automobile Manufacturers recommends that the maximum in-vehicle glance duration not exceed 2 s (5). That limit is relevant especially when different display designs or formats are compared, which in turn may inform subsequent production.

Given the importance of this upper limit in articulating regulations, it is somewhat surprising that many studies focus on the average, rather than the extreme glance duration associated with an in-vehicle device. There are, of course, some exceptions [e.g., Lansdown and Fowkes (6), Sodhi et al. (7), Victor et al. (8), and Dingus et al. (9)]

that have cited results on maximum glance durations or proportion of glances that exceeded a given threshold, in describing a number of different in-vehicle devices.

TAIL OF DISTRIBUTION

As discussed by Wickens (10), typically the unsafe circumstances or conditions that are likely to produce a crash do not reside at the mean of a given distribution (i.e., under typical conditions), but rather at the tails of the distribution. For example, a traffic crash may involve unusually adverse weather or high time pressure or a poorly skilled driver. It follows that many crashes are a function of highly unusual or unexpected conditions. (That is not to imply that all crashes involve worse drivers or poor weather—cases residing at the tail end of the distribution—the aim is merely to illustrate that crashes are the exception and not the norm.)

Summala (11) captures a situation in which longer-than-average responses have greater implications for safety. In the study, he examined driver responses to an unexpected roadway event (i.e., the sudden opening of a left-side door of a car parked near the driver's path). For this hazard event, the variability in responses and the longer (extreme) values across the 1,300-plus data points are much more relevant from a safety standpoint than would be the average. Likewise (and borrowing from the aviation literature), several studies have shown that pilot responses to unexpected events, such as automation failure (12) and runway incursions (13–15), vary considerably and that the longest responses are most problematic.

Because traditional statistical procedures rely on the expected mean and other measures of central tendency, it is possible that they may mask important, safety-relevant aspects of a given data set. Specifically, extreme values that lie in the tails of the distribution may be those that are contributing to crash risk, and not the average value. For example, considering in-vehicle glance behavior, if two different displays or in-vehicle tasks show similar mean glance durations, it may be somewhat misleading to equate them with respect to safety, without examining the nature of the distribution of glances around the mean. That is true particularly if “similar” is defined in the context of “not significantly different” using classic statistics with a $p < .05$ criterion (16).

CURRENT GOALS

In the current paper, the purpose is twofold. First, it is demonstrated, using experimental data, how important findings may reside within the tails of a given distribution—findings that may not be uncovered using traditional statistical analysis of the means. Because in-vehicle glances are associated with crash risk (2, 3), the focus is on distributions of

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in-vehicle glances of drivers engaged in a secondary visual task while driving. Second, a crash risk model is elaborated on, based on the distribution of in-vehicle glances, frequency of glances, and characteristics of the traffic environment (17).

The experimental data are derived from a study that examined visual scanning behavior of drivers engaged in a visual in-vehicle task of varying degrees of complexity. Other data from this study are presented elsewhere (18). Drivers in a simulator were asked to perform a concurrent information processing task; specifically, they had to identify whether there were more odd or more even numbers in a string of digits presented on an in-vehicle display. In the simple condition, the string was five digits long. In the complex condition, the string was 11 digits long. For the driving task, periodic wind turbulence pushed the drivers' vehicles off course. Finally, there were several hazard events in which drivers needed to maneuver to avoid a collision.

METHODS

Participants

Eleven younger drivers volunteered for this study (ages 19 to 37 years, $M = 25.6$; 6 males, 5 females). The average years of driving experience was 8.9, and the average annual mileage was 9,200 km (5,700 mi). All participants had normal or corrected-to-normal visual acuity. Drivers were paid \$8/h.

