SAVE-IT

SAfety VEhicles using adaptive Interface Technology (Task 1)

DISTRACTED-DRIVING SCENARIOS: A SYNTHESIS OF LITERATURE, 2001 CRASHWORTHINESS DATA SYSTEM (CDS) DATA, AND EXPERT FEEDBACK

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1.0 Program Overview

Driver distraction is a major contributing factor to automobile crashes. National Highway Traffic Safety Administration (NHTSA) has estimated that approximately 25% of crashes are attributed to driver distraction and inattention (Wang, Knipling, & Goodman, 1996). The issue of driver distraction may become worse in the next few years because more electronic devices (e.g., cell phones, navigation systems, wireless Internet and email devices) are brought into vehicles that can potentially create more distraction. In response to this situation, the John A. Volpe National Transportation Systems Center (VNTSC), in support of NHTSA's Office of Vehicle Safety Research, awarded a contract to Delphi Electronics & Safety to develop, demonstrate, and evaluate the potential safety benefits of adaptive interface technologies that manage the information from various in-vehicle systems based on real-time monitoring of the roadway conditions and the driver's capabilities. The contract, known as SAfety VEhicle(s) using adaptive Interface Technology (SAVE-IT), is designed to mitigate distraction with effective countermeasures and enhance the effectiveness of safety warning systems.

The SAVE-IT program serves several important objectives. Perhaps the most important objective is demonstrating a viable proof of concept that is capable of reducing distraction-related crashes and enhancing the effectiveness of safety warning systems. Program success is dependent on integrated closed-loop principles that, not only include sophisticated telematics, mobile office, entertainment and safety warning systems, but also incorporate the state of the driver. This revolutionary closed-loop vehicle environment will be achieved by measuring the driver's state, assessing the situational threat, prioritizing information presentation, providing adaptive countermeasures to minimize distraction, and optimizing advanced collision warning.

To achieve the objective, Delphi Electronics & Safety has assembled a comprehensive team including researchers and engineers from the University of Iowa, University of Michigan Transportation Research Institute (UMTRI), General Motors, Ford Motor Company, and Seeing Machines, Inc. The SAVE-IT program is divided into two phases shown in Figure i. Phase I spans one year (March 2003--March 2004) and consists of nine human factors tasks (Tasks 1-9) and one technology development task (Task 10) for determination of diagnostic measures of driver distraction and workload, architecture concept development, technology development, and Phase II planning. Each of the Phase I tasks is further divided into two sub-tasks. In the first sub-tasks (Tasks 1, 2A-10A), the literature is reviewed, major findings are summarized, and research needs are identified. In the second sub-tasks (Tasks 1, 2B-10B), experiments will be performed and data will be analyzed to identify diagnostic measures of distraction and workload and determine effective and driver-friendly countermeasures. Phase II will span approximately two years (October 2004--October 2006) and consist of a continuation of seven Phase I tasks (Tasks 2C--8C) and five additional tasks (Tasks 11-15) for algorithm and guideline development, data fusion, integrated countermeasure development, vehicle demonstration, and evaluation of benefits.

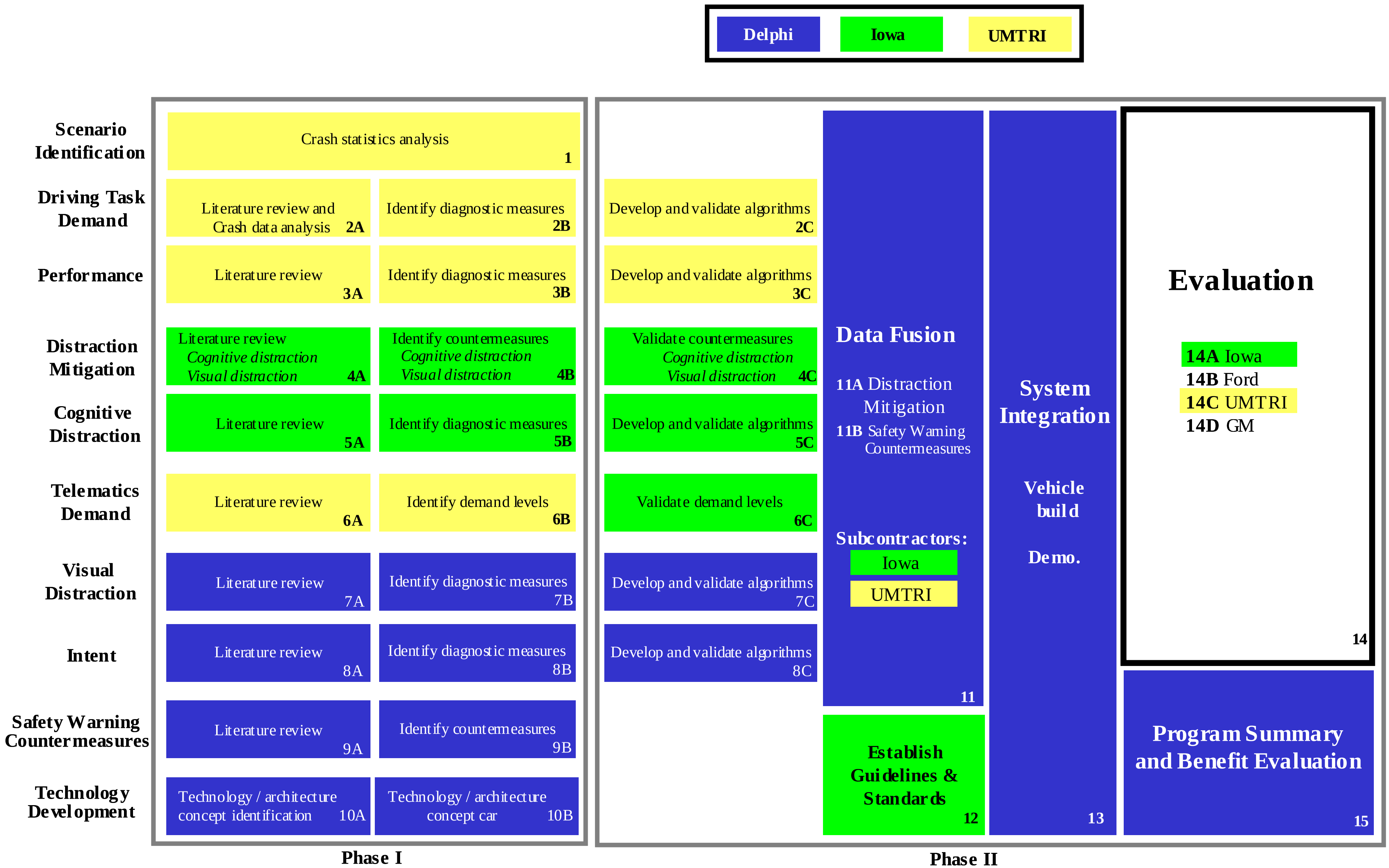

Figure i: SAVE-IT tasks

It is worthwhile to note the SAVE-IT tasks in Figure i are inter-related. They have been chosen to provide necessary human factors data for a two-pronged approach to address the driver distraction and adaptive safety warning countermeasure problems. The first prong (Safety Warning Countermeasures sub-system) uses driver distraction, intent, and driving task demand information to adaptively adjust safety warning systems such as forward collision warning (FCW) systems in order to enhance system effectiveness and user acceptance. Task 1 is designed to determine which safety warning system(s) should be deployed in the SAVE-IT system. Safety warning systems will require the use of warnings about immediate traffic threats without an annoying rate of false alarms and nuisance alerts. Both false alarms and nuisance alerts will be reduced by system intelligence that integrates driver state, intent, and driving task demand information that is obtained from Tasks 2 (Driving Task Demand), 3 (Performance), 5 (Cognitive Distraction), 7 (Visual Distraction), and 8 (Intent).

The safety warning system will adapt to the needs of the driver. When a driver is cognitively and visually attending to the lead vehicle, for example, the warning thresholds can be altered to delay the onset of the FCW alarm or reduce the intrusiveness of the alerting stimuli. When a driver intends to pass a slow-moving lead vehicle and the passing lane is open, the auditory stimulus might be suppressed in order to reduce the alert annoyance of a FCW system. Decreasing the number of false positives may reduce the tendency for drivers to disregard safety system warnings. Task 9 (Safety Warning Countermeasures) will investigate how driver state and intent information can be used to adapt safety warning systems to enhance their effectiveness and user acceptance. Tasks 10 (Technology Development), 11 (Data Fusion), 12 (Establish Guidelines and Standards), 13 (System Integration), 14 (Evaluation), and 15 (Program Summary and Benefit Evaluation) will incorporate the research results gleaned from the other tasks to demonstrate the concept of adaptive safety warning systems and evaluate and document the effectiveness, user acceptance, driver understandability, and benefits and weaknesses of the adaptive systems. It should be pointed out that the SAVE-IT system is a relatively early step in bringing the driver into the loop and therefore, system weaknesses will be evaluated, in addition to the observed benefits.

The second prong of the SAVE-IT program (Distraction Mitigation sub-system) will develop adaptive interface technologies to minimize driver distraction to mitigate against a global increase in risk due to inadequate attention allocation to the driving task. Two examples of the distraction mitigation system include the delivery of a gentle warning and the lockout of certain telematics functions when the driver is more distracted than what the current driving environment allows. A major focus of the SAVE-IT program is the comparison of various mitigation methods in terms of their effectiveness, driver understandability, and user acceptance. It is important that the mitigation system does not introduce additional distraction or driver frustration. Because the lockout method has been shown to be problematic in the aviation domain and will likely cause similar problems for drivers, it should be carefully studied before implementation. If this method is not shown to be beneficial, it will not be implemented.

The distraction mitigation system will process the environmental demand (Task 2: Driving Task Demand), the level of driver distraction [Tasks 3 (Performance), 5 (Cognitive Distraction), 7 (Visual Distraction)], the intent of the driver (Task 8: Intent), and the telematics distraction potential (Task 6: Telematics Demand) to determine which functions should be advised against under a particular circumstance. Non-driving task information and functions will be prioritized based on how crucial the information is at a specific time relative to the level of driving task demand. Task 4 will investigate distraction mitigation strategies and methods that are very well accepted by the users (i.e., with a high level of user acceptance) and understandable to the drivers. Tasks 10 (Technology Development), 11 (Data Fusion), 12 (Establish Guidelines and Standards), 13 (System Integration), 14 (Evaluation), and 15 (Program Summary and Benefit Evaluation) will incorporate the research results gleaned from the other tasks to demonstrate the concept of using adaptive interface technologies in distraction mitigation and evaluate and document the effectiveness, driver understandability, user acceptance, and benefits and potential weaknesses of these technologies.

In particular, driving task demand and driver state (including driver distraction and impairment) form the major dimensions of a driver safety system. It has been argued that crashes are frequently caused by drivers paying insufficient attention when an unexpected event occurs, requiring a novel (non-automatic) response. As displayed in Figure ii, attention to the driving task may be depleted by driver impairment (due to drowsiness, substance use, or a low level of arousal) leading to diminished attentional resources, or allocation to non-driving tasks[1]. Because NHTSA is currently sponsoring other impairment-related studies, the assessment of driver impairment is not included in the SAVE-IT program at the present time. One assumption is that safe driving requires that attention be commensurate with the driving demand or unpredictability of the environment. Low demand situations (e.g., straight country road with no traffic at daytime) may require less attention because the driver can usually predict what will happen in the next few seconds while the driver is attending elsewhere. Conversely, high demand (e.g., multi-lane winding road with erratic traffic) situations may require more attention because during any time attention is diverted away, there is a high probability that a novel response may be required. It is likely that most intuitively drivers take the driving-task demand into account when deciding whether or not to engage in a non-driving task. Although this assumption is likely to be valid in a general sense, a counter argument is that problems may also arise when the situation appears to be relatively benign and drivers overestimate the predictability of the environment. Driving environments that appear to be predictable may therefore leave drivers less prepared to respond when an unexpected threat does arise.

A safety system that mitigates the use of in-vehicle information and entertainment system (telematics) must balance both attention allocated to the driving task that will be assessed in Tasks 3 (Performance), 5 (Cognitive Distraction), and 7 (Visual Distraction) and attention demanded by the environment that will be assessed in Task 2 (Driving Task Demand). The goal of the distraction mitigation system should be to keep the level of attention allocated to the driving task above the attentional requirements demanded by the current driving environment. For example, as shown in Figure ii, "routine" driving may suffice during low or moderate driving task demand, slightly distracted driving may

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[1] The distinction between driving and non-driving tasks may become blurred sometimes. For example, reading street signs and numbers is necessary for determining the correct course of driving, but may momentarily divert visual attention away from the forward road and degrade a driver's responses to unpredictable danger evolving in the driving path. In the SAVE-IT program, any off-road glances, including those for reading street signs, will be assessed in terms of visual distraction and the information about distraction will be fed into adaptive safety warning countermeasures and distraction mitigation sub-systems.

be adequate during low driving task demand, but high driving task demand requires attentive driving.

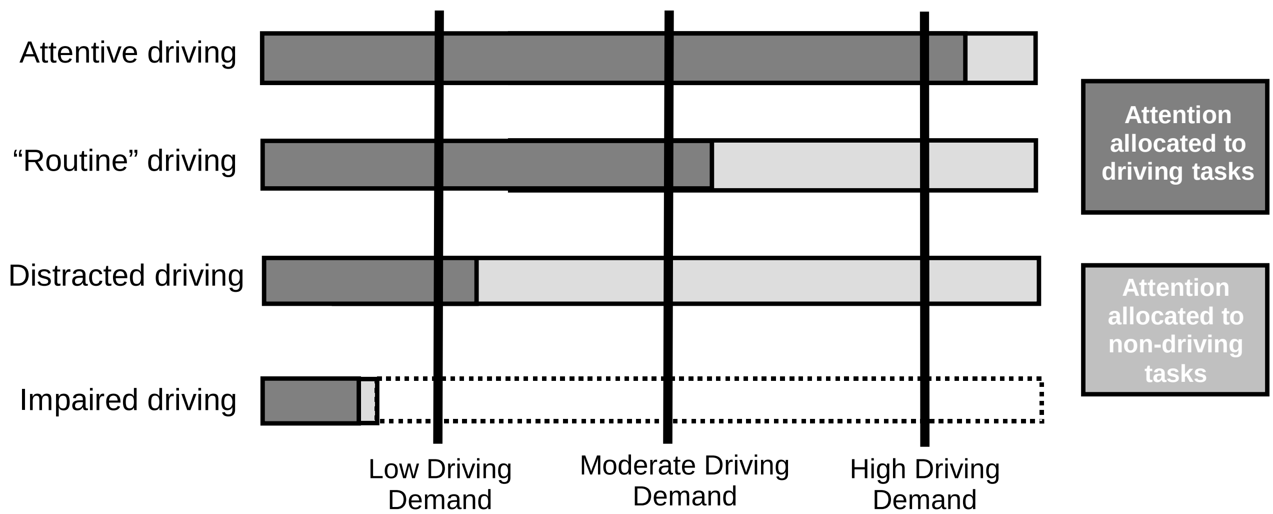


Figure ii. Attention allocation to driving and non-driving tasks

It is important to note that the SAVE-IT system addresses both high-demand and low-demand situations. With respect to the first prong (Safety Warning Countermeasures sub-system), the safety warning systems (e.g., the FCW system) will always be active, regardless of the demand. Sensors will always be assessing the driving environment and driver state. If traffic threats are detected, warnings will be issued that are commensurate with the real time attentiveness of the driver, even under low-demand situations. With respect to the second prong (Distraction Mitigation sub-system), driver state including driver distraction and intent will be continuously assessed under all circumstances. Warnings may be issued and telematics functions may be screened out under both high-demand and low-demand situations, although the threshold for distraction mitigation may be different for these situations.

It should be pointed out that drivers tend to adapt their driving, including distraction behavior and maintenance of speed and headway, based on driving (e.g., traffic and weather) and non-driving conditions (e.g., availability of telematics services), either consciously or unconsciously. For example, drivers may shed non-driving tasks (e.g., ending a cell phone conversation) when driving under unfavorable traffic and weather conditions. It is critical to understand this "driver adaptation" phenomenon. In principle, the "system adaptation" in the SAVE-IT program (i.e., adaptive safety warning countermeasures and adaptive distraction mitigation sub-systems) should be carefully implemented to ensure a fit between the two types of adaptation: "system adaptation" and "driver adaptation". One potential problem in a system that is inappropriately implemented is that the system and the driver may be reacting to each other in an unstable manner. If the system adaptation is on a shorter time scale than the driver adaptation, the driver may become confused and frustrated. Therefore, it is important to take the time scale into account. System adaptation should fit the driver's mental model in order to ensure driver understandability and user acceptance. Because of individual difference, it may also be important to tailor the system to individual drivers in order to maximize driver understandability and user acceptance. Due to resource constraints, however, a nominal driver model will be adopted in the initial SAVE-IT system. Driver profiling, machine learning of driver behavior, individual difference-based system tailoring may be investigated in future research programs.

Communication and Commonalities Among Tasks and Sites

In the SAVE-IT program, a "divide-and-conquer" approach has been taken. The program is first divided into different tasks so that a particular research question can be studied in a particular task. The research findings from the various tasks are then brought together to enable us to develop and evaluate integrated systems. Therefore, a sensible balance of commonality and diversity is crucial to the program success. Diversity is reflected by the fact that every task is designed to address a unique question to achieve a particular objective. As a matter of fact, no tasks are redundant or unnecessary. Diversity is clearly demonstrated in the respective task reports. Also documented in the task reports is the creativity of different task owners in attacking different research problems.

Task commonality is very important to the integration of the research results from the various tasks into a coherent system and is reflected in terms of the common methods across the various tasks. Because of the large number of tasks (a total of 15 tasks depicted in Figure i) and the participation of multiple sites (Delphi Electronics & Safety, University of Iowa, UMTRI, Ford Motor Company, and General Motors), close coordination and commonality among the tasks and sites are key to program success. Coordination mechanisms, task and site commonalities have been built into the program and are reinforced with the bi-weekly teleconference meetings and regular email and telephone communications. It should be pointed out that little time was wasted in meetings. Indeed, some bi-weekly meetings were brief when decisions can be made quickly, or canceled when issues can be resolved before the meetings. The level of coordination and commonality among multiple sites and tasks is unprecedented and has greatly contributed to program success. A selection of commonalities is described below.

Commonalities Among Driving Simulators and Eye Tracking Systems In Phase I
Although the Phase I tasks are performed at three sites (Delphi Electronics & Safety, University of Iowa, and UMTRI), the same driving simulator software, Drive Safety™ (formerly called GlobalSim™) from Drive Safety Inc., and the same eye tracking system, FaceLab™ from Seeing Machines, Inc. are used in Phase I tasks at all sites. The performance variables (e.g., steering angle, lane position, headway) and eye gaze measures (e.g., gaze coordinate) are defined in the same manner across tasks.

Common Dependent Variables An important activity of the driving task is tactical maneuvering such as speed and lane choice, navigation, and hazard monitoring. A key component of tactical maneuvering is responding to unpredictable and probabilistic events (e.g., lead vehicle braking, vehicles cutting in front) in a timely fashion. Timely responses are critical for collision avoidance. If a driver is distracted, attention is diverted from tactical maneuvering and vehicle control, and consequently, reaction time (RT) to probabilistic events increases. Because of the tight coupling between reaction time and attention allocation, RT is a useful metric for operationally defining the concept of driver distraction. Furthermore, brake RT can be readily measured in a driving simulator and is widely used as input to algorithms, such as the forward collision warning algorithm (Task 9: Safety Warning Countermeasures). In other words, RT is directly related to driver safety. Because of these reasons, RT to probabilistic events is chosen as a primary, “ground-truth” dependent variable in Tasks 2 (Driving Task Demand), 5 (Cognitive Distraction), 6 (Telematics Demand), 7 (Visual Distraction), and 9 (Safety Warning Countermeasures).

Because RT may not account for all of the variance in driver behavior, other measures such as steering entropy (Boer, 2001), headway, lane position and variance (e.g., standard deviation of lane position or SDLP), lane departures, and eye glance behavior (e.g., glance duration and frequency) are also be considered. Together these measures will provide a comprehensive picture about driver distraction, demand, and workload.

Common Driving Scenarios For the tasks that measure the brake RT, the "lead vehicle following" scenario is used. Because human factors and psychological research has indicated that RT may be influenced by many factors (e.g., headway), care has been taken to ensure a certain level of uniformity across different tasks. For instance, a common lead vehicle (a white passenger car) was used. The lead vehicle may brake infrequently (no more than 1 braking per minute) and at an unpredictable moment. The vehicle braking was non-imminent in all experiments (e.g., a low value of deceleration), except in Task 9 (Safety Warning Countermeasures) that requires an imminent braking. In addition, the lead vehicle speed and the time headway between the lead vehicle and the host vehicle are commonized across tasks to a large extent.

Subject Demographics It has been shown in the past that driver ages influence driving performance, user acceptance, and driver understandability. Because the age effect is not the focus of the SAVE-IT program, it is not possible to include all driver ages in every task with the budgetary and resource constraints. Rather than using different subject ages in different tasks, however, driver ages are commonized across tasks. Three age groups are defined: younger group (18-25 years old), middle group (35-55 years old), and older group (65-75 years old). Because not all age groups can be used in all tasks, one age group (the middle group) is chosen as the common age group that is used in every task. One reason for this choice is that drivers of 35-55 years old are the likely initial buyers and users of vehicles with advanced technologies such as the SAVE-IT systems. Although the age effect is not the focus of the program, it is examined in some tasks. In those tasks, multiple age groups were used.

The number of subjects per condition per task is based on the particular experimental design and condition, the effect size shown in the literature, and resource constraints. In order to ensure a reasonable level of uniformity across tasks and confidence in the research results, a minimum of eight subjects is used for each and every condition. The typical number of subjects is considerably larger than the minimum, frequently between 10-20.