Materials

Simulator Hardware and Software

This study was conducted in the Beckman Institute driving simulator, a fixed-based simulator consisting of a 1998 Saturn SL positioned in a wraparound environment (see Figure 1). Six Epson Powerlite 703C projectors ($1,024 \times 768$ pixels of resolution) projected the driving scenes onto separate 1.5-m-high by 2-m-wide screens (the Walltalkers' Nuvurite model). The forward and rear

horizontal fields subtended 135° of visual angle. An AEI 6.4" LCD screen (with 640×480 pixels of resolution) was mounted near the center console (approximately 38° diagonal offset). Eye movements were measured with a Smart Eye Pro tracking system (Version 3.0.1), which consisted of three Sony XC HR50 monochrome cameras and two IR-illuminators. A 3.2 GHz Pentium PC with 496 MB of RAM powered the tracking system.

The simulator control dynamics were configured for a midsize sedan and controlled and coordinated through Drive Safety's Vection Simulation Software Version 1.6.1. Driving environments and scenarios were created using the HyperDrive Authoring Suite Version 1.6.1 (Drive Safety). In-house software was developed to reduce and analyze eye data.

Driving Environment Overview

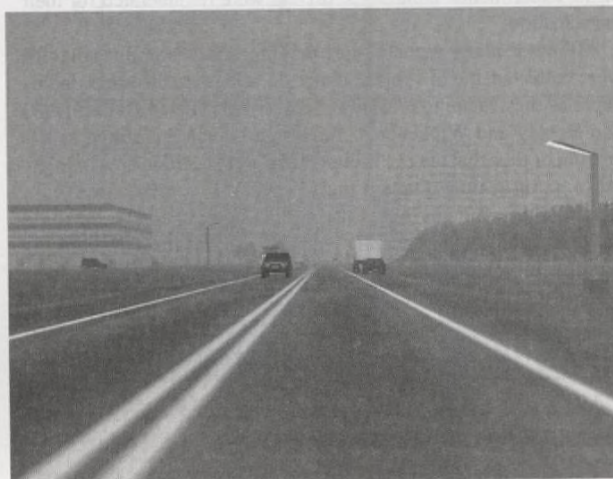
A straight, single-lane industrial city road with a single opposing lane was used for this study (Figure 1). The road environment included some surrounding buildings, a limited number of parked vehicles (approximately nine to 10 per km of roadway), and some ambient traffic in the oncoming lane of travel (at a rate of approximately five per kilometer of roadway). There was no traffic in the drivers' lane. Wind turbulence involved a simulated, external force exerted on the simulator vehicle, within a range of 700 to 1,200 N [e.g., Klasson (19)].

Critical Hazard Events

Several hazard events were included in the form of incursion objects—that is, objects that moved into the driver's path. For these events, a pedestrian, animal (dog), bicyclist, or vehicle traveled on a perpendicular trajectory into the driver's path from behind an initially occluding object (e.g., a parked car). Time-based triggers initiated these hazard events, in each case giving drivers approximately 2.5 s in which to respond to avoid a collision. The frequency of these discrete incursions, however, was limited to reduce the driver's expectancies (six events over the course of eight 3-min blocks).



(a)



(b)

FIGURE 1 Photos of (a) Beckman Institute driving simulator (BIDS) and (b) example of the driving environment.

Procedure

At the start of the 70-min session, participants completed an informed consent form and simulator sickness questionnaire. Drivers were then introduced to the simulator and given a short practice scenario to familiarize them with the control dynamics of the simulator vehicle. Following the practice block, investigators built a profile (head model) of the driver for the eye tracker; the process involved placing digital reference markers in a series of tracker camera photos. During this 15-min process, drivers were asked to complete several questionnaires. Participants were then provided with a description of the experimental tasks.

For the experimental blocks, drivers performed two concurrent tasks: driving and an IVT task. For the driving task, drivers were asked to keep their vehicles in the center of their lane and to obey the speed limit (45 mph). To increase tracking difficulty, lateral wind turbulence was presented at two different rates: low (0.2 Hz) and high wind (0.4 Hz).

The IVT task was intended to mimic the demands of a very compelling in-vehicle task and to induce cognitive load on drivers (over and above what they would encounter when just reading information). Drivers were asked to determine whether there were more odd or more even numbers in a five- (simple) or 11-digit (complex) string of numbers presented on the in-vehicle display. Drivers indicated their response by way of two buttons mounted on the steering wheel (one button for "odd" and one for "even"). For example, the string 58632 has more even digits. The task was presented approximately every 8.5 s (± 1 s). New IVT information could replace old, even if they had not yet finished the task. As such, rapid responses were required to perform this task. Furthermore, the salience of the digits was reduced such that they would be less easily detected with peripheral vision yet could be easily read with focal (foveal) vision. Drivers, therefore, were required to scan to the display to determine whether IVT information was available.

There was a total of eight experimental blocks, each lasting approximately 3 min. Drivers were offered a short break in between each block. Each task combination was completed twice (at both levels of wind frequency and IVT task complexity), the blocks counterbalanced across participant. In six of the eight blocks, drivers were exposed to a discrete hazard event. Following completion of the experimental conditions, drivers were remunerated for their participation.

Although many measures of driving and scanning behavior were collected, the in-vehicle glance durations are discussed in this paper as they relate to crash risk [e.g., Wierwille and Tijerina (2) and Horrey and Wickens (17)]. Here a glance is defined as the amount of time that the eye is directed toward a certain area of interest (e.g., in-vehicle display) until it moves to another area (e.g., windshield/traffic environment). Glances can, therefore, include multiple fixations. In general, Wierwille's (20) 1.6-s threshold is used for in-vehicle glances in describing results, although other more stringent criteria would yield similar results. Other measures of eye behavior and task performance from this study are presented elsewhere [e.g., see Experiment 2 in Horrey et al. (18) for details].

RESULTS AND DISCUSSION

In this section, the data are analyzed in two different ways. First, measures of central tendency are analyzed, as is typical of most experimental endeavors. Following that, the tails of the distribution are examined more closely, specifically, the proportions of longer

than normal in-vehicle glances, because these may have greater implications for driver safety than does the average glance (10).

For the data set, the minimum criterion for a glance was set at 100 ms to filter out samples of transitional eye data (e.g., saccades; 21, 22). Others have used alternate cutoff values, ranging from 60 ms to 200 ms [e.g., Sodhi et al. (7)].

Analysis of Means

Before analysis, extreme values that were ± 2 standard deviations from the mean were removed. Approximately 4% of the glances were removed with that technique. It is acknowledged that the removal of these outliers seemingly contradicts the thesis concerning the relevance of extreme values; however, the purpose in the current section is to employ a typical approach toward data analysis—one that would likely consider outlier removal. (Results do not change with the inclusion of these data.)

Because of the inherent positive skew in the distributions of glance durations, there were violations of normality for some conditions (Shapiro–Wilk, $W = 0.84$, $p < .05$). A log transformation (I) was therefore applied before analysis to improve normality ($W > 0.93$, $p > .36$).

A 2×2 repeated measures analysis of variance (ANOVA) for glance duration was performed with the variables of wind frequency (low, high) and IVT task complexity (simple, complex). This analysis did not reveal any significant main effects for wind [$F(1,10) = 1.3$, $p = .28$] or IVT complexity [$F(1,10) = 2.8$, $p = .13$]; this finding suggests that drivers' in-vehicle glance durations were not moderated by increased driving demands [compare Tsimhoni and Green (23)] or greater task demands for the complex IVT task [e.g., Gellatly and Kleiss (24)]. Furthermore, the two-way interaction was not significant [$F(1,10) = 1.3$, $p = .28$]. Finally, the mean glance durations across the four conditions were well below the 1.6-s threshold ($M = 0.73$ to 0.94 s) discussed by Wierwille (20) as well as the recommended limits (5).

Although there was no difference in the average glance duration, drivers using the complex IVT did fixate on the display more frequently ($M = 114$) than for the simple IVT [$M = 75$; $t(10) = 3.5$, $p = .003$]. According to Wierwille's (20) prescriptive model, shorter-duration, albeit more frequent, glances are intermixed with periods in which the eyes are on the roadway, during which time drivers are preserving safety. Models of supervisory control and optimal sampling suggest that this scanning is determined partially by the bandwidth and expected value of task-relevant information (e.g., 18, 25–30).