Other Commonalities In addition to the commonalities across all tasks and all sites, there are additional common features between two or three tasks. For example, the simulator roadway environment and scripting events (e.g., the TCL scripts used in the driving simulator for the headway control and braking event onset) may be shared between experiments, the same distraction (non-driving) tasks may be used in different experiments, and the same research methods and models (e.g., Hidden Markov Model) may be deployed in various tasks. These commonalities afford the consistency among the tasks that is needed to develop and demonstrate a coherent SAVE-IT system.

The Content and Structure of the Report

This document reports on the results of Task 1 of the SAVE-IT project. This document presents the methods utilized for analysis of CDS crash data and the soliciting of opinions from several experts in the field of driver distraction. Results from the crash database analyses are presented along with the feedback from the experts. The report concludes with an analysis of the previous literature review, crash analyses, and expert opinions to determine the most important crash types, driving scenarios, and distractors for the SAVE-IT system.

1.1 INTRODUCTION

As described in the literature review for this task (Eby & Kostyniuk, 2003), the safe operation of a motor vehicle requires that a driver focus a substantial portion of his or her attentional resources on driving-related tasks, including monitoring the roadway, anticipating the actions of other drivers, and controlling the vehicle. A driver may also, however, be engaged in other non-driving activities that compete for his or her attentional resources. As these non-driving activities increase, the driver allocates greater attention to them, or the driver's attentional capacity is reduced (e.g., fatigue), and there is a reduction in the attentional resources necessary for safe driving. Driver inattention has been found to be a major factor in traffic crashes, with 20-50 percent of crashes involving some form of inattention (Goodman, Bents, Tijerina, Wierwille, Lerner, & Benel, 1997; Ranney, Garrott, & Goodman, 2001; Stutts, Reinfurt, & Rodgman, 2001; Sussman, Bishop, Madnick, & Walter, 1985; Wang, Knipling & Goodman, 1996).

Development of technology to reduce distraction-related crashes is proceeding, including the development of a workload/distraction management system in the SAfety VEhicle(s) using adaptive Interface Technology (SAVE-IT) program. In order to determine the potential benefits of systems such as SAVE-IT, it is necessary to understand the crash scenarios in which driver distraction is a likely contributor. The purpose of this report is to present the results of detailed analyses of distraction-related crashes to help guide the SAVE-IT team in developing algorithms and technology best suited for the types of crashes and situations that the SAVE-IT system is most likely to be able to prevent.

This task entailed three activities. The first was a literature review (Eby & Kostyniuk, 2003) that reviewed past work on crash-based distracted-driving scenarios, other distracted-driving scenarios that may not show up in crash databases. The literature review also considered several crash databases for their appropriateness for use in this study. The second task was a detailed analysis of distraction-related crashes. Determining the effect of distraction on crash risk is challenging for a variety of reasons. Crash reports, from which detailed crash databases are derived, often lack good information about distraction-related events leading up to the crash and surrogate measures of distraction-related crashes, such as "rear-end crashes," can be overly subjective and inaccurate. In addition, even when crash data contain good distraction-related information, interpretation of these data is difficult because information about the frequency of exposure to the distraction scenario is not available. With these limitations in mind, we reviewed all available crash databases and selected the National Accident Sampling System (NASS) Crashworthiness Data System (CDS) as the most appropriate for our purpose (see Eby & Kostyniuk, 2003 for more details). The third task was to send the literature review and the crash analysis results to a group of experts on distraction-related crashes to obtain their opinions on which scenarios the SAVE-IT system should be designed to prevent. This document reports the results of the final two activities.

1.2 METHODS

1.2.1. CRASH DATA ANALYSIS

1.2.1.1. Data Source

The NASS-CDS data for 2001 was used in this analysis, the most recent CDS data available at the time of the study. All analyses and reported percentages are based upon weighted data using the NASS-derived weights.

1.2.1.2. Method

Logically and anecdotally, distracted driving must be a frequent occurrence and crashes do not happen each time a driver becomes distracted. Instead, in most cases, the distraction does not cause the driver to miss critical information needed to prevent a crash (such as a lead vehicle decelerating) because these critical events are infrequent. Even if the driver is delayed in recognizing critical information, he or she may still be able to react with enough time to avoid a crash. Similarly, drivers who are attentive get in crashes, either because they incorrectly interpreted critical information, recognized the information too late to avoid a crash, or reacted incorrectly to the information. Thus, the difference between the proportions of distracted and attentive crashes for a given set of variables is related to the added element of distraction. Based upon this concept, we compare attentive to distracted crashes to determine the sets of variables where the proportion of distracted-driving crashes is greater than the proportion of attentive crashes for the same variables.

The CDS variable *Driver Distraction/Inattention to Driving* was used in this analysis. This variable may either be not coded, coded as "attentive", or take on one of the following distraction/inattention values:

$ Looked, but did not see
$ By other occupant(s)
$ By moving object in vehicle
$ While talking/listening cell phone
$ While dialing cell phone
$ While adjusting climate controls
$ While adjusting radio, cassette, CD
$ While using other device/controls integral to vehicle
$ While using/reaching device/object brought into vehicle
$ Inattentive lost in thought
$ Sleepy or fell asleep
$ Distracted by outside person, object, or event
$ Eating or drinking
$ Smoking related
$ Other, distraction/inattention
$ Unknown

Based upon this variable, crashes (unweighted n = 4,090) were divided into three categories. *Distracted crashes* were all crashes in which a distraction/inattention variable was coded. Since the SAVE-IT system is not designed to target "Drowsy Driving" those crashes listed with this variable (unweighted n = 181) were removed from the analysis and placed in a separate category. The distraction/inattention variable "looked, but did not see" is a difficult variable to understand. The NASS (2001) coding manual defines this variable as:

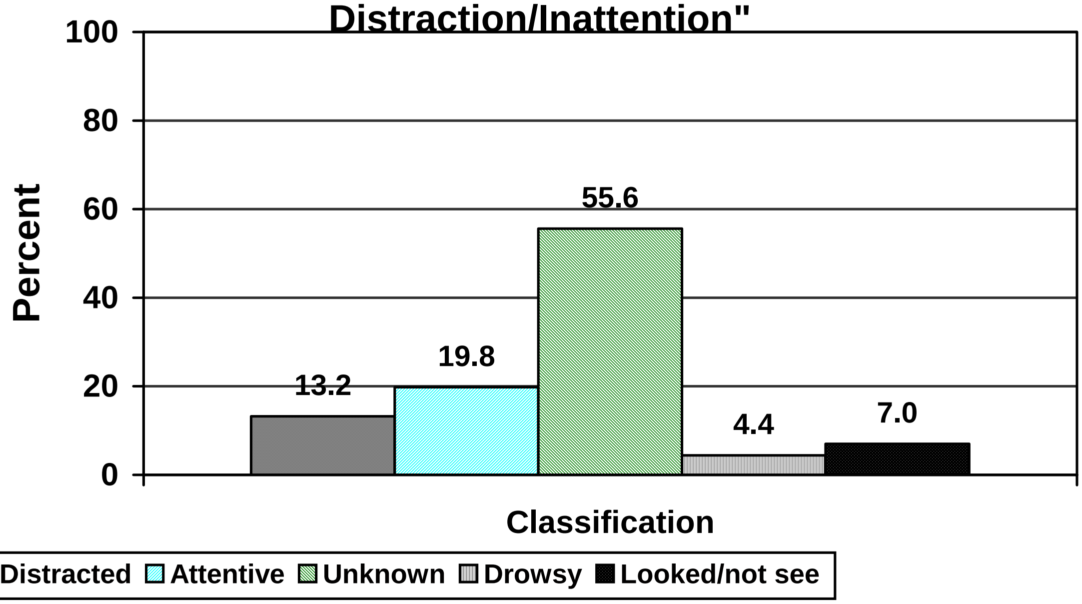
> "...selected when the driver is paying attention to driving, but does not see the relevant vehicle, object, etc. This attribute should be used when a driver has an opportunity to take some action prior to impact, but the driver takes no action and no other distractions apply. This situation frequently occurs when an overtaking vehicle is in the driver's blind spot or at intersections when you look both ways and a crossing vehicle is not noticed. If the driver sees the vehicle, object, etc., but does no consider it a danger, and no other distractions apply, then select 'attentive or not distracted'." (NASS, 2001, pg 215).

Based upon this coding definition, crashes listed as "looked, but did not see" should all be considered as a special class of attentive crashes. This variable is coded based upon driver interview. If one realistically considers the reasons why someone might state that they looked but did not see an oncoming vehicle, only a few possibilities emerge. The first is the vehicle was out of the line of sight and therefore physically blocked. In other words, the design characteristics of the roadway are not appropriate for safe intersection negotiation. While undoubtedly this is the case for some intersections, it cannot explain that fact that this code is used in nearly 21 percent of all intersection-related and vehicle-crossing-path-related crashes. If it did, then it would suggest that there are serious civil engineering problems with our nation's intersections. The second possibility is that the weather conditions such as fog occluded the vehicle. Again, while this may be the case in a few instances, this severe type of weather is not common. The third reason is that the driver's visual or cognitive abilities are impaired to the extent that they cannot perceive or process the vehicle information. While, impairment to this extent is quite uncommon in the general population, it is possible that some of the crashes coded with this variable are due to physical impairments in older drivers. However, preliminary analysis of this code showed that it was much more common for drivers under 65 years of age than for older drivers. The final reason is that the driver was distracted and is, knowingly or unknowingly, incorrectly stating the reason for their crash as "looked, but did not see." This final reason is supported by the results of recent research that has found that conversations (McCarley, et al., 2001) and cell phone use (Srayer, Drews, & Johnston, 2003) while driving can disrupt visual processing of information even when the driver is looking at the traffic scene, a form of inattention blindness. We discussed this final possibility with a highly experienced NASS-CDS crash investigator. This investigator indicated that *at least* the majority of cases that are coded "looked, but did not see" are really distracted drivers.

All crashes in which at least one driver was coded as "looked, but did not see" (unweighted n = 208) were included in the "distracted" crash category (unweighted n = 801; total distracted-crash unweighted n = 985) for three reasons: (1) as we have just described, it is likely that the majority of these crashes are distraction-related; (2) the SAVE-IT system will be designed to help mitigate crashes in which a driver merges into a vehicle in the driver's "blind spot" as well as assisting in detecting vehicles around the driver; and (3) so that the present results can be compared to results in which "looked, but did not see" were either removed from the analyses or included as attentive crashes. This final reason is important since this code is utilized quite frequently for certain crash types and infrequently for other crashes types. Depending upon what researchers do with this variable, quite different results may be obtained. When the distracted-crash category is combined with the "looked, but did not see" crashes, the percentage of distraction-related crashes is 20.2.

Attentive crashes were all crashes in which all involved drivers were listed in this variable as "attentive" (unweighted n = 1,746). The final category was "unknown" (unweighted N = 2,532). This category included the set of all crashes that were not included as "distracted" or "attentive" as well as "drowsy". As shown in Figure 1.1, about 56 percent of crashes in the 2001 CDS database were in this latter category. Note that these percentages are based on weighted rather than unweighted numbers.

Figure 1.1: Distribution of CDS Crashes Based Upon The Variable "Driver Distraction/Inattention"



Both distracted and attentive crashes were further divided into the five crash types defined by NASS (2001). These crash types were defined as follows.

Single driver (SD)*:* As shown in Figure 1.2, this type includes all roadside departures either to the left or the right side of the road for various reasons as well as impacting stationary objects and road-end departures (distracted unweighted n = 203; attentive unweighted n = 445).

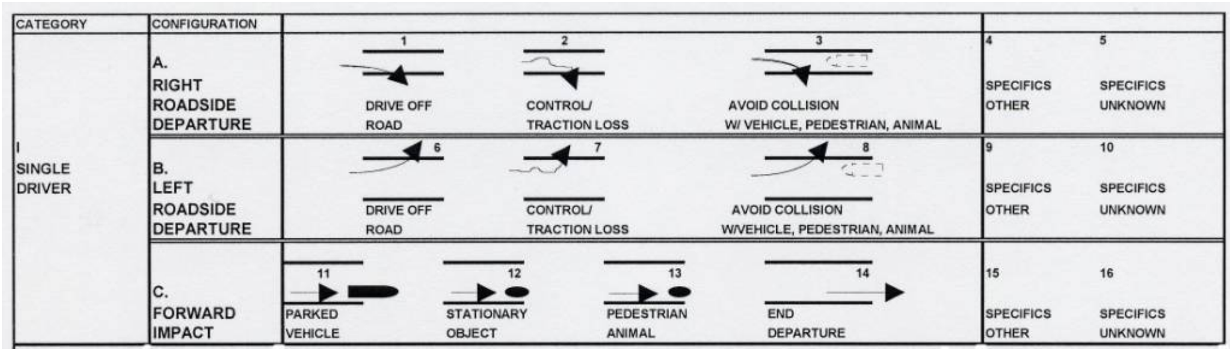


Figure 1.2: NASS definition for crashes in the single driver (SD) type.

***Same Trafficway, Same Direction (STSD)**:* As shown in Figure 1.3, this type includes crashes in which two or more vehicles traveling in the same direction and roadway are involved. This includes various types of rear-end crashes as well as sideswipe crashes departures (distracted unweighted n = 148; attentive unweighted n = 71).

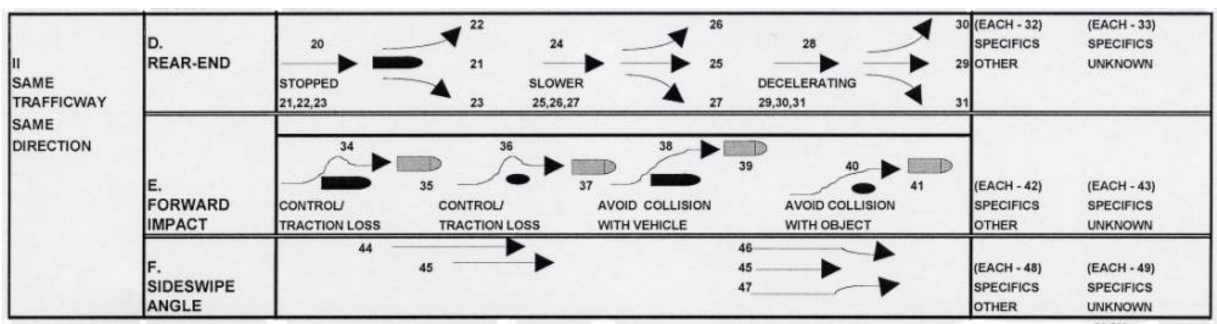


Figure 1.3: NASS definition for crashes in the same trafficway same direction STSD) type.

***Intersecting Path (IP)**:* As shown in Figure 1.4, this type includes crashes where vehicles are traveling in straight but intersecting paths, such as at a roadway intersection departures (distracted unweighted n = 112; attentive unweighted n = 69).

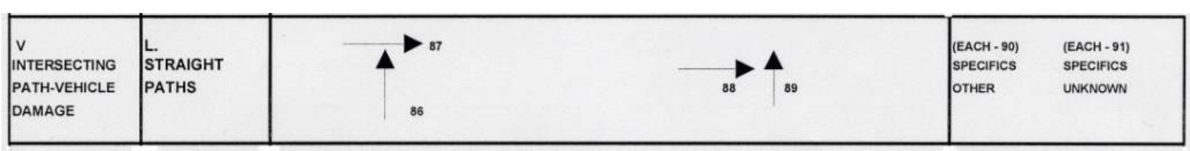


Figure 1.4: NASS definition for crashes in the intersecting path (IP) type.

***Change Trafficway, Vehicle Turning (CTVT)**:* As shown in Figure 1.5, this type includes crashes where one vehicle is either turning across or into the path of another vehicle, such as during a merge or a turn into a driveway departures (distracted unweighted n = 284; attentive unweighted n = 128).

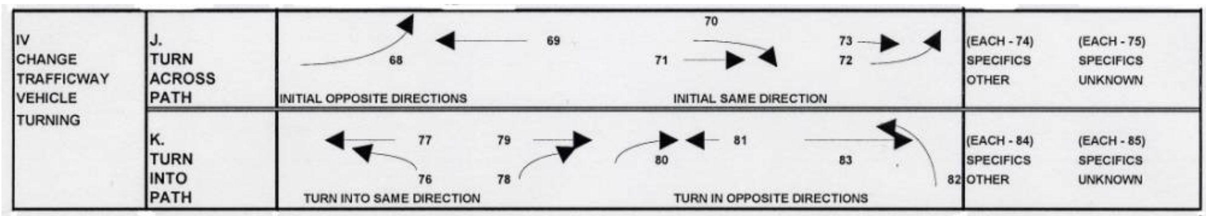


Figure 1.5: NASS definition for crashes in the change trafficway, vehicle turning (CTVT) type.

***Same Trafficway, Opposite Direction (STOD)**:* As shown in Figure 1.6, this type includes crashes between two or more vehicles traveling in the opposite direction on the same roadway. This includes various types of head-on crashes as well as angle/sideswipe crashes departures (distracted unweighted n = 40; attentive unweighted n = 35).

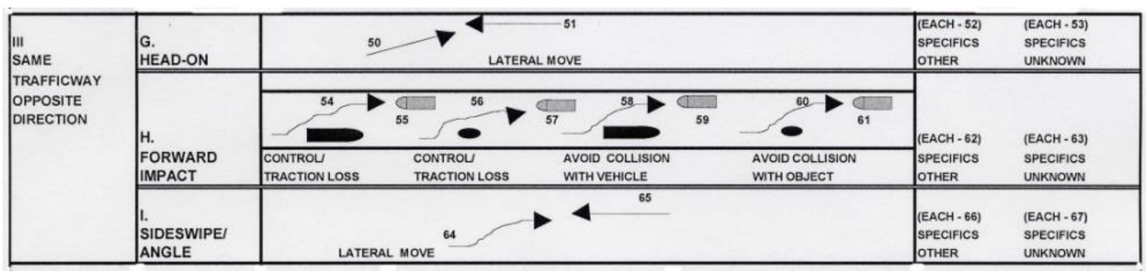


Figure 1.6: NASS definition for crashes in the same trafficway, opposite direction (STOD) type.

NASS also defines a miscellaneous category that includes backing up crashes, untripped rollovers, and unknown crash types. This category was not included in these analyses.

In order to determine scenarios in which distraction-related crashes are disproportionately high, we compared nationally weighted proportions of both attentive and distracted crashes on similar variables. Those cases where the weighted proportion of distracted crashes was higher than the weighted proportion of attentive crashes, are scenarios in which distraction may be a potentially important contributor to the crash. The results are presented in three parts: Distracted versus attentive crashes; comparisons among crash types; and comparisons by crash type.

1.2.2. EXPERT PANEL ANALYSIS

Based upon feedback from SAVE-IT team members, a number of experts in driver distraction and distraction-related-crash-database analysis were selected from outside of the SAVE-IT team. In addition to these experts, several researchers from within the SAVE-IT team also were included as experts. Each selected person received a copy of the literature review (Eby & Kostyniuk, 2003) and the CDS crash analyses reported in the results section of this document. Experts were given the following instructions:

1) First read the literature review. This review begins with a brief overview of the SAVE-IT program and proposed technology. The remainder of the review discusses crash databases for possible assessment of distraction-related crashes, literature on distracted-driving crash scenarios, and distracted driving scenarios that may not appear in crash records directly, but are, nonetheless, likely to be related to distraction-related crashes.

2) Next read the CDS crash data analysis report. These analyses compare proportions of distracted and attentive crashes as a function of numerous factors.

3) Based upon these two documents and your expertise in this field, please list the ten most important distracted-driving scenarios that could be mitigated by the SAVE-IT technology. Please, also, list them in rank order from the most to least important. If possible, please write a few sentences giving us your reasons or justification for your selections.

4) Please provide us with any other written comments you have.

5) Email your response to Dr. David Eby by February 20th, 2004.

We received gracious responses from the following five experts: Dr. Dan Cohen and Dr. Jim Foley (Mitretek), who provided joint comments; Dr. Neil Lerner (Westat); Dr. Louis Tijerina (Ford); and Dr. Harry Zhang (Delphi Delco). No follow-up with the other experts was possible due to project time constraints.

1.3 RESULTS

1.3.1. CRASH DATA ANALYSIS

1.3.1.1 Distracted Versus Attentive Crashes

Month: Figure 1.7 shows the proportion of all distracted and all attentive crashes by month. As can be seen, distraction-related crashes were more frequent during the fall and early winter months (September to January).

Day of Week: Figure 1.8 shows the proportion of distraction-related and attentive crashes by day of week. Distracted crashes were more common during the weekdays (Monday through Thursday) than during weekends (Friday through Sunday). The greatest difference between proportions was found for Monday, where distracted crashes were about 6 percentage points higher.

Time of Day: Figure 1.9 shows the proportion of distracted and attentive crashes by time of day. The proportion of distracted crashed was higher than the proportions of attentive crashes for the time period of 10:00 to 14:59, with distracted crashes nearly twice as common from 12:00 to 14:59.

Sex: Figure 1.10 shows the proportion of distraction-related and attentive crashes by sex. Distracted crashes were slightly more common for females than for males.

Age Group: Figure 1.11 shows the proportion of all distracted and all attentive crashes by age group. Distracted crashes were more frequent than attentive crashes for the 18-25-year-old drivers and drivers 56 years of age or older.

Age Group and Sex: Figures 1.12-1.13 shows the proportion of all distracted and all attentive crashes by males (Figure 1.12) and females (Figure 1.13) by age group. For males, distraction-related crashes were more common for drivers under 19 years of age and drivers more than 65 years of age. The greatest difference was found for male drivers in the 65-75-year-old age group. For females, distraction related crashes were more frequent for drivers 18-25 years of age and for drivers more than 55 years of age, with relatively large differences found for female drivers aged 56-64 and 76 and over.

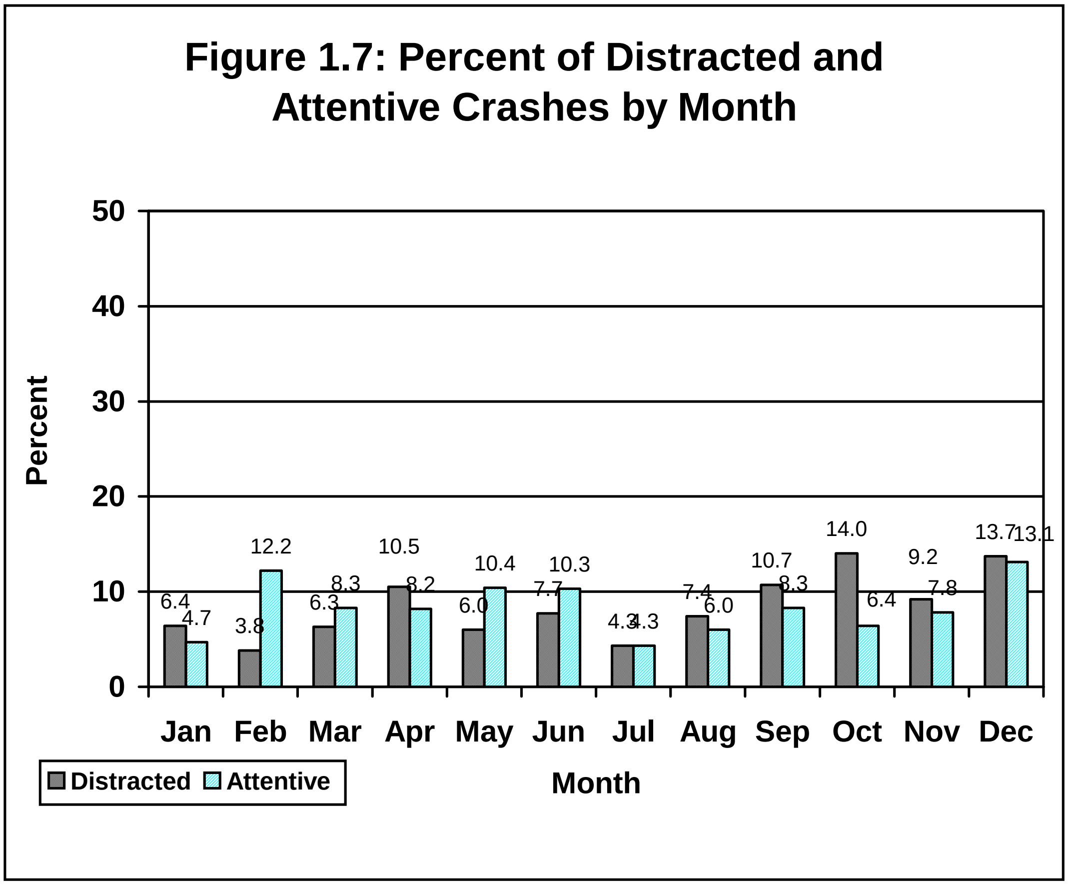


Figure 1.7: Percent of Distracted and Attentive Crashes by Month
Percent
50
40
30
20
10
0
6.4
4.7
3.8
12.2
6.3
8.3
10.5
8.2
6.0
10.4
7.7
10.3
4.3
4.3
7.4
6.0
10.7
8.3
14.0
6.4
9.2
7.8
13.7
13.1
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Distracted
Attentive
Month

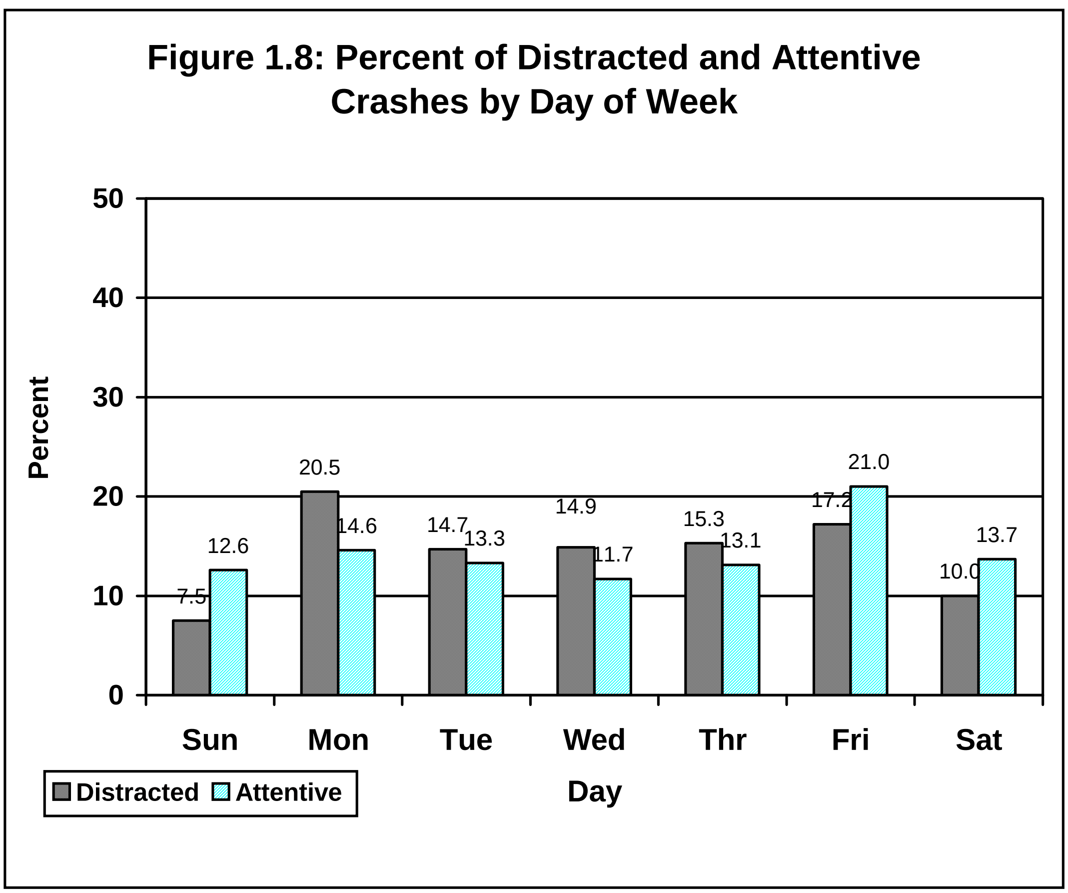


Figure 1.8: Percent of Distracted and Attentive Crashes by Day of Week
Percent
50
40
30
20
10
0
7.5
12.6
20.5
14.6
14.7
13.3
14.9
11.7
15.3
13.1
17.2
21.0
10.0
13.7
Sun
Mon
Tue
Wed
Thr
Fri
Sat
Distracted
Attentive
Day

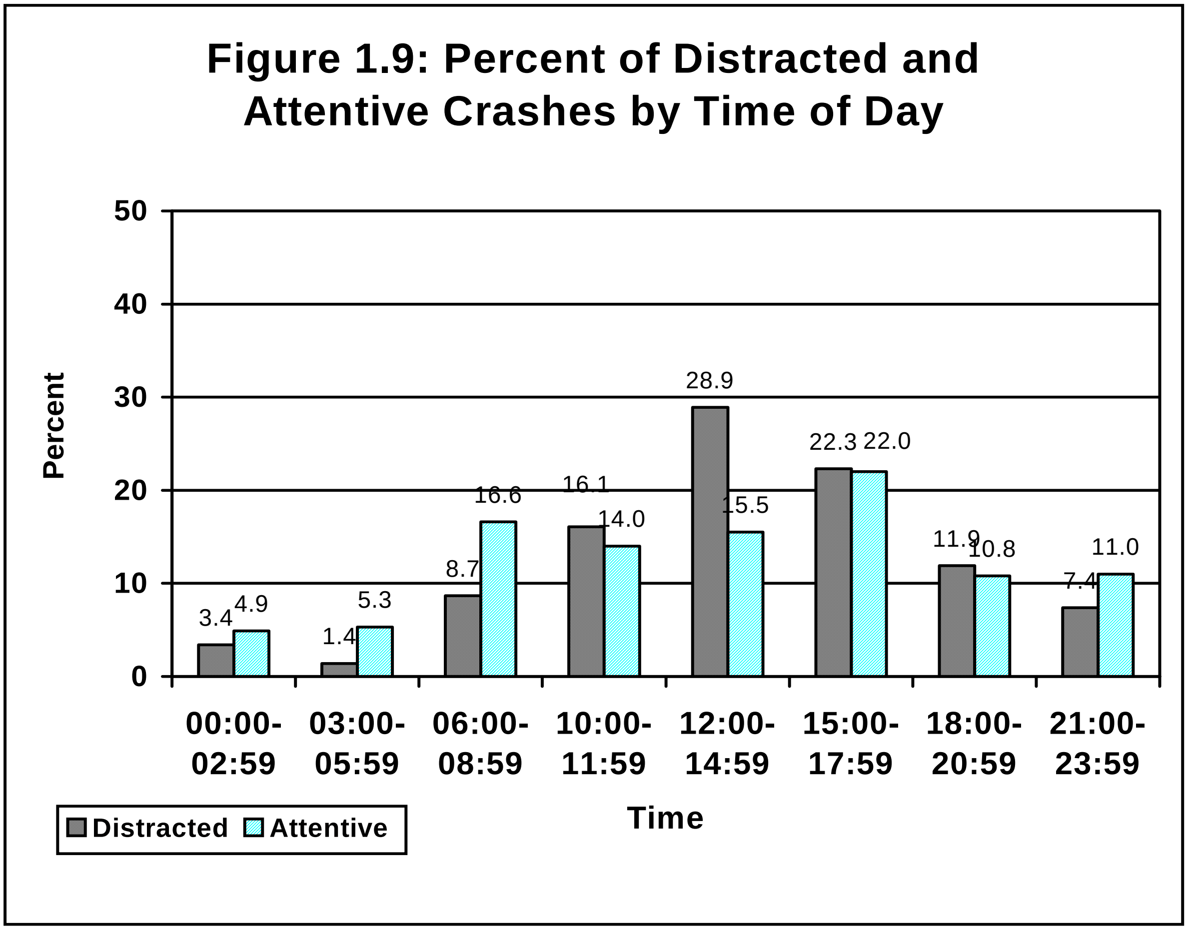


Figure 1.9: Percent of Distracted and Attentive Crashes by Time of Day
Percent
50
40
30
20
10
0
3.4
4.9
1.4
5.3
8.7
16.6
16.1
14.0
28.9
15.5
22.3
22.0
11.9
10.8
7.4
11.0
00:00-02:59
03:00-05:59
06:00-08:59
10:00-11:59
12:00-14:59
15:00-17:59
18:00-20:59
21:00-23:59
Time
Distracted
Attentive

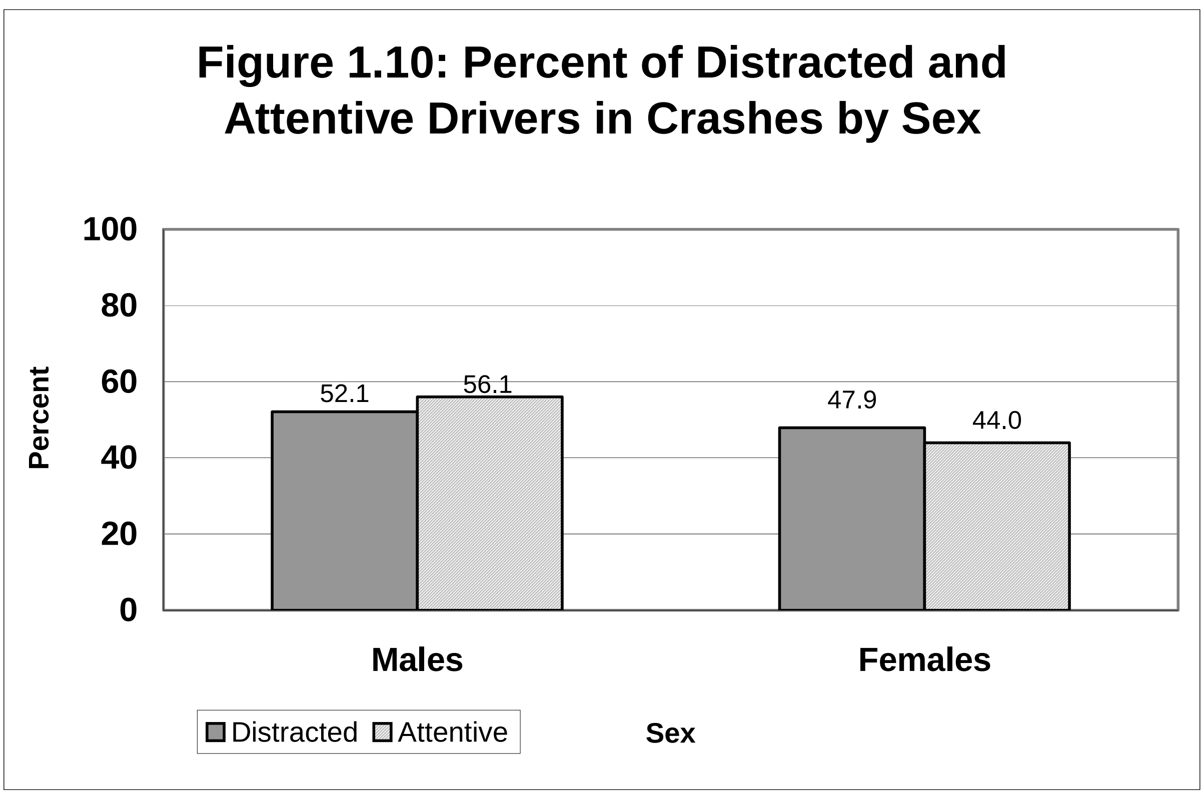


Figure 1.10: Percent of Distracted and Attentive Drivers in Crashes by Sex
Percent
100
80
60
40
20
0
52.1
56.1
47.9
44.0
Males
Females
Sex
Distracted
Attentive

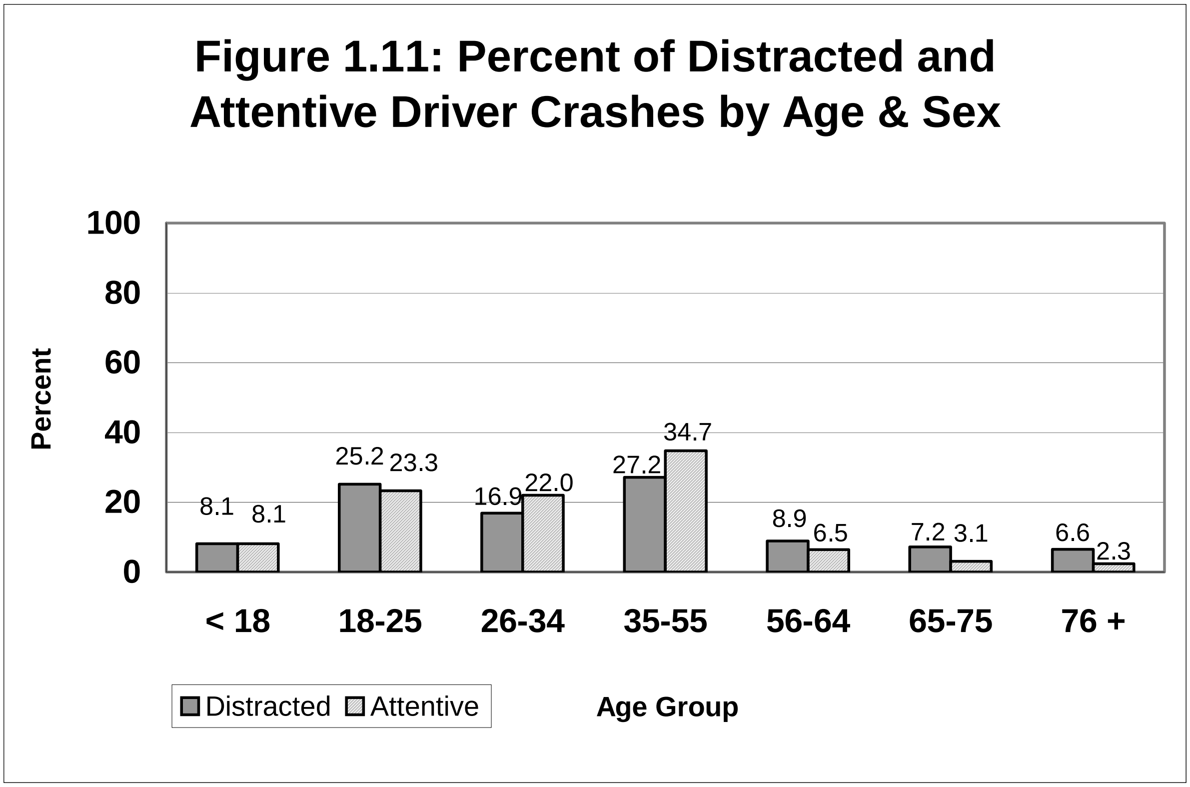


Figure 1.11: Percent of Distracted and Attentive Driver Crashes by Age & Sex
Percent
100
80
60
40
20
0
8.1 8.1
25.2 23.3
16.9 22.0
27.2 34.7
8.9 6.5
7.2 3.1
6.6 2.3
< 18
18-25
26-34
35-55
56-64
65-75
76 +
Distracted
Attentive
Age Group

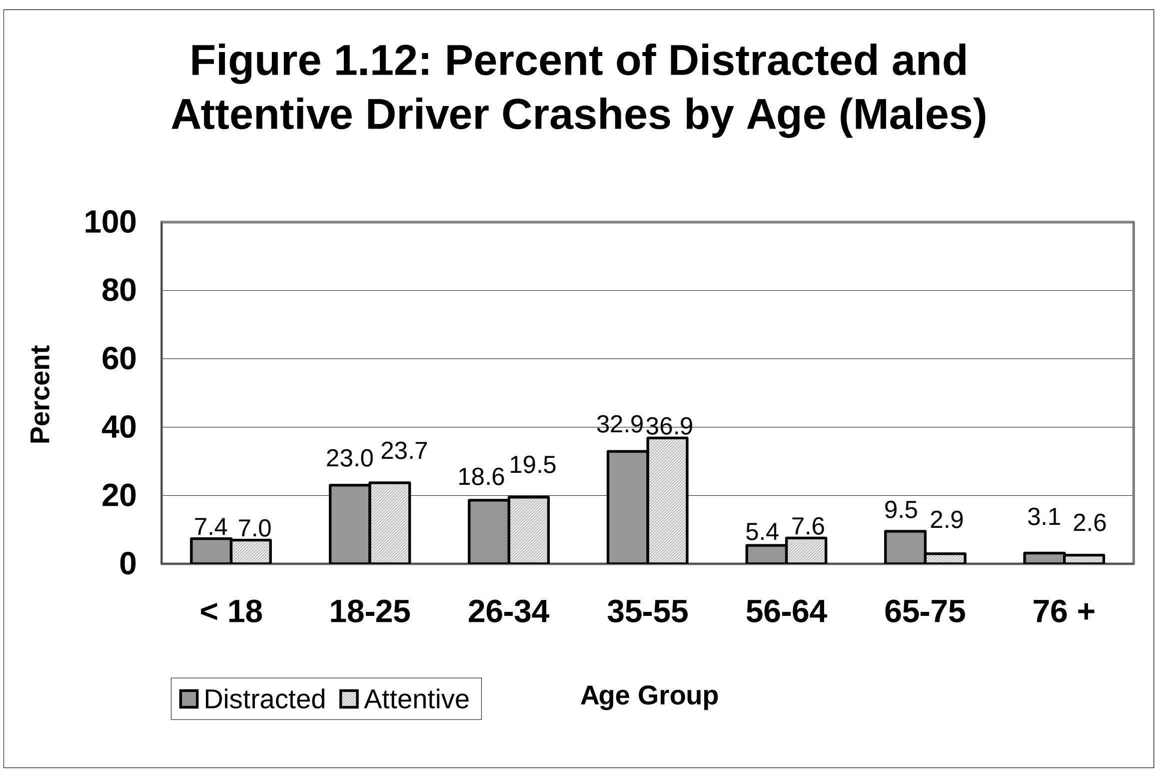


Figure 1.12: Percent of Distracted and Attentive Driver Crashes by Age (Males)
Percent
100
80
60
40
20
0
7.4 7.0
23.0 23.7
18.6 19.5
32.9 36.9
5.4 7.6
9.5 2.9
3.1 2.6
< 18
18-25
26-34
35-55
56-64
65-75
76 +
Distracted
Attentive
Age Group