Thus, for a single in-vehicle glance, one might conclude that drivers performing a more complex in-vehicle task are not exposing themselves to greater risk because the average glance duration is within the previously established tolerance levels (to the extent that the intermittent glances to the roadway are sufficient for updating driving-relevant information). However, within the distribution of glances for a given display or in-vehicle task, there may be values that might be considered unsafe. Although these are masked by a larger number of shorter-duration values, they represent instances in which the driver was at risk; however, because of the low probability of a critical driving event, the driver "got away with it." That issue is considered in the following.

Analysis of Tails

The distributions of raw glance durations for each of the four conditions are shown in Figure 2 (here the outliers are not removed). As

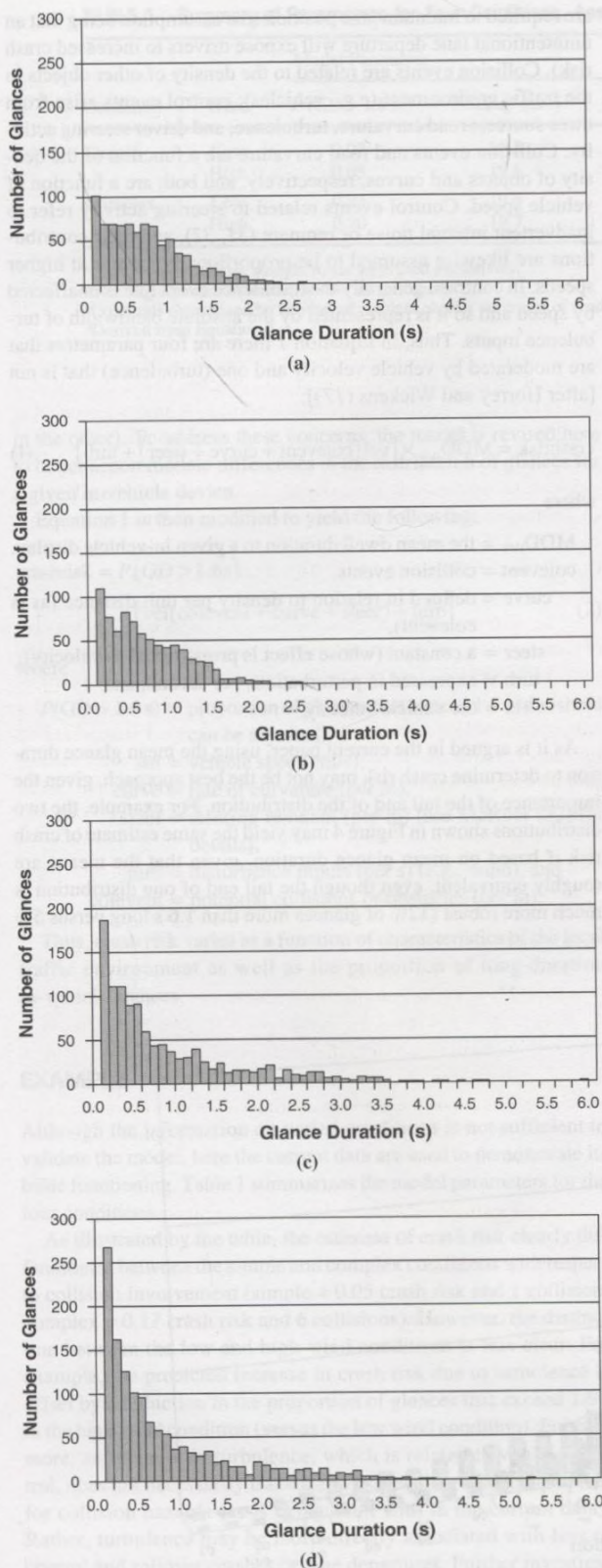


FIGURE 2 Distribution of glance durations by IVT complexity and wind frequency: (a) simple IVT, low wind; (b) simple IVT, high wind; (c) complex IVT, low wind; and (d) complex IVT, high wind.

noted above, the mean glance duration was similar across all conditions, although there were a greater number of fixations in the complex IVT condition. However, here differences in the tail end of the distributions are emphasized. As shown, there were more long-duration glances in the complex IVT conditions (some greater than 4 s) and, as argued by Wickens (10), it may be the unusually long in-vehicle glance that contributes to crash risk and not the average glance duration.