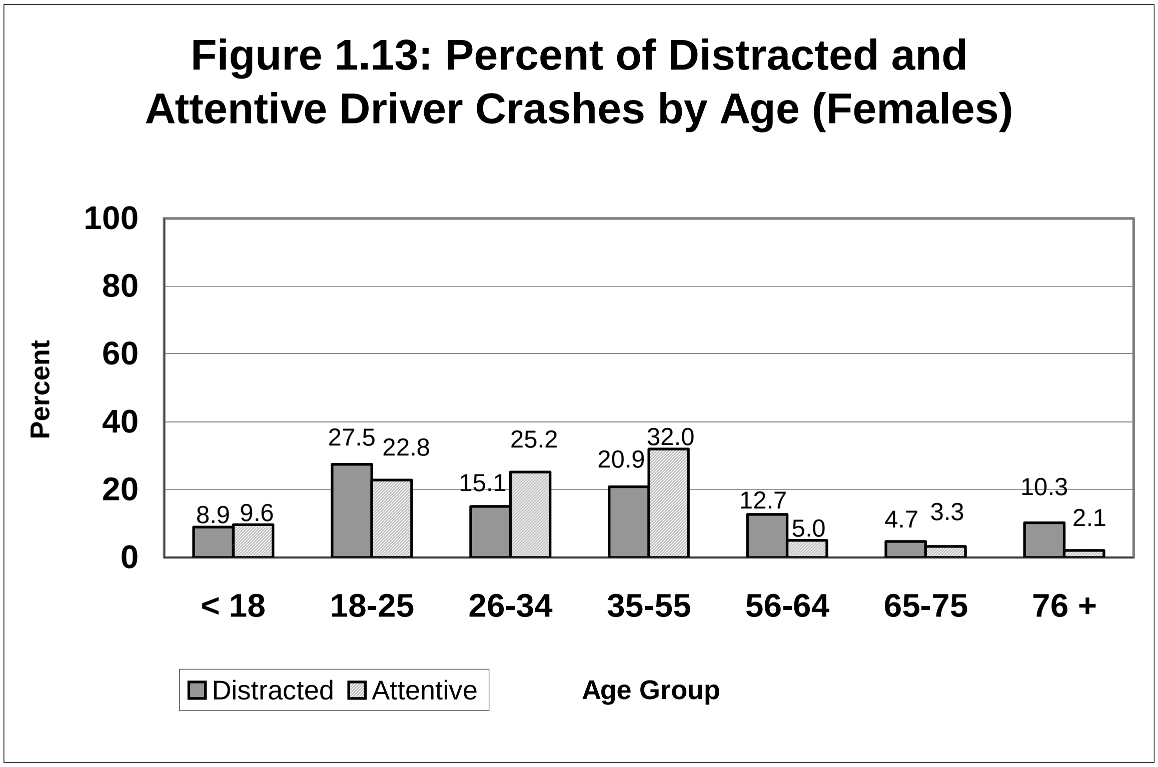


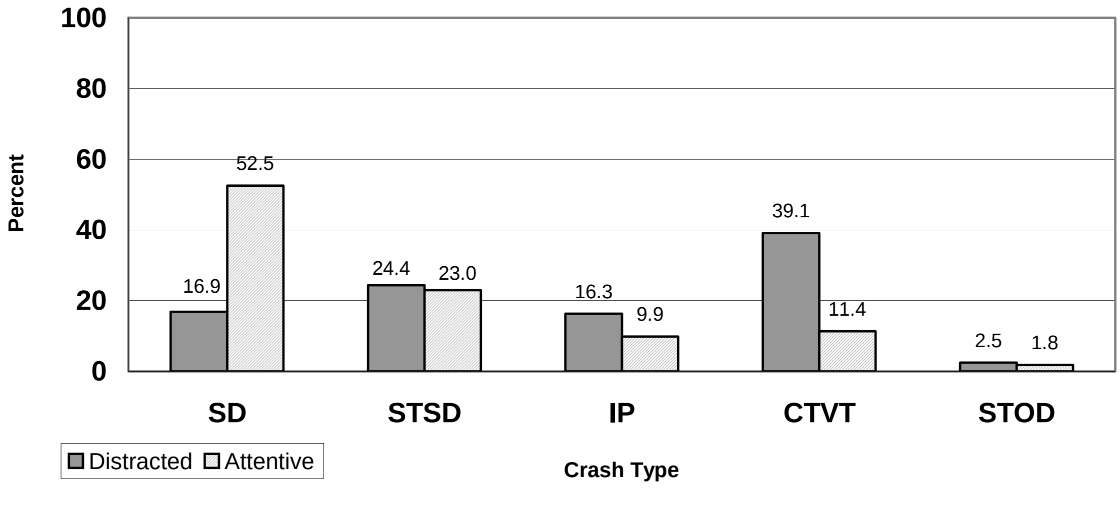
Figure 1.13: Percent of Distracted and
Attentive Driver Crashes by Age (Females)
100
80
60
40
20
0
Percent
8.9 9.6
27.5 22.8
15.1 25.2
20.9 32.0
12.7 5.0
4.7 3.3
10.3 2.1
< 18
18-25
26-34
35-55
56-64
65-75
76 +
Distracted Attentive
Age Group

1.3.1.2. Comparisons Among Crash Types

Figures 1.14-1.16 show distracted and attentive crashes by crash type. Figure 1.14 compares the proportions within all distracted and all attentive crashes. Thus, the proportions of all distracted crashes will sum to 100, as will the proportions for attentive crashes. Figure 1.15 shows the proportions of attentive and distracted crashes for all crashes of that type. In this figure, for each crash type, the proportions for attentive and distracted plus the proportion for "unknown" will sum to 100 percent. Figure 1.16 shows the proportion of attentive and distracted crashes among all crashes in the CDS database. In this figure, summing all bars together with unknown and "drowsy" will add to 100 percent.

These three different ways of calculating proportions of crashes between attentive and distracted crashes revealed similar results. The two main crash types where distraction-related crashes were considerably more frequent were CTVT (see Figure 1.5) and IP (see Figure 1.4) crashes. It is important to note that attentive crashes were much more common in SD (see Figure 1.2) crashes than were distracted crashes. This result differs from what has been found in the literature (see e.g., Wang, Knipling, & Goodman, 1996). However, it is important to note that in the present analyses, crashes coded as "drowsy" in the distraction/inattention variable have been excluded from the "distracted" category, because the SAVE-IT system will not be designed to target drowsy driving. In addition, crashes coded as "looked, but did not see" were included in the "distracted" category.

Figure 1.14: Percent of Distracted and Attentive Crashes by Crash Type



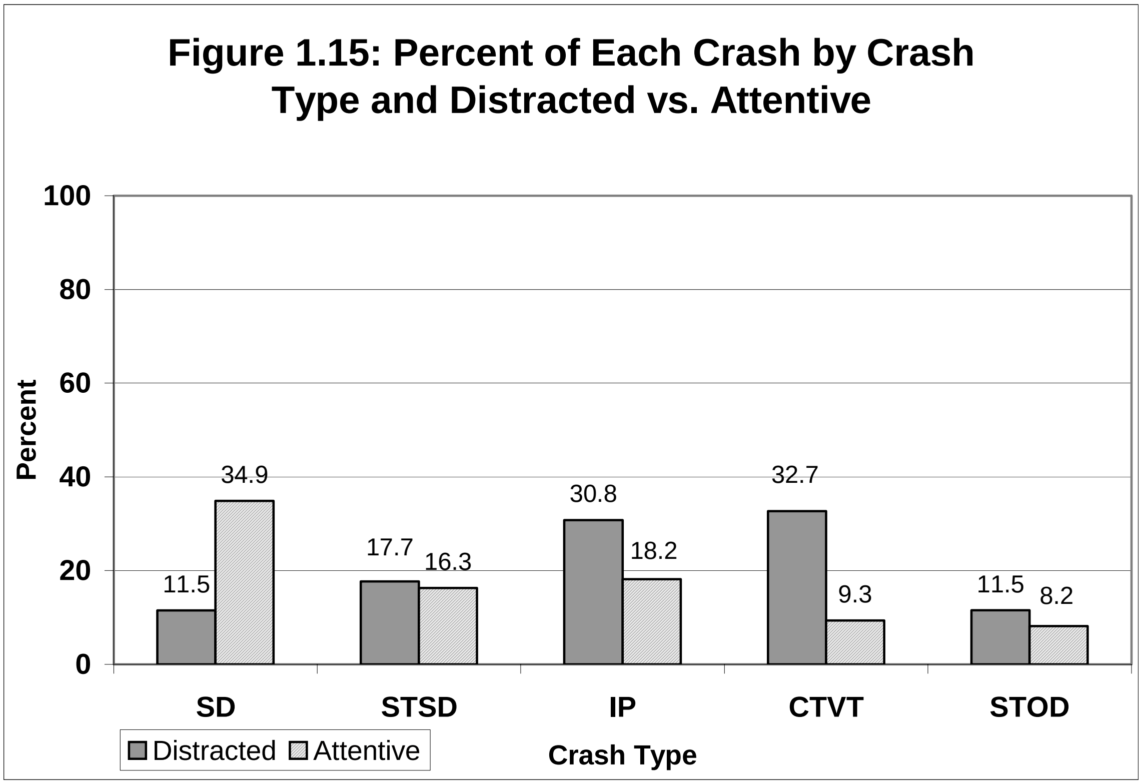


Figure 1.15: Percent of Each Crash by Crash Type and Distracted vs. Attentive
100
80
60
40
20
0
Percent
34.9
11.5
17.7
16.3
30.8
18.2
32.7
9.3
11.5
8.2
SD
STSD
IP
CTVT
STOD
Distracted
Attentive
Crash Type

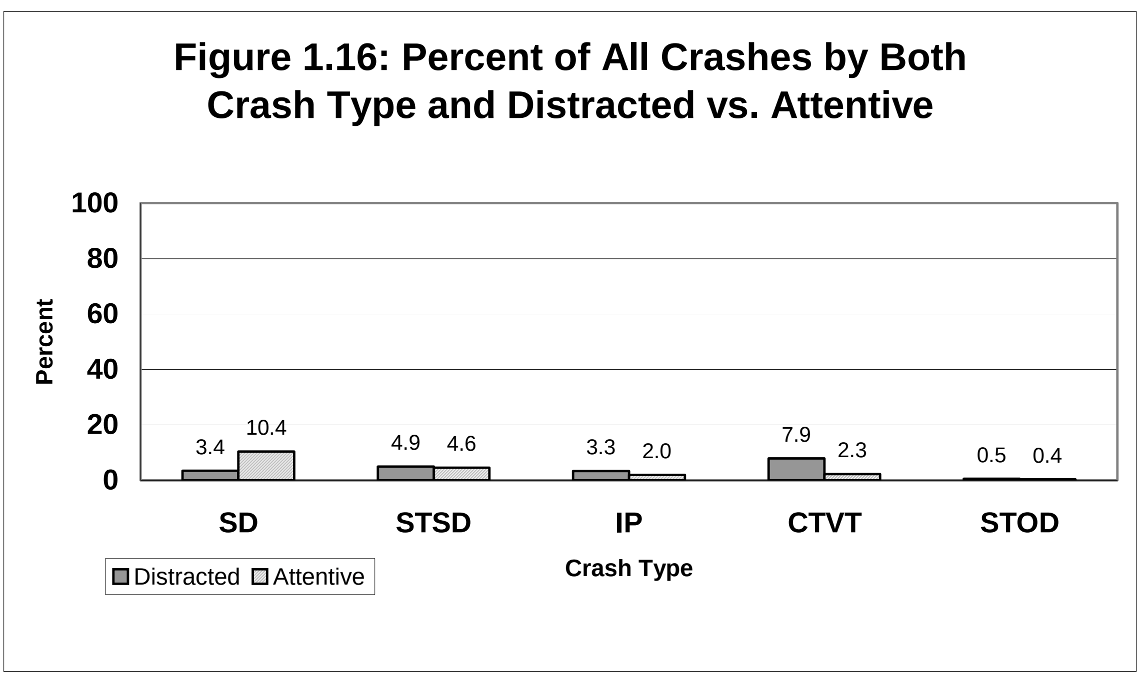


Figure 1.16: Percent of All Crashes by Both Crash Type and Distracted vs. Attentive
100
80
60
40
20
0
Percent
3.4
10.4
4.9
4.6
3.3
2.0
7.9
2.3
0.5
0.4
SD
STSD
IP
CTVT
STOD
Distracted
Attentive
Crash Type

1.3.1.3. Results by Crash Type

1.3.1.3.1. Single Driver (SD)

Sex: Figures 1.17-1.18 show the proportion of all SD distracted and all SD attentive crashes (Figure 1.17) and the proportion of distracted and attentive SD crashes (Figure 1.18) by sex. A greater proportion of both distracted and attentive crashes were attributed to males. Little difference was found between attentive and distracted crashes when the proportions within the crash categories (attentive vs. distracted) are compared. A large difference, however, was found when the proportions were determined as a function of all SD crashes, with distracted crashes much less frequent than attentive crashes for both sexes.

Age Group: The proportion of all distracted and all attentive SD crashes and the proportions of distracted and attentive SD crashes by age group are shown in Figures 1.19 and 1.20. When proportions were compared within the crash categories (Figure 1.19), we found that distracted SD crashes were more common for drivers aged 18-25 and aged 56 or more. When compared among all SD crashes, distracted crashes were slightly more common only for drivers aged 65-75.

Age Group and Sex: Figures 1.21-1.24 show the proportions of SD crashes by male and age (Figure 1.21-1.22) and by female and age (Figures 1.23-1.24). For males, SD distracted crashes were more common for drivers ages 26-34 and for drivers over 55 years of age when proportions were compared within crash categories. When compared among all SD crashes, distracted crashes for males were more common only for drivers aged 65-75. Similar results were found for females.

Number of Lanes: Figures 1.25 and 1.26 show SD crashes by the number of traffic lanes. Distracted SD crashes were common for two, five, and six when proportions are compared within crash categories (Figure 1.25). Attentive crashes were more frequent for all lane numbers when proportions were compared among all SD crashes, except for six occupants.

Roadway Profile: Figures 1.27 and 1.28 show the distributions of distracted and attentive SD crashes by the roadway profile. Comparisons within the crash categories showed that distracted SD crashes were slightly more frequent for level, uphill, and hill crest profiles and less frequent for downhill grades (Figure 1.27). Comparing proportions among all SD crashes showed that distracted SD crashes were less frequent than attentive crashes for all roadway profiles, except hill crests.

Relation to Junction: Figures 1.29 and 1.30 show the distributions of distracted and attentive crashes by the relation to junctions. Comparison within the crash categories showed that distracted SD crashes were more frequent for nonintersection/nonjunction areas (Figure 1.29). Attentive SD crashes were more common in all cases when proportions were compared relative to all SD crashes (Figure 1.30).

Light Conditions: Figures 1.31 and 1.32 show the distributions of distracted and attentive SD crashes by the light conditions. Comparisons within the crash categories showed that distracted SD crashes were slightly more frequent for “dark”, “dark but lighted” and “dusk” lighting conditions (Figure 1.31). Comparing proportions among all SD crashes showed that distracted SD crashes were less frequent than, or equal to, attentive crashes for all lighting conditions.

Roadway Surface Conditions: Figures 1.33 and 1.34 show the distributions of distracted and attentive SD crashes by the roadway surface conditions. Comparisons within the crash categories showed that distracted SD crashes were more frequent for dry roads (Figure 1.33). Comparing proportions among all SD crashes showed that distracted SD crashes were less frequent for all surface conditions (Figure 1.34).

Roadway Surface Type: Figures 1.35 and 1.36 show the distributions of distracted and attentive SD crashes by the roadway surface type. Comparisons within the crash categories showed essentially no difference by type of surface (Figure 1.35). Comparing proportions among all SD crashes showed that distracted SD crashes were less frequent then, or equal to, attentive crashes for all surface types (Figure 1.36).

Trafficway Flow: Figures 1.37 and 1.38 show the distributions of distracted and attentive SD crashes by the trafficway flow. Comparisons within the crash categories showed that distracted SD crashes were more frequent for not-divided and divided/no barrier roads (Figure 1.37). Comparing proportions among all SD crashes showed that distracted SD crashes were less frequent for all trafficway flow types, except for divided/no barrier roads (Figure 1.38).

Weather Conditions: Figures 1.39 and 1.40 show the distributions of distracted and attentive SD crashes by the prevailing weather conditions. Comparisons within the crash categories showed that distracted SD crashes were more frequent for “not adverse” and “foggy” weather (Figure 1.39). Comparing proportions among all SD crashes showed that distracted SD crashes were less frequent than, or equal to, attentive crashes for all weather conditions, except for foggy weather (Figure 1.40).

Number of Occupants: Figures 1.41 and 1.42 show the distributions of distracted and attentive SD crashes by the number of occupants in the vehicle. Distracted SD crashes were generally more common with one, two, or four occupants in the vehicle. When compared within all SD crashes, distracted crashes were less common, or the same, for all numbers of occupants.

Roadway Alignment: Figures 1.43 and 1.44 show the distributions of distracted and attentive SD crashes by the roadway alignment. Comparisons within the crash categories showed that distracted SD crashes were slightly more frequent for straight segments and curves to the left (Figure 1.43). Comparing proportions among all SD crashes showed that distracted SD crashes were less frequent for all roadway alignments (Figure 1.44).

SD Crashes by Distraction Code: Figure 1.45 shows the distribution of the distraction codes for SD crashes. Note again, that “drowsy driving” has been removed from these analyses. As shown in this figure, more than one-quarter of distracted SD crashes were coded as the driver being distracted by another occupant. Another 20 percent were coded as being distracted by an outside event.

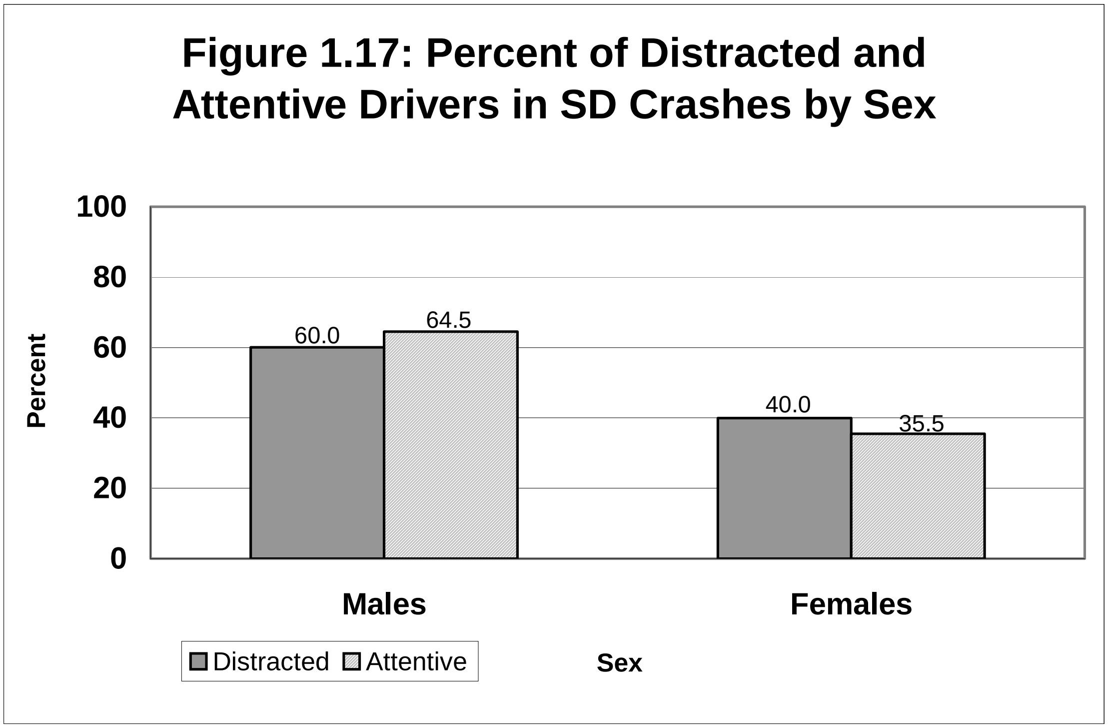


Figure 1.17: Percent of Distracted and Attentive Drivers in SD Crashes by Sex
100
80
60
40
20
0
Percent
60.0
64.5
40.0
35.5
Males
Females
Distracted
Attentive
Sex

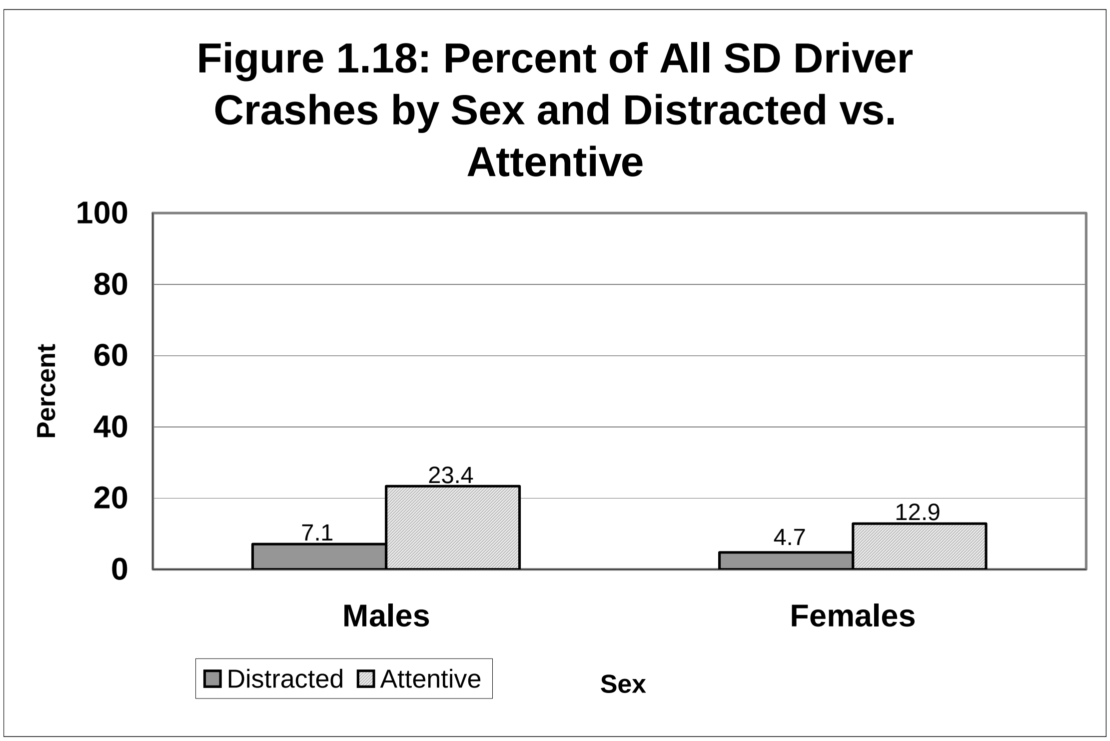


Figure 1.18: Percent of All SD Driver Crashes by Sex and Distracted vs. Attentive
100
80
60
40
20
0
Percent
7.1
23.4
4.7
12.9
Males
Females
Distracted
Attentive
Sex