To illustrate, responses to the critical hazard events are examined. In Figure 3, the distribution of in-vehicle glances that occurred immediately before a hazard event are plotted. Response times and collision rates are shown for a few different regions of the distribution. For example, in-vehicle glances exceeding 1.6 s (right side of distribution in Figure 3) resulted in an average hazard response time of 2.0 s. Thus, as the glance duration increases, so does the response time to the hazard event ($r = .81, p < .05$) as well as the likelihood of getting in a collision ($r = .74, p < .05$). Put another way, the longest 22% of in-vehicle glances are accounting for 86% of the observed collisions.

For these discrete hazard events, drivers using the complex IVT were not more likely than those using the simple IVT to be glancing inside the vehicle at the onset of the event [$t(10) = 0.52, p = .32$]. That is, even though there were more overall fixations downward in the complex condition in nonhazard intervals (see previous analysis of frequency), when the hazard events are examined in isolation, the likelihood of looking down was the same across condition. These data suggest that the differences in hazard response times across the two conditions are not simply due to differences in scan frequency for these discrete events. Rather, they are a function of glance duration. The complex IVT conditions, which resulted in 21% of fixations in excess of 1.6 s, were implicated in six of the seven collisions.

Given Figure 3, it is further noted that relying on the average glance duration might lead to an underestimation of the crash risk. That is, the average glance duration for all of the conditions ($M = 0.73$ to 0.94 s) would fall in the portion of the distribution that is

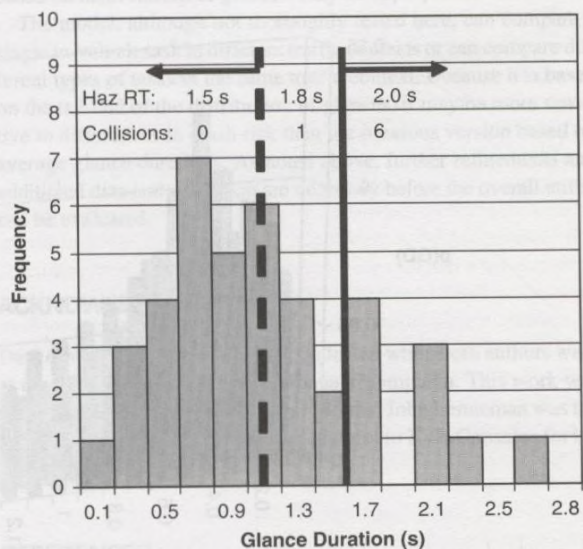


FIGURE 3 Distribution of glance durations immediately before hazard events. Overall mean glance duration (1.1 s) is marked by dashed line. The 1.6-s threshold is marked by the solid line. Mean hazard response time (Haz RT) and collision rate for different portions of curve are shown.

characterized by the fastest hazard responses and the lowest crash rate (i.e., the leftmost region of the distribution in Figure 3).

To quantify and analyze the data in the tails of the distribution, the proportion of glances that exceeded 1.6 s were examined [the threshold cited by Wierwille (20)]. Others have used alternative cutoff points [e.g., Lansdown and Fowkes (6) and Victor et al. (8)]. Overall, roughly 12% of glances to the IVT display exceeded the 1.6-s threshold. These values were not normally distributed ($W = 0.81$, $p = .02$); a log transformation was applied to obtain a distribution that did not significantly deviate from normal ($W > 0.86$, $p > .06$).

A repeated measures ANOVA for the proportion of glances over 1.6 s yielded a significant main effect for IVT complexity [$F(1,10) = 26.3$, $p < .001$]. There was a large difference in the proportion of glances longer than 1.6 s between the simple ($M = 6\%$) and the complex conditions ($M = 21\%$). The main effect for wind was not significant [$F(1,10) = 1.4$, $p = .26$], nor was the two-way interaction [$F(1,10) = 0.8$, $p = .40$]. Unlike for the analysis of mean glance durations, here large differences were observed between the simple and complex IVT task (Cohen's $d = 1.25$), suggesting that characteristics of an IVT task can push drivers to increase the frequency of downward glances that exceed the limit proposed by Wierwille (20), even in cases in which the average glance durations do not differ significantly.