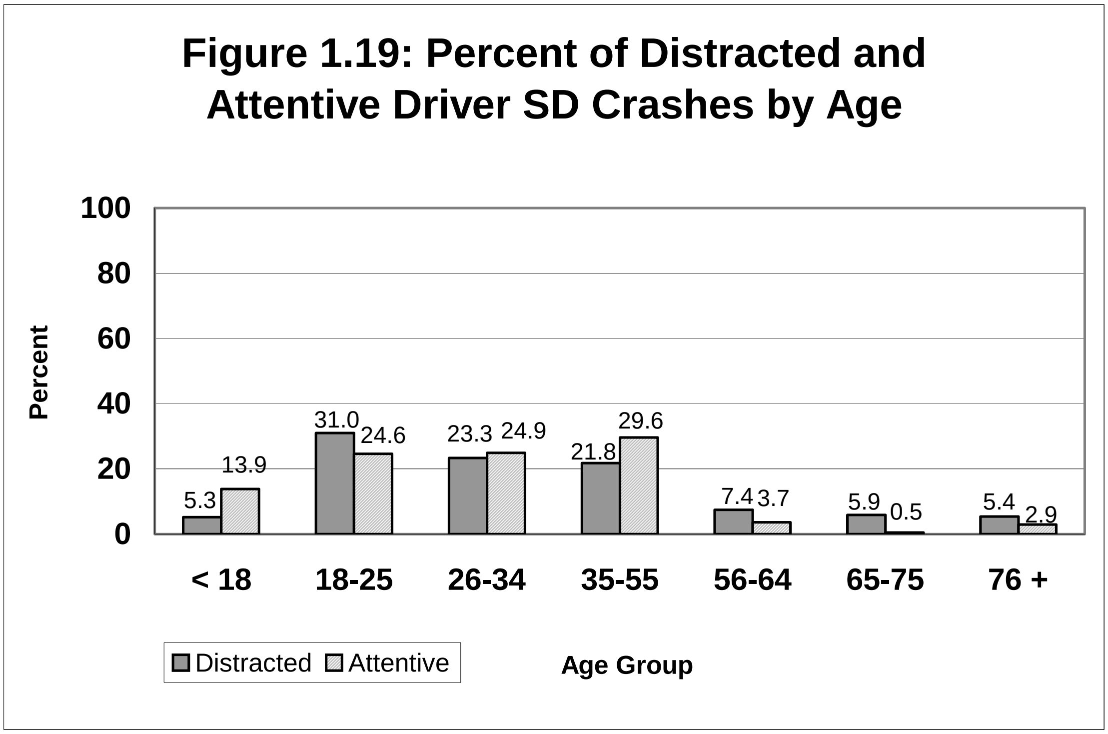


Figure 1.19: Percent of Distracted and Attentive Driver SD Crashes by Age
100
80
60
40
20
0
Percent
5.3
13.9
31.0
24.6
23.3
24.9
21.8
29.6
7.4
3.7
5.9
0.5
5.4
2.9
< 18
18-25
26-34
35-55
56-64
65-75
76 +
Distracted
Attentive
Age Group

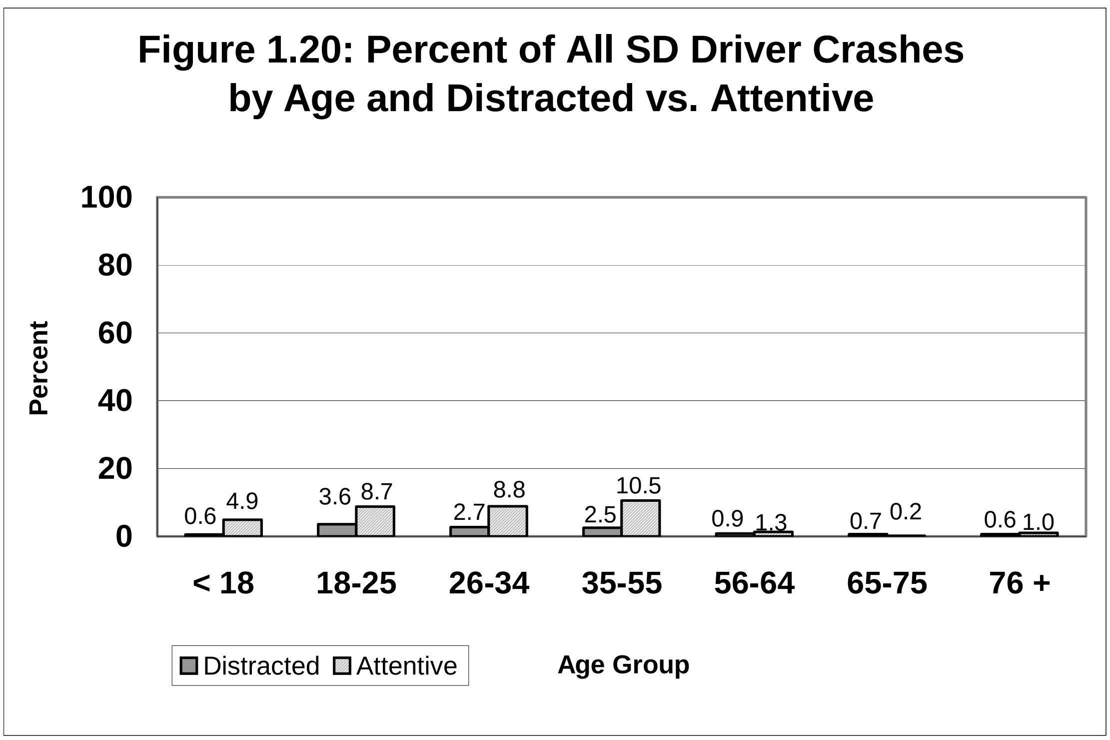


Figure 1.20: Percent of All SD Driver Crashes by Age and Distracted vs. Attentive
100
80
60
40
20
0
Percent
0.6
4.9
3.6
8.7
2.7
8.8
2.5
10.5
0.9
1.3
0.7
0.2
0.6
1.0
< 18
18-25
26-34
35-55
56-64
65-75
76 +
Distracted
Attentive
Age Group

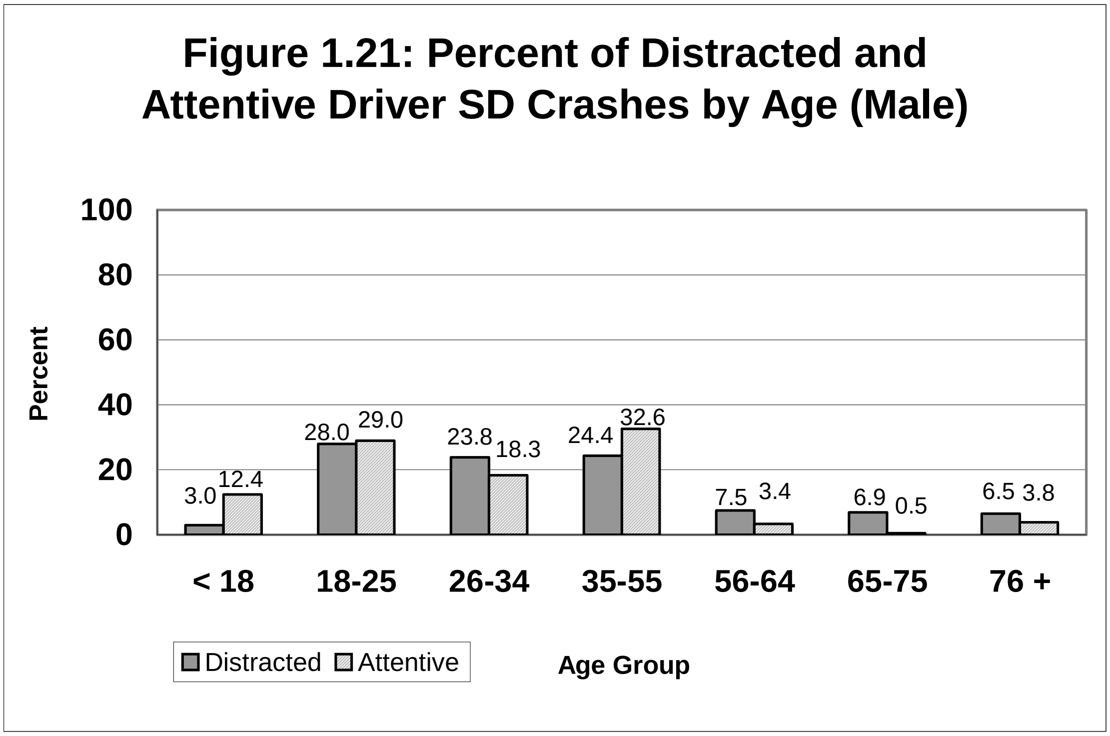


Figure 1.21: Percent of Distracted and Attentive Driver SD Crashes by Age (Male)
100
80
60
40
20
0
Percent
3.0
12.4
28.0
29.0
23.8
18.3
24.4
32.6
7.5
3.4
6.9
0.5
6.5
3.8
< 18
18-25
26-34
35-55
56-64
65-75
76 +
Distracted
Attentive
Age Group

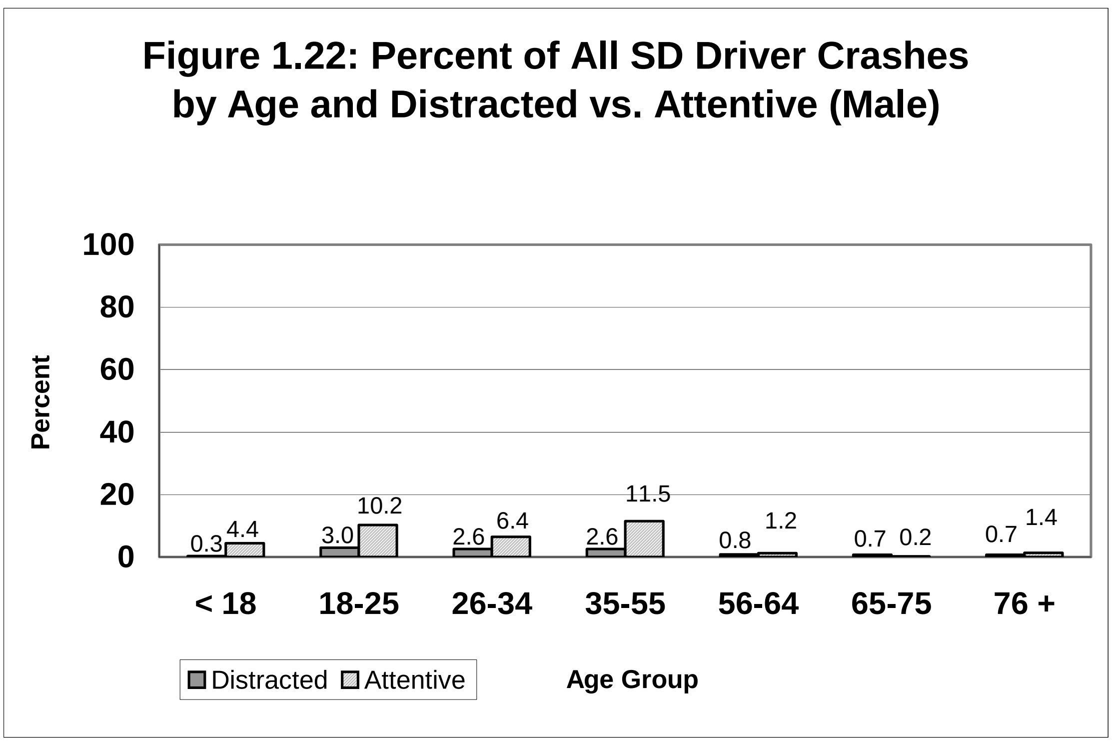


Figure 1.22: Percent of All SD Driver Crashes by Age and Distracted vs. Attentive (Male)
100
80
60
40
20
0
Percent
0.3
4.4
3.0
10.2
2.6
6.4
2.6
11.5
0.8
1.2
0.7
0.2
0.7
1.4
< 18
18-25
26-34
35-55
56-64
65-75
76 +
Distracted
Attentive
Age Group

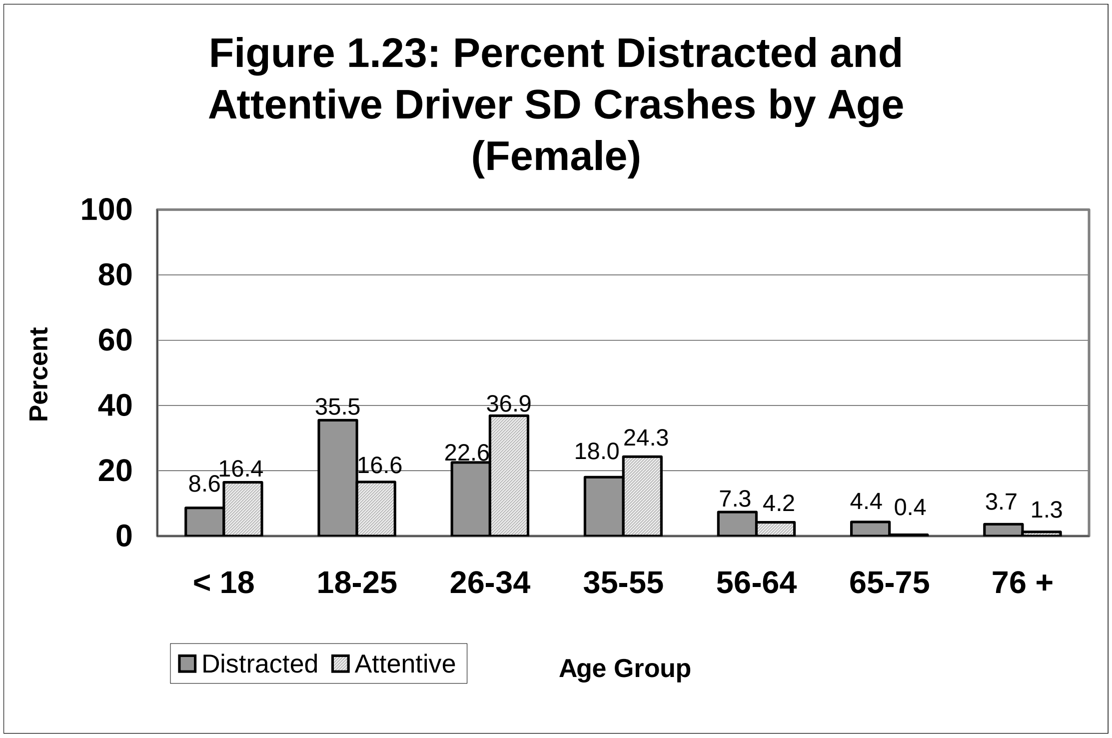


Figure 1.23: Percent Distracted and Attentive Driver SD Crashes by Age (Female)
100
80
60
40
20
0
Percent
8.6
16.4
35.5
16.6
22.6
36.9
18.0
24.3
7.3
4.2
4.4
0.4
3.7
1.3
< 18
18-25
26-34
35-55
56-64
65-75
76 +
Distracted
Attentive
Age Group

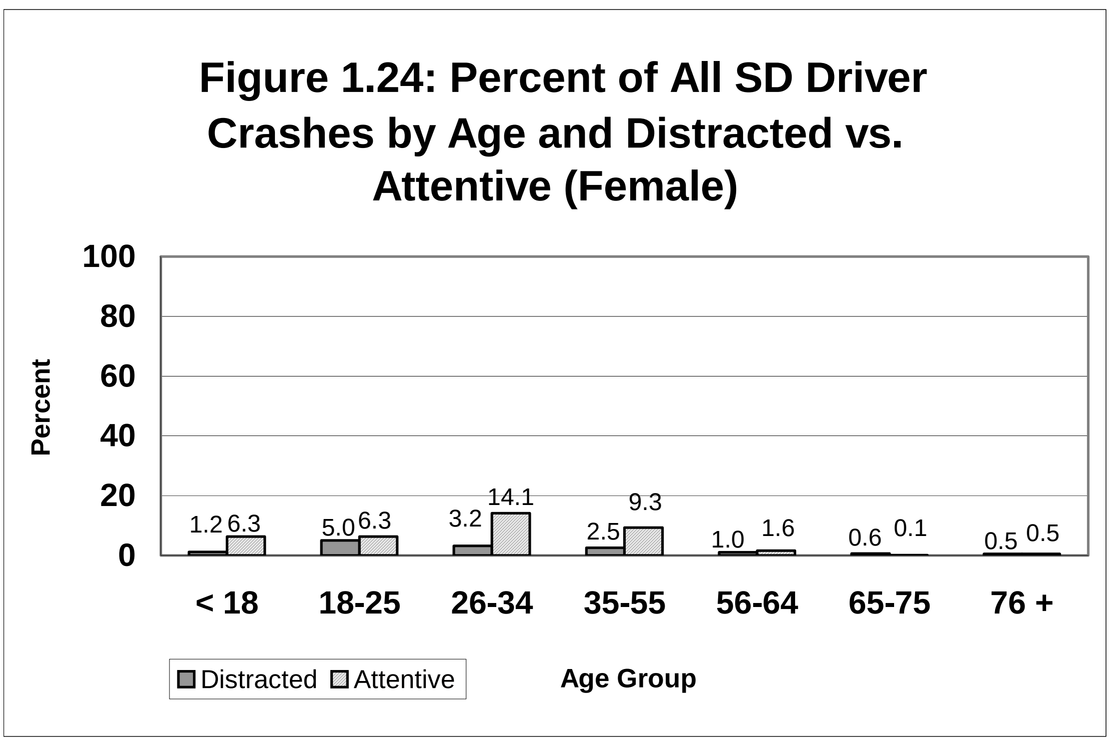


Figure 1.24: Percent of All SD Driver Crashes by Age and Distracted vs. Attentive (Female)
100
80
60
40
20
0
Percent
1.2
6.3
5.0
6.3
3.2
14.1
2.5
9.3
1.0
1.6
0.6
0.1
0.5
0.5
< 18
18-25
26-34
35-55
56-64
65-75
76 +
Distracted
Attentive
Age Group

Figure 1.25: Percent of Distracted and Attentive SD Crashes by Number of Lanes

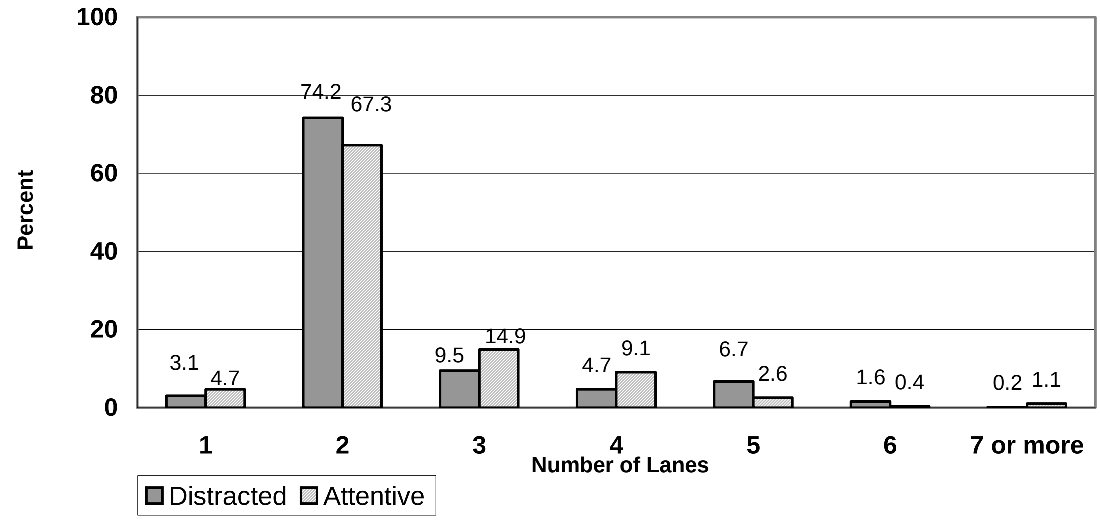


Figure 1.26: Percent of All SD Crashes by Number of Lanes and Distracted vs. Attentive

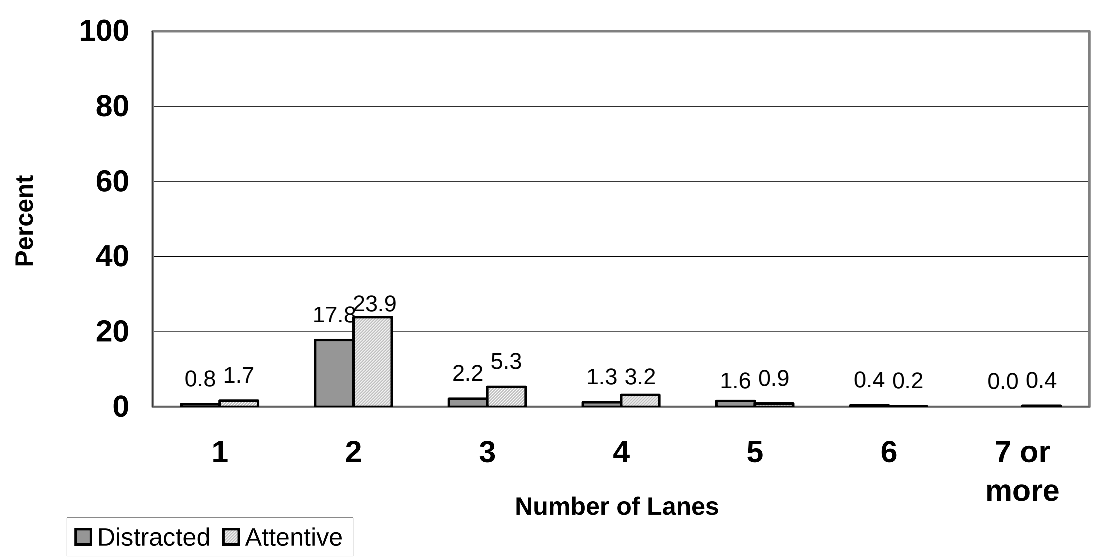


Figure 1.27: Percent of Distracted and Attentive SD Crashes by Roadway Profile

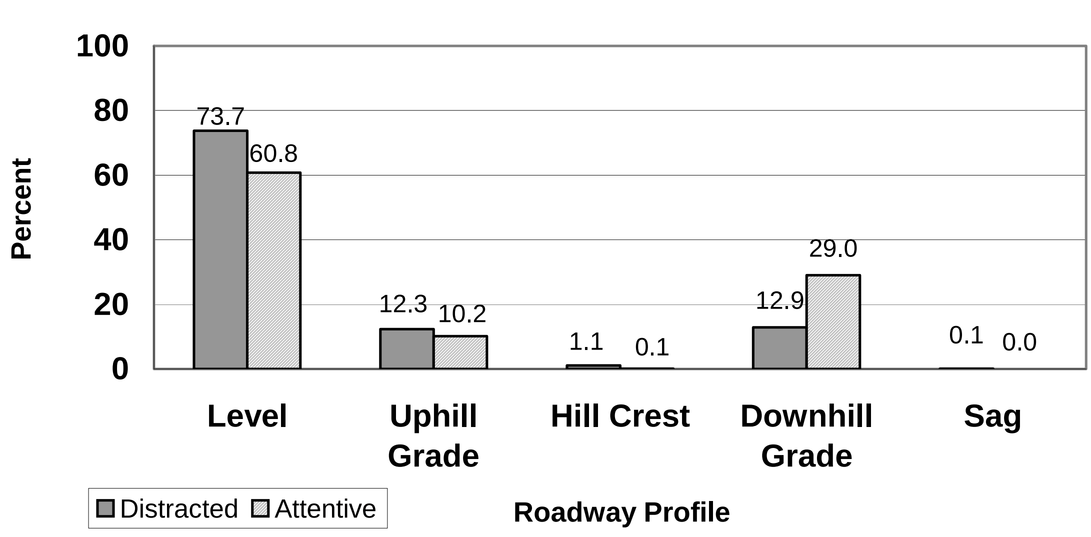


Figure 1.28: Percent of All SD Crashes by Roadway Profile and Distracted vs. Attentive

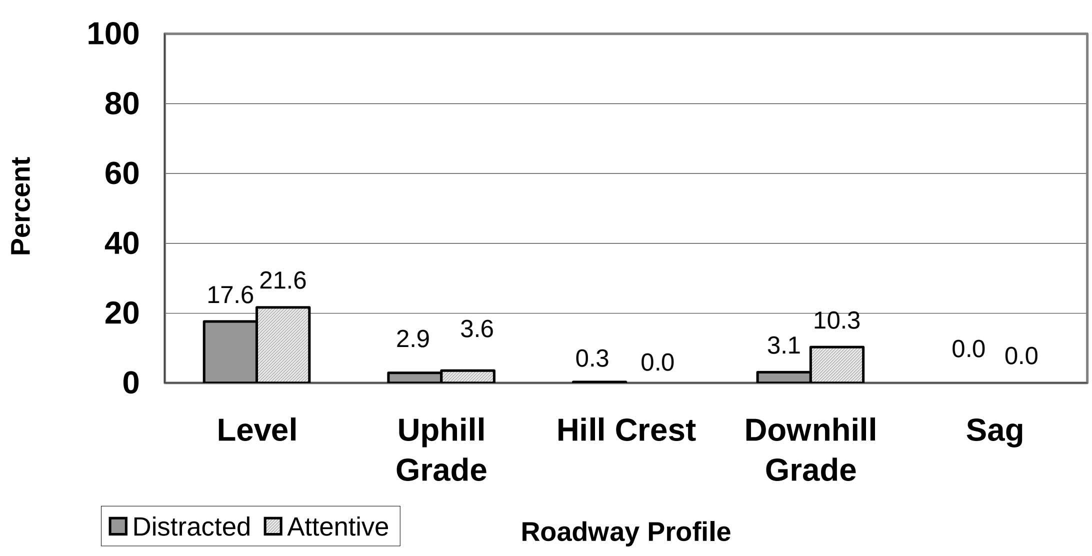


Figure 1.29: Percent Distracted and Attentive SD Crashes by Relation to Junction

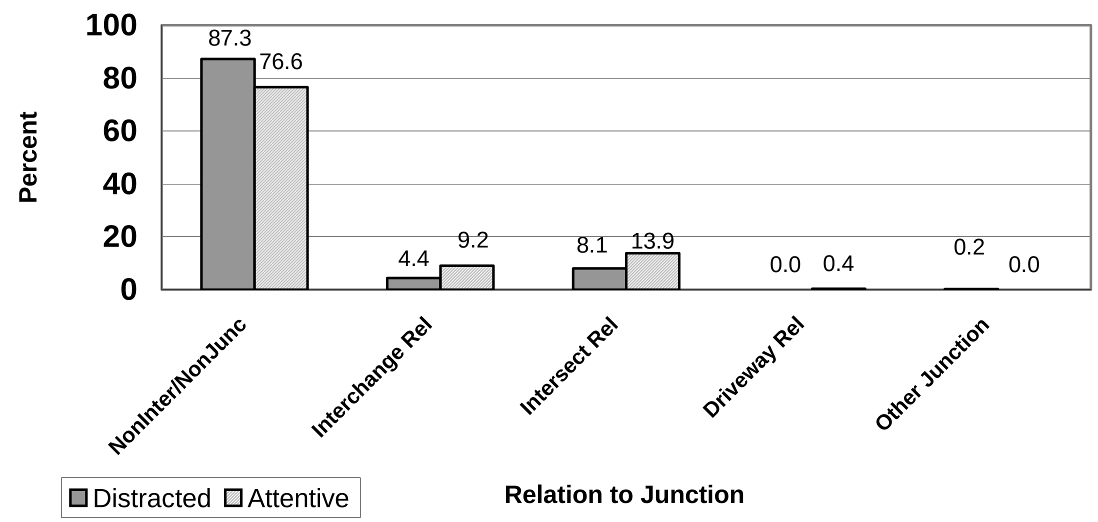
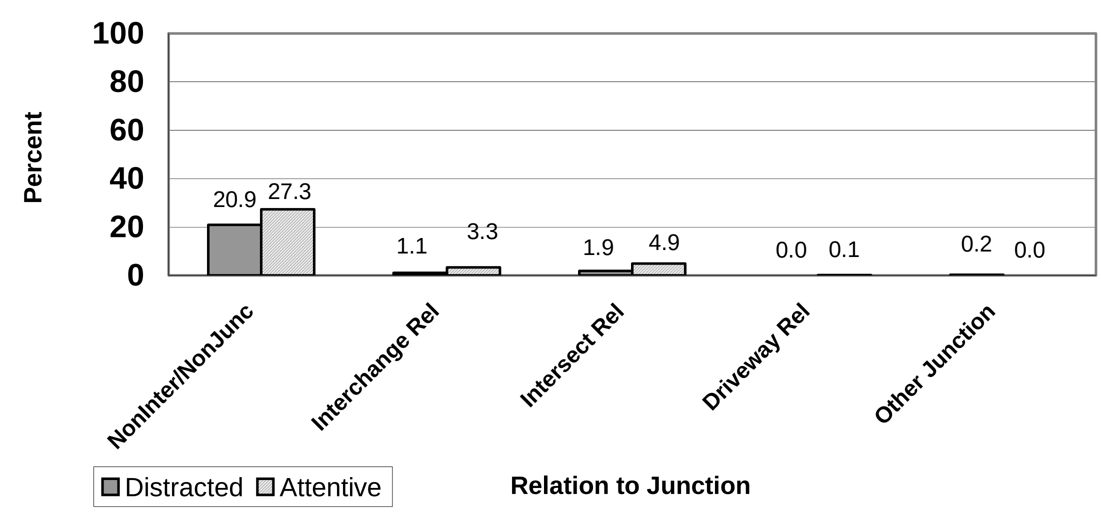


Figure 1.30: Percent of All SD Crashes by Relation to Junction and Distracted vs Attentive



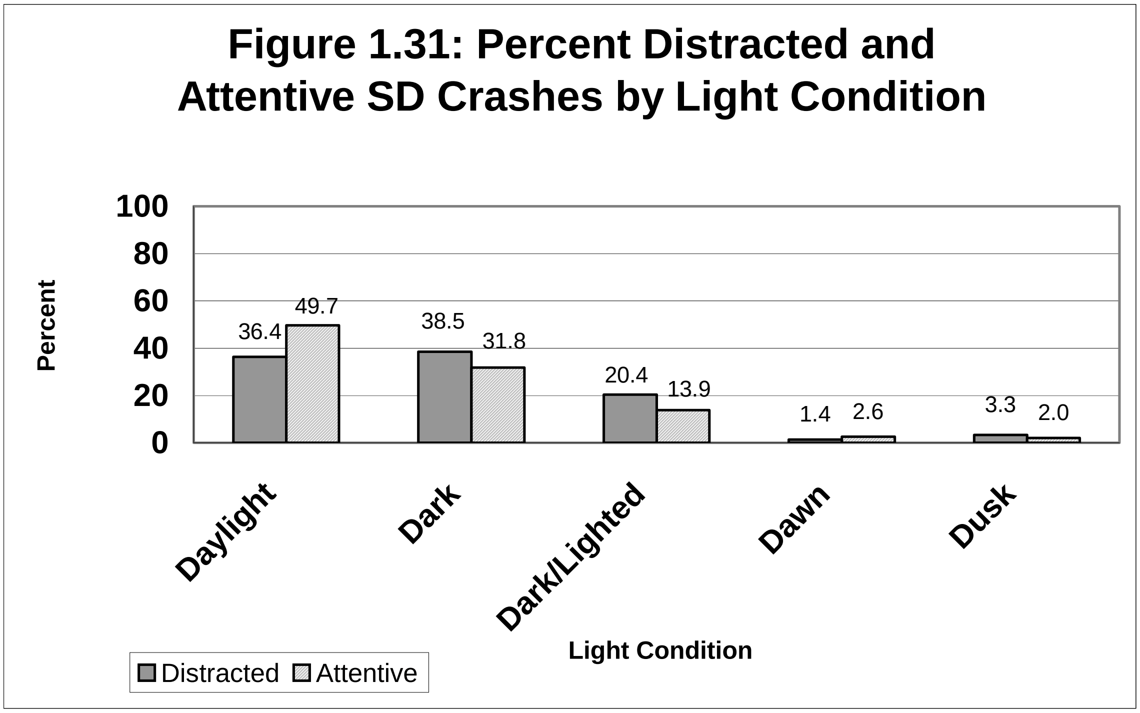


Figure 1.31: Percent Distracted and
Attentive SD Crashes by Light Condition
Percent
100
80
60
40
20
0
36.4
49.7
38.5
31.8
20.4
13.9
1.4
2.6
3.3
2.0
Daylight
Dark
Dark/Lighted
Dawn
Dusk
Light Condition
Distracted
Attentive

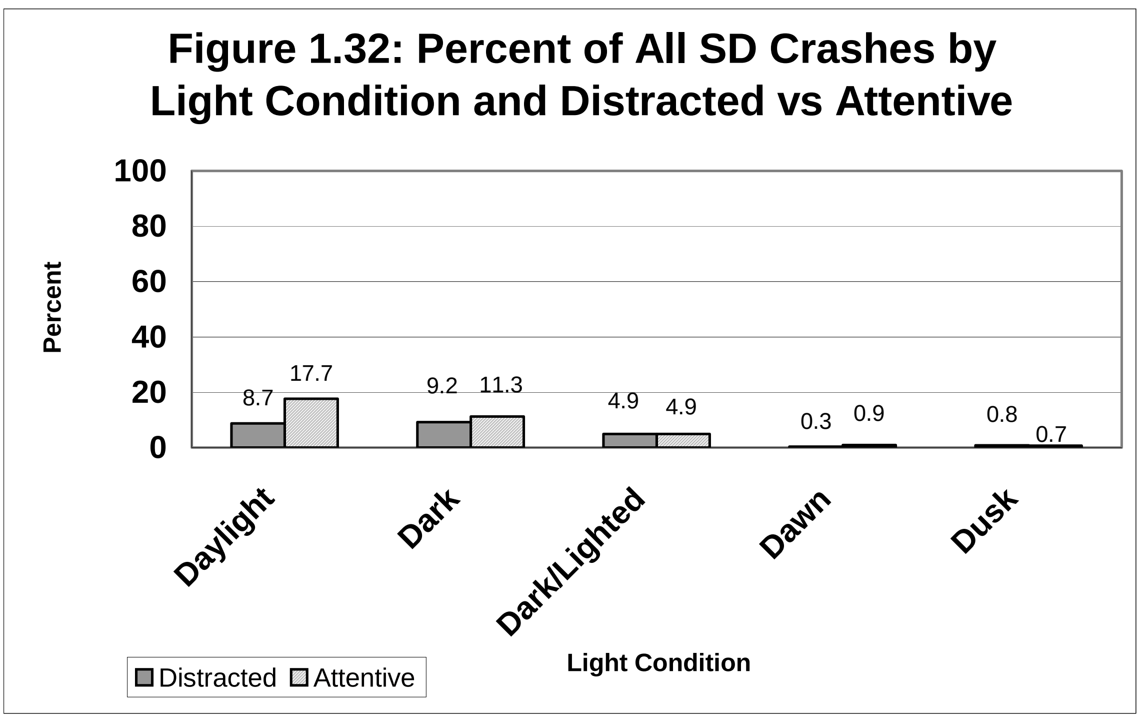


Figure 1.32: Percent of All SD Crashes by
Light Condition and Distracted vs Attentive
Percent
100
80
60
40
20
0
8.7
17.7
9.2
11.3
4.9
4.9
0.3
0.9
0.8
0.7
Daylight
Dark
Dark/Lighted
Dawn
Dusk
Light Condition
Distracted
Attentive

Figure 1.33: Percent Distracted and Attentive SD Crashes by Roadway Surface Condition

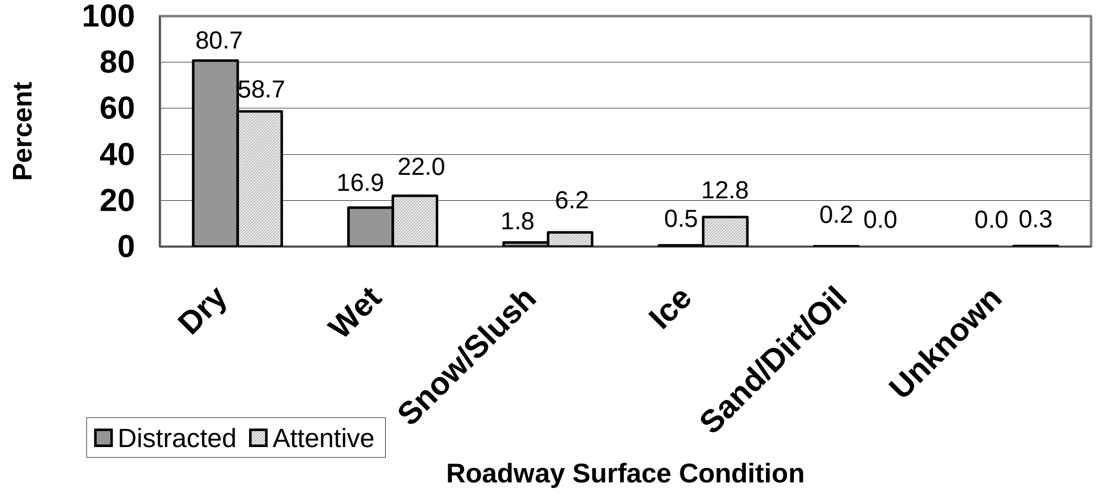
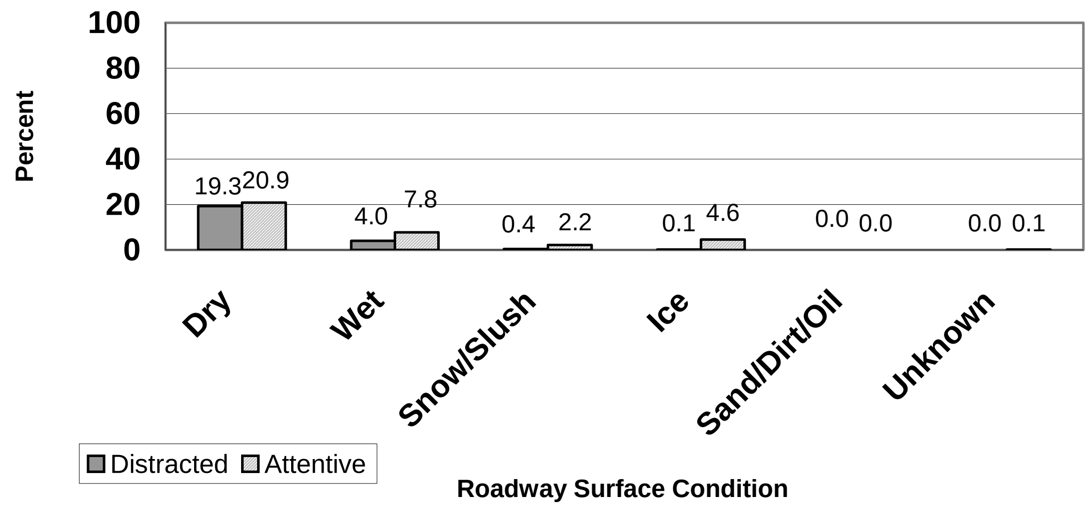


Figure 1.34: Percent of All SD Crashes by Roadway Surface Condition and Distracted vs. Attentive



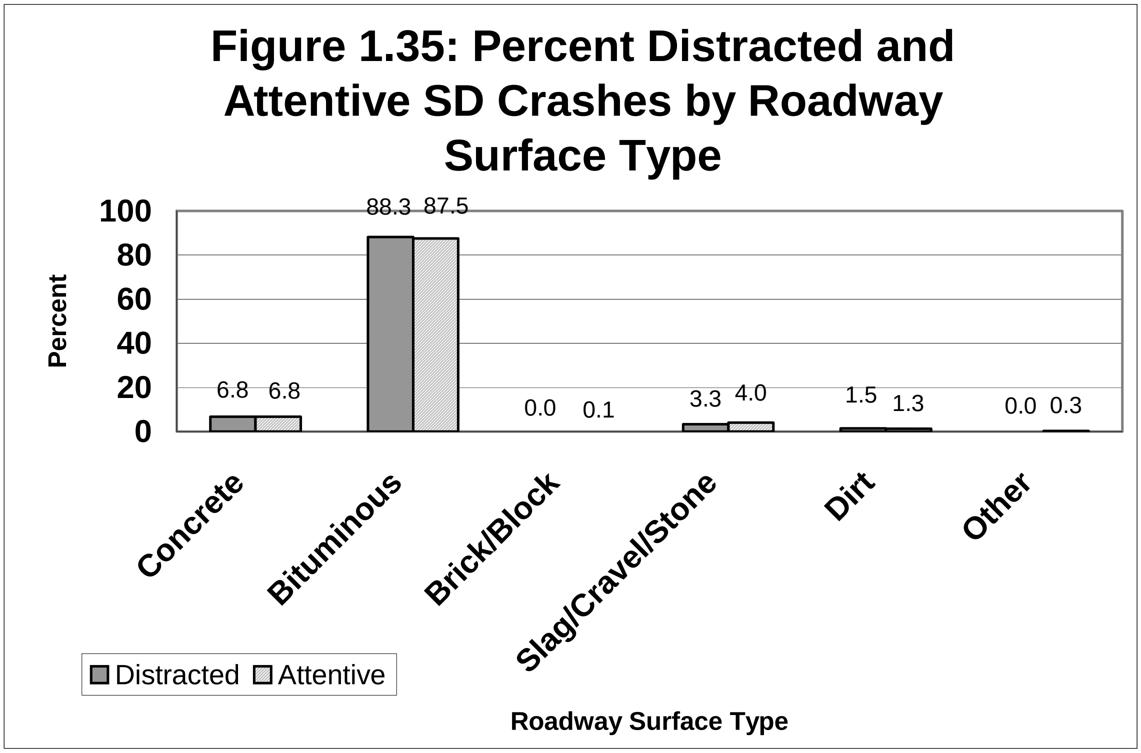


Figure 1.35: Percent Distracted and Attentive SD Crashes by Roadway Surface Type
100
80
60
40
20
0
Percent
88.3
87.5
6.8
6.8
0.0
0.1
3.3
4.0
1.5
1.3
0.0
0.3
Concrete
Bituminous
Brick/Block
Slag/Cravel/Stone
Dirt
Other
Distracted
Attentive
Roadway Surface Type

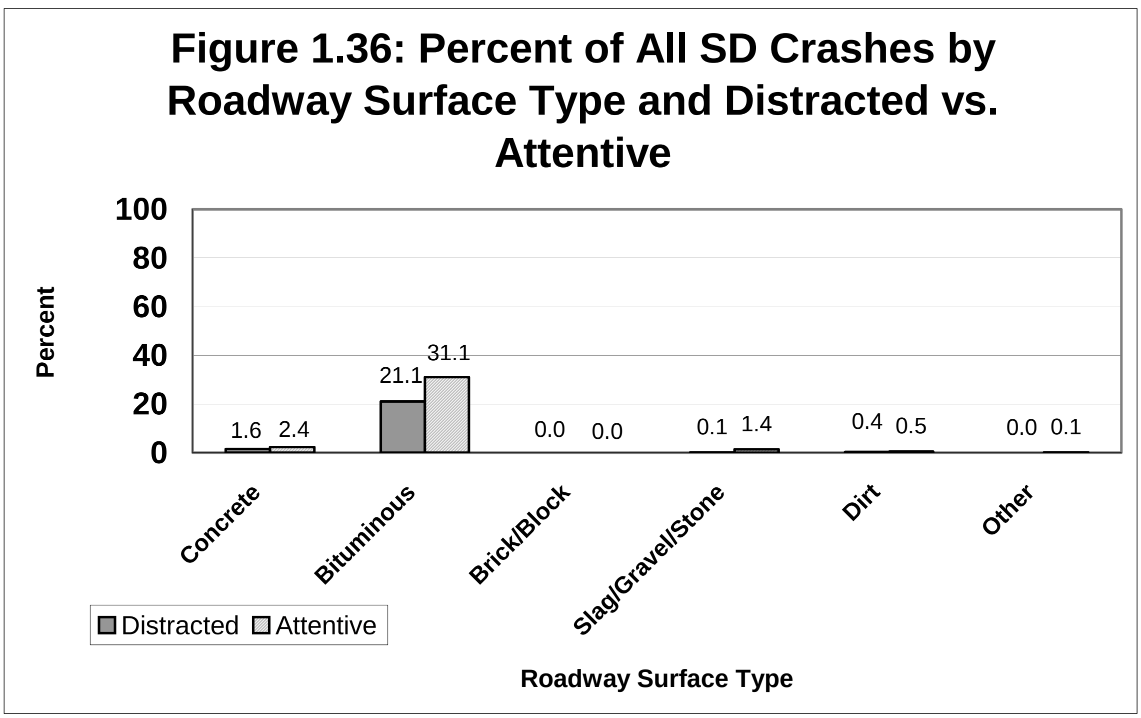


Figure 1.36: Percent of All SD Crashes by Roadway Surface Type and Distracted vs. Attentive
100
80
60
40
20
0
Percent
1.6
2.4
21.1
31.1
0.0
0.0
0.1
1.4
0.4
0.5
0.0
0.1
Concrete
Bituminous
Brick/Block
Slag/Gravel/Stone
Dirt
Other
Distracted
Attentive
Roadway Surface Type