MODIFIED CRASH RISK MODEL

In an earlier paper, a proposed model of crash risk was outlined (17). According to the model, drivers' visual attention could be directed either toward the roadway or to an in-vehicle device; crash risk was, therefore, a function of the mean duration of in-vehicle glances and the frequency of driving events. Events were classified as either (a) potential collisions with on-road objects (e.g., pedestrians, other vehicles) or (b) control events in which steering inputs

are required to maintain lane position (the assumption being that an unintentional lane departure will expose drivers to increased crash risk). Collision events are related to the density of other objects in the traffic environment (e.g., vehicles); control events arise from three sources: road curvature, turbulence, and driver steering activity. Collision events and road curvature are a function of the density of objects and curves, respectively, and both are a function of vehicle speed. Control events related to steering activity refer to inadvertent internal noise or remnant (31, 32), and their contributions are likewise assumed to be proportionally greater at higher speeds. In contrast, generally the turbulence event rate is unaffected by speed and so it is represented by the absolute bandwidth of turbulence inputs. Thus, in Equation 1 there are four parameters that are moderated by vehicle velocity and one (turbulence) that is not [after Horrey and Wickens (17)]:

$$\text{crashrisk} = \text{MDD}_{\text{IVT}} \times [\text{vel}(\text{colevent} + \text{curve} + \text{steer}) + \text{turb}] \quad (1)$$

where

MDD_{IVT} = the mean dwell duration to a given in-vehicle display,

colevent = collision events,

curve = defined in relation to density per unit distance (as is colevent),

steer = a constant (whose effect is proportional to velocity),

turb = expressed in perturbations per second, and

vel = the vehicle velocity.

As it is argued in the current paper, using the mean glance duration to determine crash risk may not be the best approach, given the importance of the tail end of the distribution. For example, the two distributions shown in Figure 4 may yield the same estimate of crash risk if based on mean glance duration, given that the means are roughly equivalent, even though the tail end of one distribution is much more robust (12% of glances more than 1.6 s long versus 5%

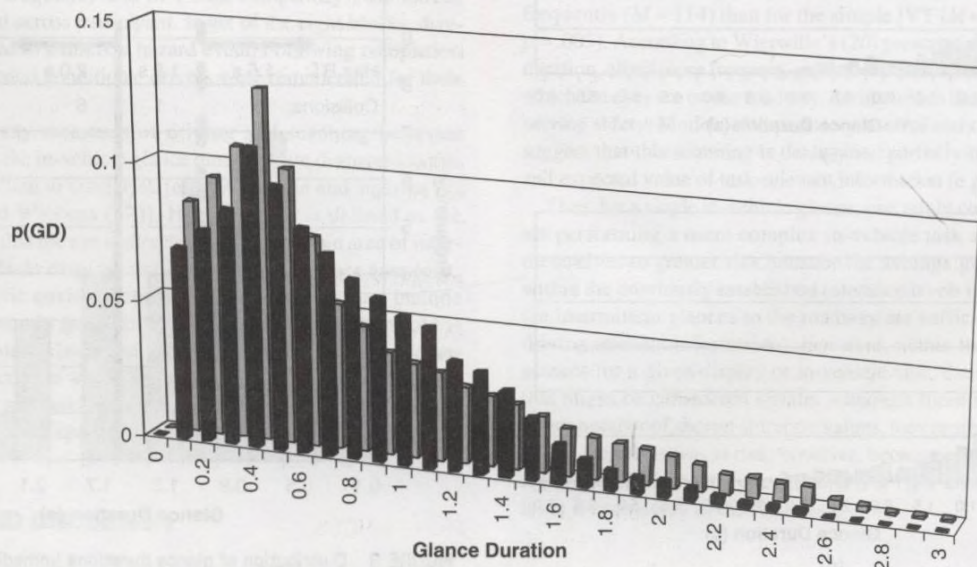


FIGURE 4 Sample distributions with roughly equivalent means ($M = 0.73$); tail ends of distributions vary, however.