Figure 1.37: Percent Distracted and Attentive SD Crashes by Trafficway Flow

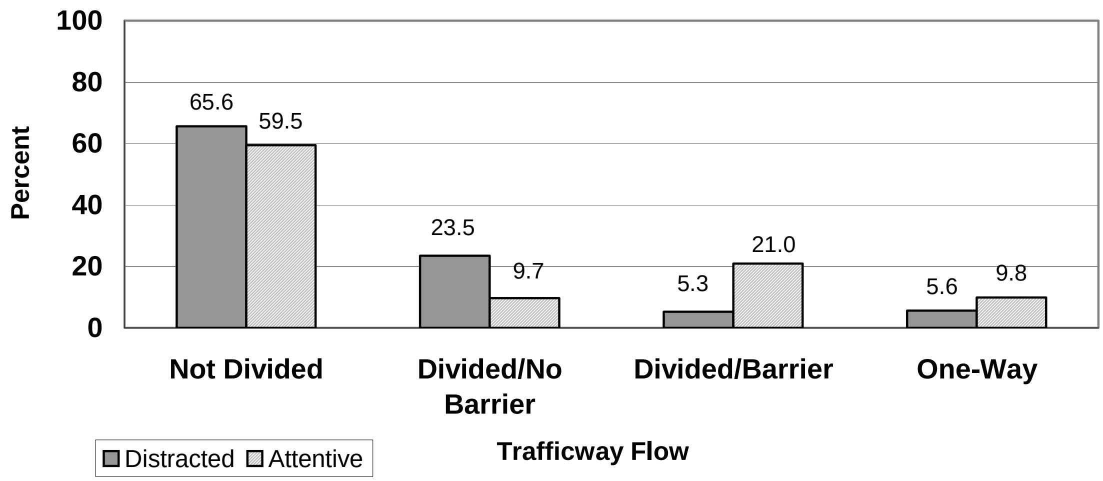
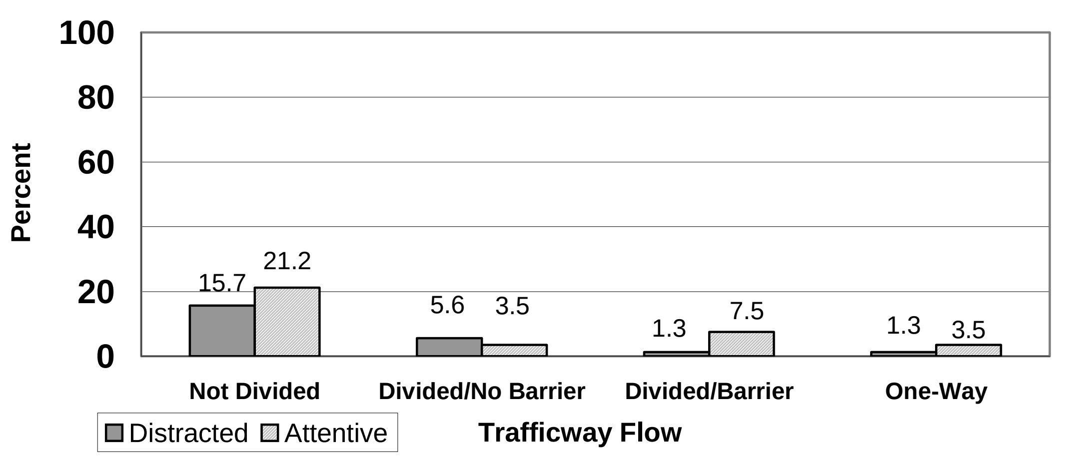


Figure 1.38: Percent of All SD Crashes by Trafficway Flow and Distracted vs. Attentive



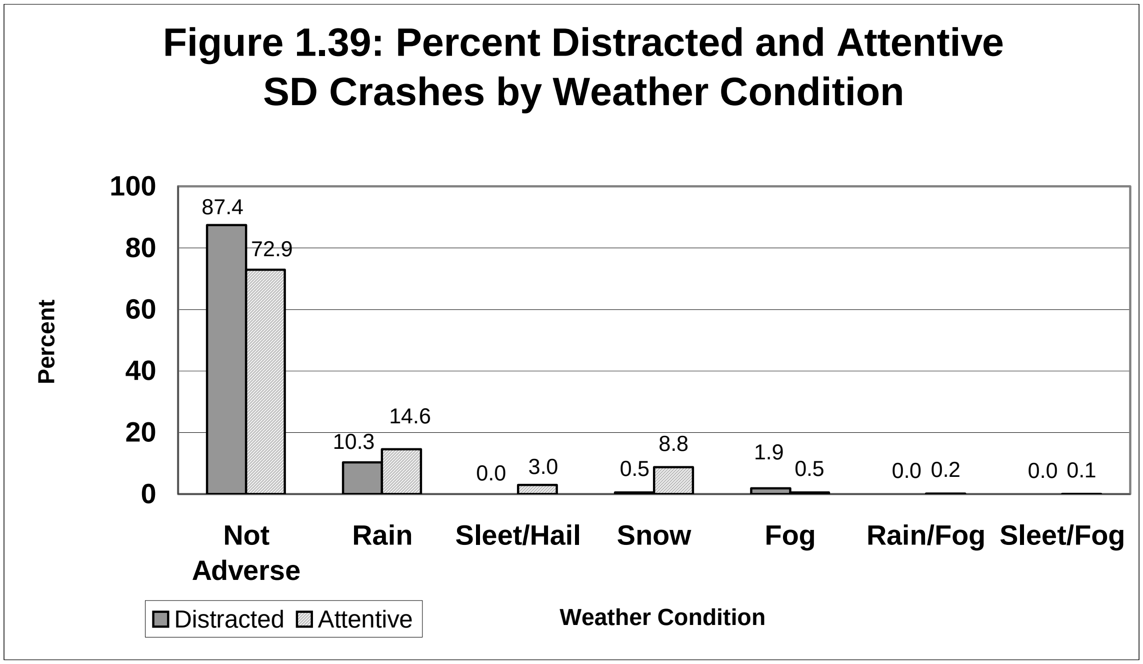


Figure 1.39: Percent Distracted and Attentive SD Crashes by Weather Condition
Percent
100
80
60
40
20
0
87.4
72.9
10.3
14.6
0.0
3.0
0.5
8.8
1.9
0.5
0.0 0.2
0.0 0.1
Not Adverse
Rain
Sleet/Hail
Snow
Fog
Rain/Fog
Sleet/Fog
Distracted
Attentive
Weather Condition

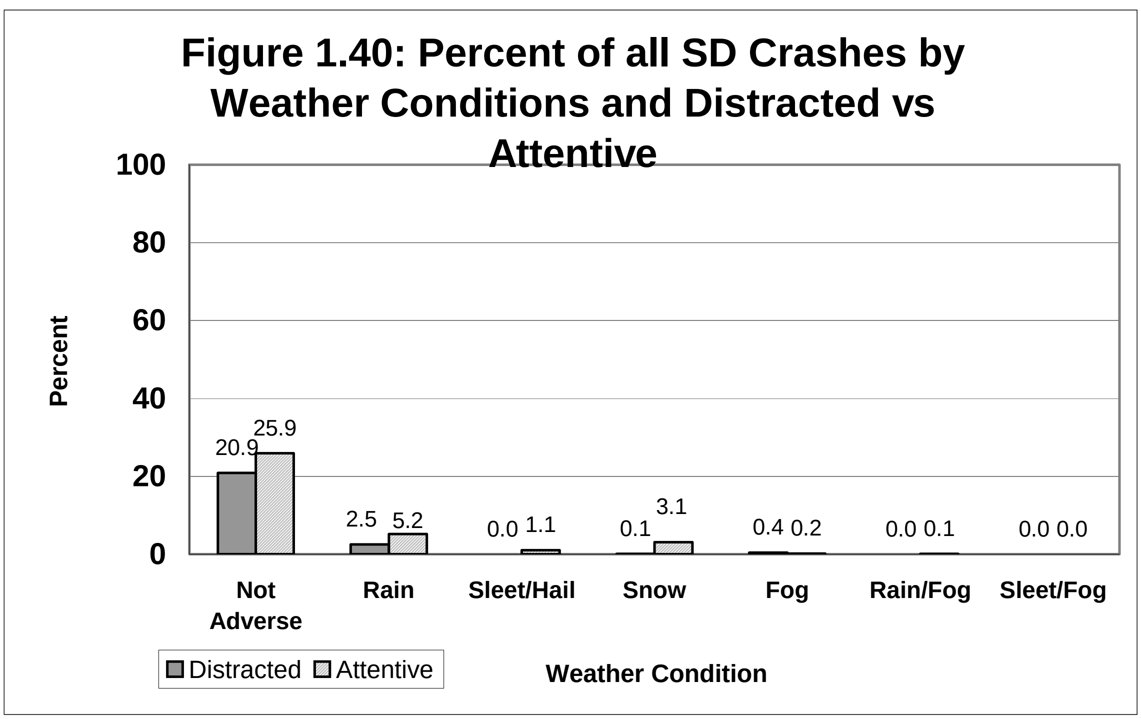


Figure 1.40: Percent of all SD Crashes by Weather Conditions and Distracted vs Attentive
Percent
100
80
60
40
20
0
20.9
25.9
2.5 5.2
0.0 1.1
0.1
3.1
0.4 0.2
0.0 0.1
0.0 0.0
Not Adverse
Rain
Sleet/Hail
Snow
Fog
Rain/Fog
Sleet/Fog
Distracted
Attentive
Weather Condition

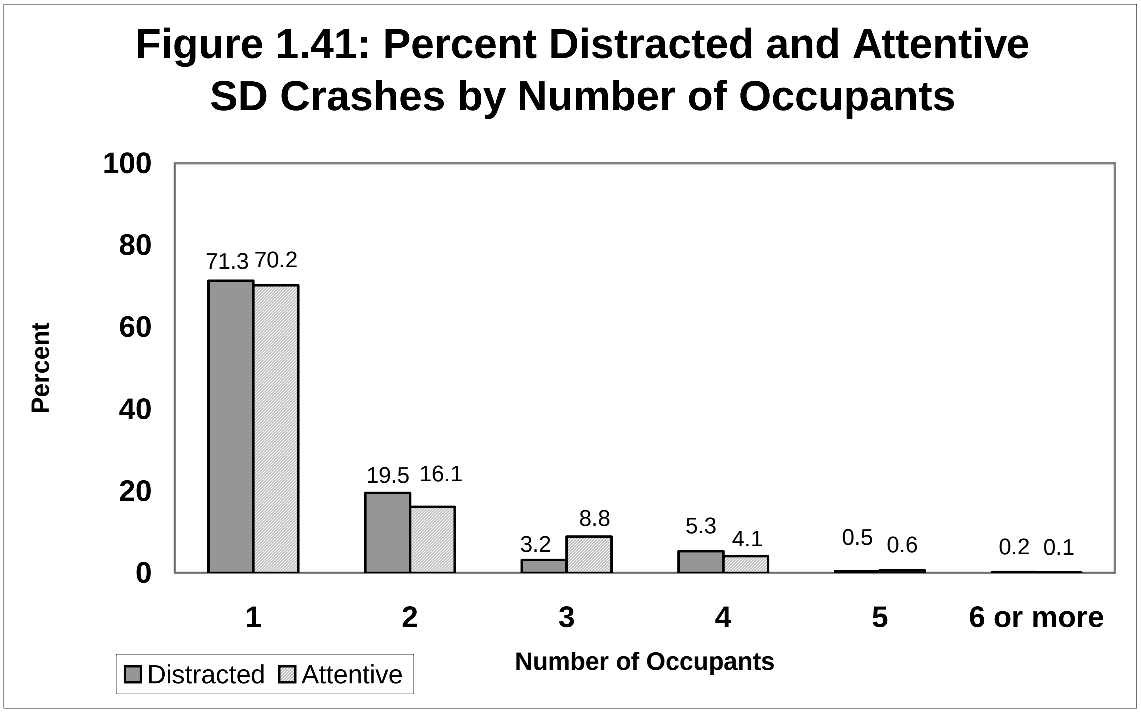


Figure 1.41: Percent Distracted and Attentive SD Crashes by Number of Occupants
100
80
60
40
20
0
Percent
71.3 70.2
19.5 16.1
3.2 8.8
5.3 4.1
0.5 0.6
0.2 0.1
1
2
3
4
5
6 or more
Number of Occupants
Distracted
Attentive

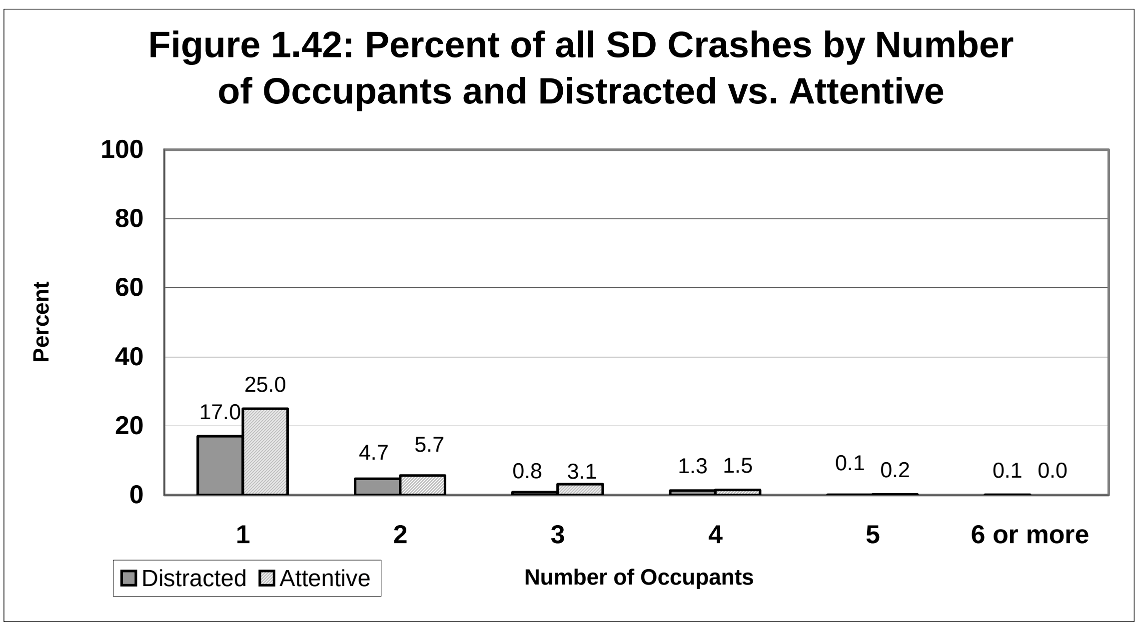


Figure 1.42: Percent of all SD Crashes by Number of Occupants and Distracted vs. Attentive
100
80
60
40
20
0
Percent
17.0 25.0
4.7 5.7
0.8 3.1
1.3 1.5
0.1 0.2
0.1 0.0
1
2
3
4
5
6 or more
Number of Occupants
Distracted
Attentive

Figure 1.43: Percent Distracted and Attentive SD Crashes by Roadway Alignment

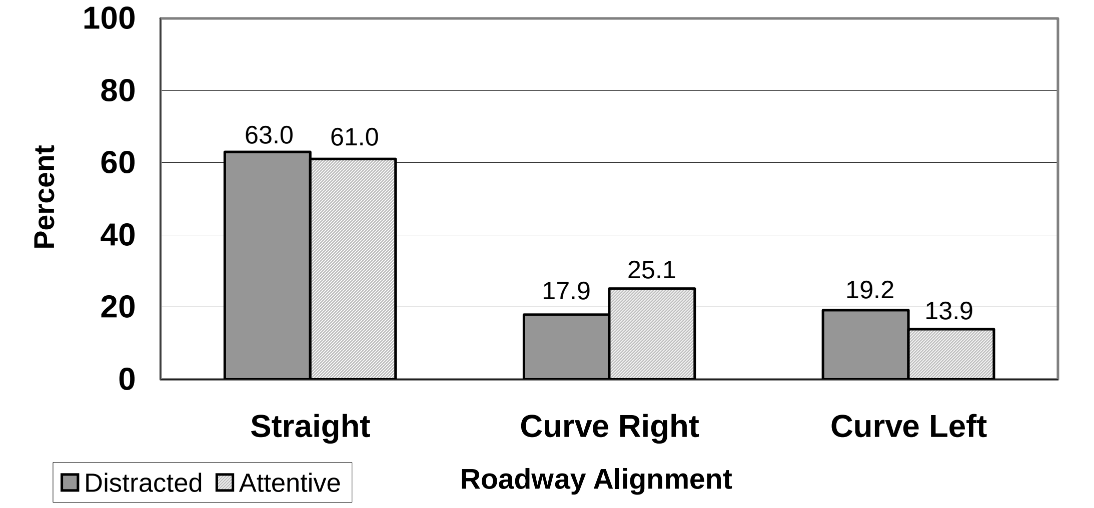


Figure 1.44: Percent of All SD Crashes by Roadway Alignment and Distracted vs. Attentive

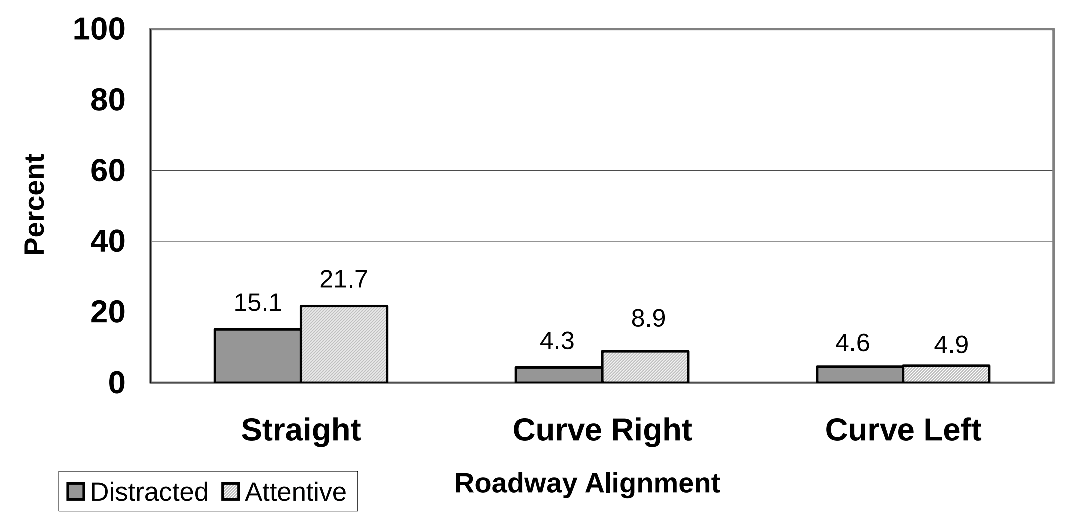
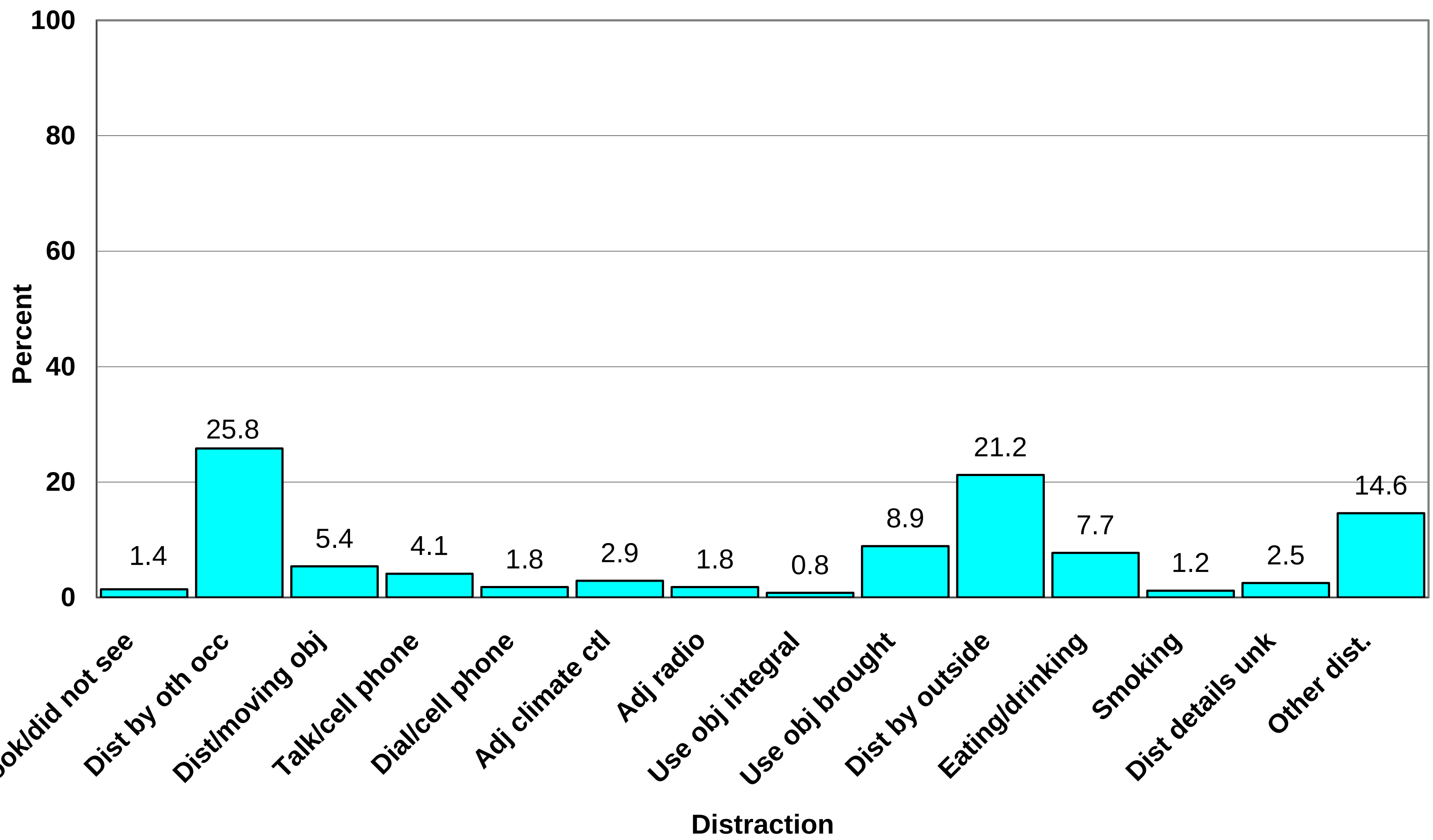


Figure 1.45: Percent Recorded Distraction for Drivers in SD Crashes



1.3.1.3.2. Same Trafficway, Same Direction (STSD)

Sex: Figures 1.46-1.47 show the proportion of all STSD distracted and all STSD attentive crashes (Figure 1.46) and the proportion of distracted and attentive STSD crashes (Figure 1.47) by sex. A greater proportion of both distracted and attentive crashes were attributed to males. A small difference was found for females between attentive and distracted crashes when the proportions within the crash categories (attentive vs. distracted) were compared. A large difference, however, was found when the proportions were determined as a function of all STSD crashes, with distracted crashes much less frequent than attentive crashes for both sexes.