TABLE 1 Summary of Parameters for Four Conditions, Associated Crash Risk, and Number of Collisions Observed

Condition	Wind	Model Parameter						Crash Risk ^d	Collisions Observed
		$P(GD > 1.6\text{ s})$	Velocity (m/s)	Curve ^a	Steer ^b	Turb	Colevent ^c		
Simple	Low	0.07	19.5	0	0.01	0.2	0.015	0.05	0
	High	0.05	19.6	0	0.01	0.4	0.015	0.04	1
Complex	Low	0.23	19.6	0	0.01	0.2	0.015	0.16	2
	High	0.20	19.7	0	0.01	0.4	0.015	0.18	4

^aCurve is null because straight roads were used exclusively.

^bSteering remnant is constant across all conditions.

^cColevents determined by number of ambient objects per meter of roadway.

^dDerived from Equation 2.

in the other). To address these concerns, the model is revised here to better accommodate differences in the distribution of glances for a given in-vehicle device.

Equation 1 is then modified to yield the following:

$$\text{crashrisk} = P(GD > 1.6s) \times [\text{vel}(\text{colevent} + \text{curve} + \text{steer}) + \text{turb}] \quad (2)$$

where

$P(GD > 1.6\text{ s})$ = proportion of glances that exceed 1.6 s (threshold can be adjusted),

vel = vehicle speed (m/s),

curve = rate of curvature (per m),

steer = steering remnant (per m) [see McRuer (32) for details],

turb = disturbance inputs (per s) (e.g., wind), and

colevent = potential collisions or obstacles (per m).

Thus, crash risk varies as a function of characteristics of the local traffic environment as well as the proportion of long-duration in-vehicle glances.

EXAMPLE

Although the information on varied conditions is not sufficient to validate the model, here the current data are used to demonstrate its basic functioning. Table 1 summarizes the model parameters for the four conditions.

As illustrated by the table, the estimate of crash risk clearly differentiates between the simple and complex conditions with respect to collision involvement (simple = 0.05 crash risk and 1 collision; complex = 0.17 crash risk and 6 collisions). However, the distinction between the low and high wind conditions is less clear. For example, the predicted increase in crash risk due to turbulence is offset by a reduction in the proportion of glances that exceed 1.6 s in the high wind condition (versus the low wind condition). Furthermore, an increase in turbulence, which is related to vehicle control, does not necessarily translate to a direct increase in crash risk for collision hazards (as is being dealt with in the current data). Rather, turbulence may be more directly associated with loss of control and rollover crashes or lane departures. Further investigations using wide-ranging parameter values and larger data sets are warranted.

CONCLUSION

Here a discussion is presented about how safety-related phenomena may be more strongly linked to those observations that lie in the tail of a given distribution and not necessarily to the mean (10). In this experiment, statistical analysis of the mean glance duration did not clearly differentiate between in-vehicle tasks of varying complexity, the assumption being that crash risk is not elevated on a per-glance basis because drivers are scanning to the traffic environment intermittently (20, 24). However, an examination of the tail of the distributions of glances associated with each task revealed very large differences—differences that had implications for hazard response times and collision involvement. Thus, traditional analysis of the means, although certainly not inappropriate, may limit the understanding of these phenomena. Using additional, alternate measures may allow researchers to better address these potentially important data points [e.g., Green (1)]. Furthermore, many proposed in-vehicle device design standards have recommended that there be limits on the average in-vehicle glance duration in operating these devices [e.g., Green (4) and McGehee (5)]. It is possible that further restrictions, based on distributions of glances, may be appropriate.

The model, although not thoroughly tested here, can compare a single in-vehicle task in different traffic contexts or can compare different types of tasks in the same traffic context. Because it is based on the tail end of the distribution of glances, it may be more sensitive to differences in crash risk than the previous version based on average glance durations. As noted above, further refinements and additional data and validation are necessary before the overall utility can be evaluated.

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