Age Group: The proportion of all distracted and all attentive STSD crashes and the proportion of distracted and attentive STSD crashes by age group are shown in Figures 1.48 and 1.49. When proportions were compared within the crash categories (Figure 1.48), we found that distracted STSD crashes were more common for drivers under age 18 and drivers aged 65-75. When compared among all STSD crashes, distracted crashes were less common than attentive crashes for all age groups.

Age Group and Sex: Figures 1.50-1.53 show the proportions of STSD crashes by males and age (Figure 1.50-1.51) and by females and age (Figures 1.52-1.53). For males, STSD distracted crashes were more common for drivers ages 26-34 and for drivers aged 65-75 when proportions were compared within crash categories. When compared among all STSD crashes, distracted crashes for males were less common than attentive crashes for all age groups. For females, distracted STSD crashes were more common for drivers under 26 years of age and drivers aged 56-75 when proportions were compared within crash categories. Comparing within all STSD crashes, we found that attentive crashes were more common for all age groups except for drivers under age 18.

Number of Lanes: Figures 1.54 and 1.55 show STSD crashes by the number of traffic lanes. Little difference was found comparing proportions within crash categories, except that distracted crashes were more frequent for 4-lane roads (Figure 1.54) while attentive crashes were more frequent for all lane numbers when proportions were compared among all STSD crashes.

Roadway Profile: Figures 1.56 and 1.57 show the distributions of distracted and attentive STSD crashes by the roadway profile. Comparisons within the crash categories showed that distracted STSD crashes were slightly more frequent for uphill, and downhill grades (Figure 56). Comparing proportions among all STSD crashes showed that distracted SD crashes were less frequent than attentive crashes for all roadway profiles.

Relation to Junction: Figures 1.58 and 1.59 show the distributions of distracted and attentive STSD crashes by the relation to junctions. Comparison within the crash categories showed little difference by relation to junction (Figure 1.58) and attentive STSD crashes were more common in all cases when proportions were compared relative to all STSD crashes (Figure 1.59).

Light Conditions: Figures 1.60 and 1.61 show the distributions of distracted and attentive STSD crashes by the light conditions. Comparisons within the crash categories showed that distracted STSD crashes were more frequent during daylight (Figure 1.60). Comparing proportions among all STSD crashes showed that distracted STSD crashes were less frequent than attentive crashes for all lighting conditions.

Roadway Surface Conditions: Figures 1.62 and 1.63 show the distributions of distracted and attentive STSD crashes by the roadway surface conditions. Comparisons within the crash categories showed that distracted STSD crashes were more frequent only for dry road surfaces (Figure 1.62). Comparing proportions among all STSD crashes showed that distracted STSD crashes were less frequent than, or equal to, attentive crashes for all roadway conditions (Figure 1.63).

Roadway Surface Type: Figures 1.64 and 1.65 show the distributions of distracted and attentive STSD crashes by the roadway surface type. Comparisons within the crash categories shows that distracted STSD crashes were slightly more frequent for bituminous roads (Figure 1.64). Comparing proportions among all STSD crashes showed that distracted STSD crashes were less frequent than, or equal to, attentive crashes for all surface types (Figure 1.65).

Trafficway Flow: Figures 1.66 and 1.67 show the distributions of distracted and attentive STSD crashes by the trafficway flow. Comparisons within the crash categories showed that distracted STSD crashes were slightly more frequent for not-divided and divided-with-a-barrier roads (Figure 1.66). Comparing proportions among all STSD crashes showed that distracted STSD crashes were less frequent for all trafficway flow types (Figure 1.67).

Weather Conditions: Figures 1.68 and 1.69 show the distributions of distracted and attentive STSD crashes by the prevailing weather conditions. Comparisons within the crash categories showed that distracted STSD crashes were more frequent for “not adverse” and “sleet/fog” weather conditions (Figure 1.68). Comparing proportions among all STSD crashes showed that distracted STSD crashes were less frequent than, or equal to, attentive crashes for all weather conditions, except for “sleet/fog” weather (Figure 1.69).

Number of Occupants: Figures 1.70 and 1.71 show the distributions of distracted and attentive STSD crashes by the number of occupants in the vehicle. Comparisons within the crash categories showed that distracted STSD crashes were more frequent for a single passenger and when there were 5 or more passengers (Figure 1.70). Comparing proportions among all STSD crashes showed that distracted STSD crashes were less frequent, or equal to, attentive crashes for all numbers of passengers (Figure 1.71).

Roadway Alignment: Figures 1.72 and 1.73 show the distributions of distracted and attentive STSD crashes by the roadway alignment. Comparisons within the crash categories showed that distracted STSD crashes were slightly more frequent for curves to the right (Figure 1.72). Comparing proportions among all STSD crashes showed that distracted STSD crashes were less frequent for all roadway alignments (Figure 1.73).

STSD Crashes by Distraction Code: Figure 1.74 shows the distribution of the distraction codes for STSD crashes. As shown in this figure, in about 20 percent of STSD distracted crashes, the cited distraction was “looked, but did not see,” while another 20 percent were “distracted by an outside event.” A large number of these crashes were also coded as “other distraction.”

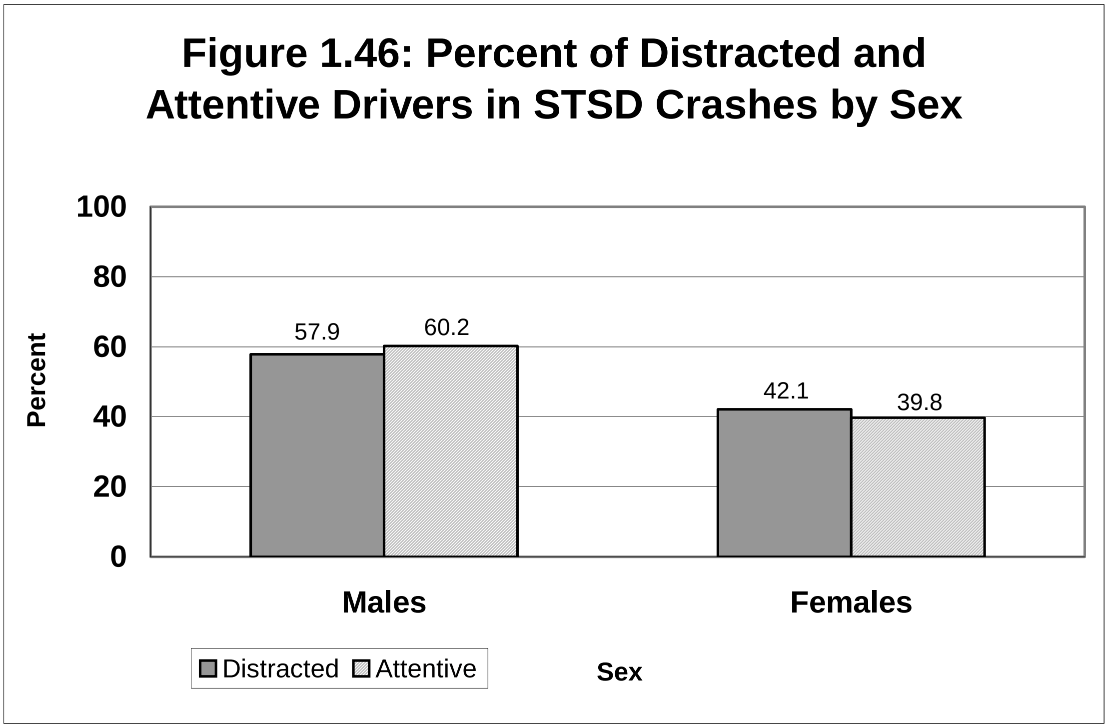


Figure 1.46: Percent of Distracted and Attentive Drivers in STSD Crashes by Sex
Percent
100
80
60
40
20
0
57.9
60.2
42.1
39.8
Males
Females
Distracted
Attentive
Sex

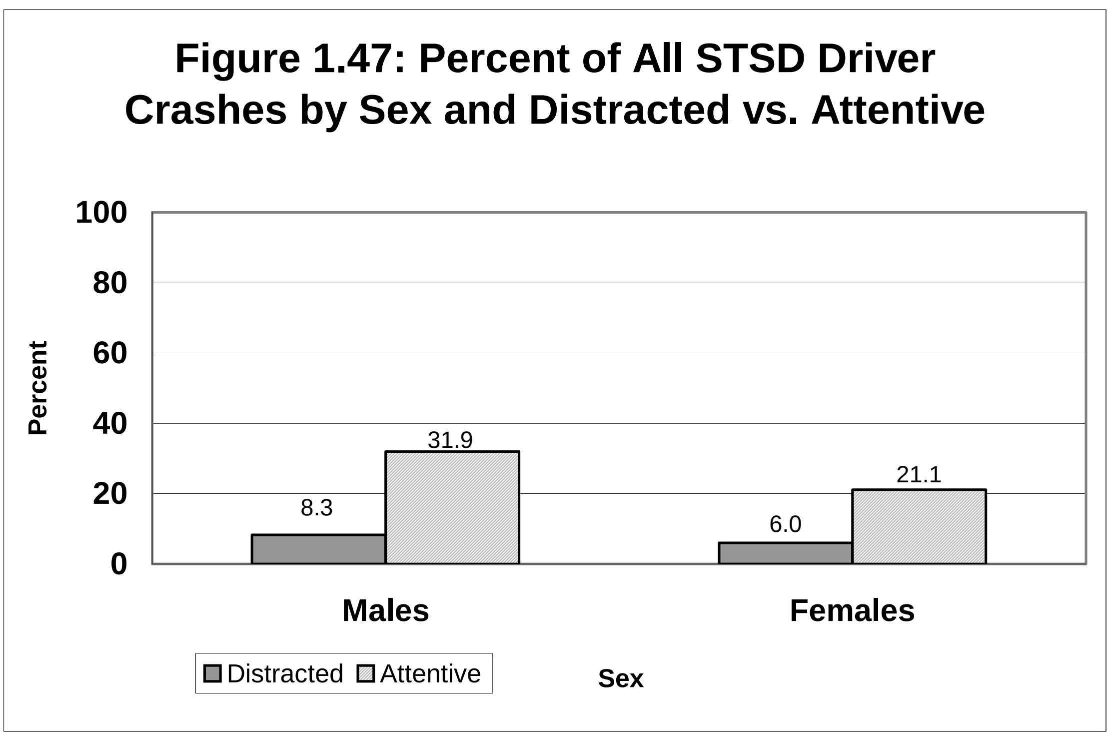


Figure 1.47: Percent of All STSD Driver Crashes by Sex and Distracted vs. Attentive
Percent
100
80
60
40
20
0
8.3
31.9
6.0
21.1
Males
Females
Distracted
Attentive
Sex

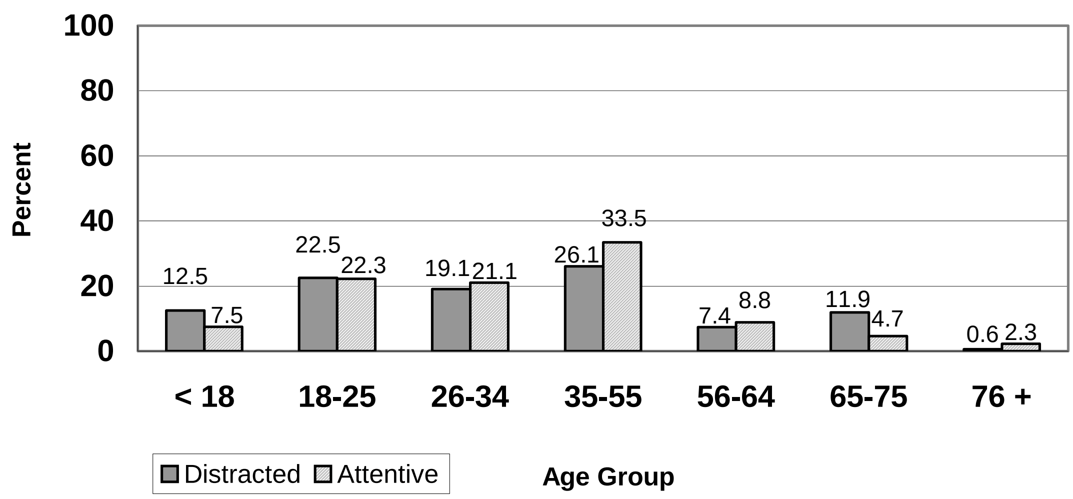


Figure 1.48: Percent of Distracted and Attentive Driver STSD Crashes by Age

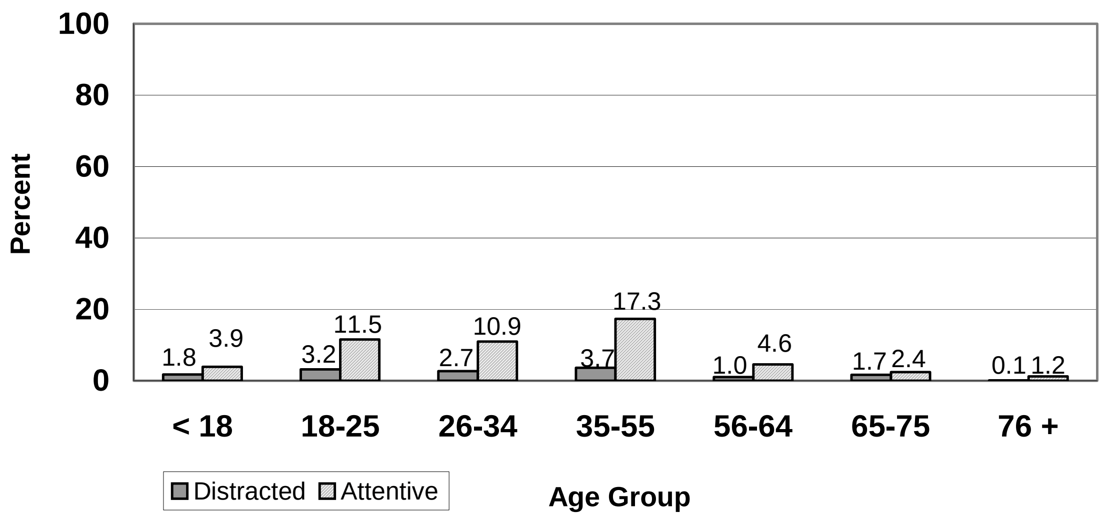


Figure 1.49: Percent of All STSD Driver Crashes By Age and Distracted vs. Attentive

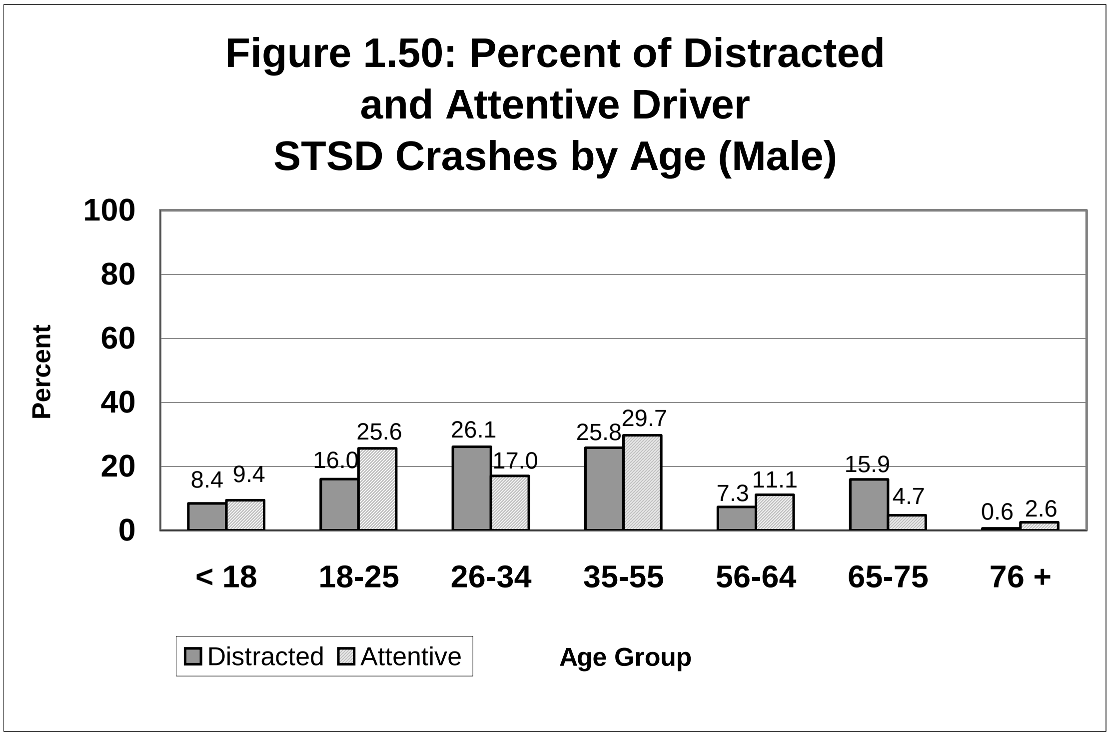


Figure 1.50: Percent of Distracted
and Attentive Driver
STSD Crashes by Age (Male)
100
80
60
40
20
0
Percent
8.4
9.4
16.0
25.6
26.1
17.0
25.8
29.7
7.3
11.1
15.9
4.7
0.6
2.6
< 18
18-25
26-34
35-55
56-64
65-75
76 +
Distracted
Attentive
Age Group

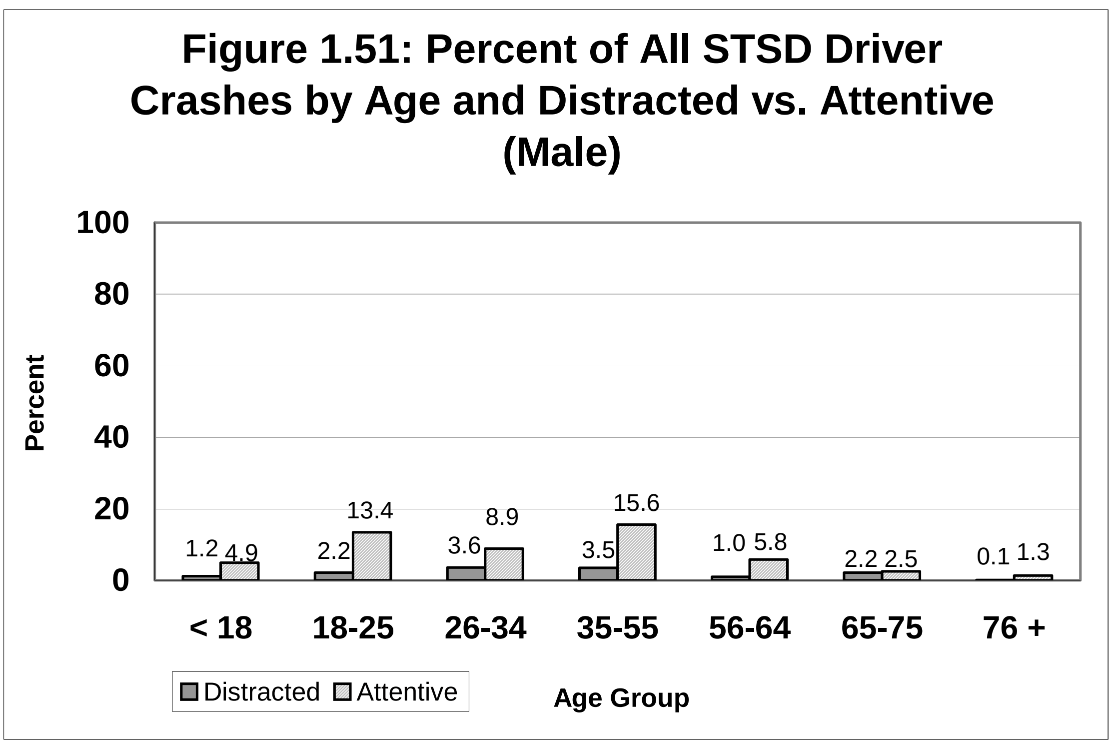


Figure 1.51: Percent of All STSD Driver
Crashes by Age and Distracted vs. Attentive
(Male)
100
80
60
40
20
0
Percent
1.2
4.9
2.2
13.4
3.6
8.9
3.5
15.6
1.0
5.8
2.2
2.5
0.1
1.3
< 18
18-25
26-34
35-55
56-64
65-75
76 +
Distracted
Attentive
Age Group

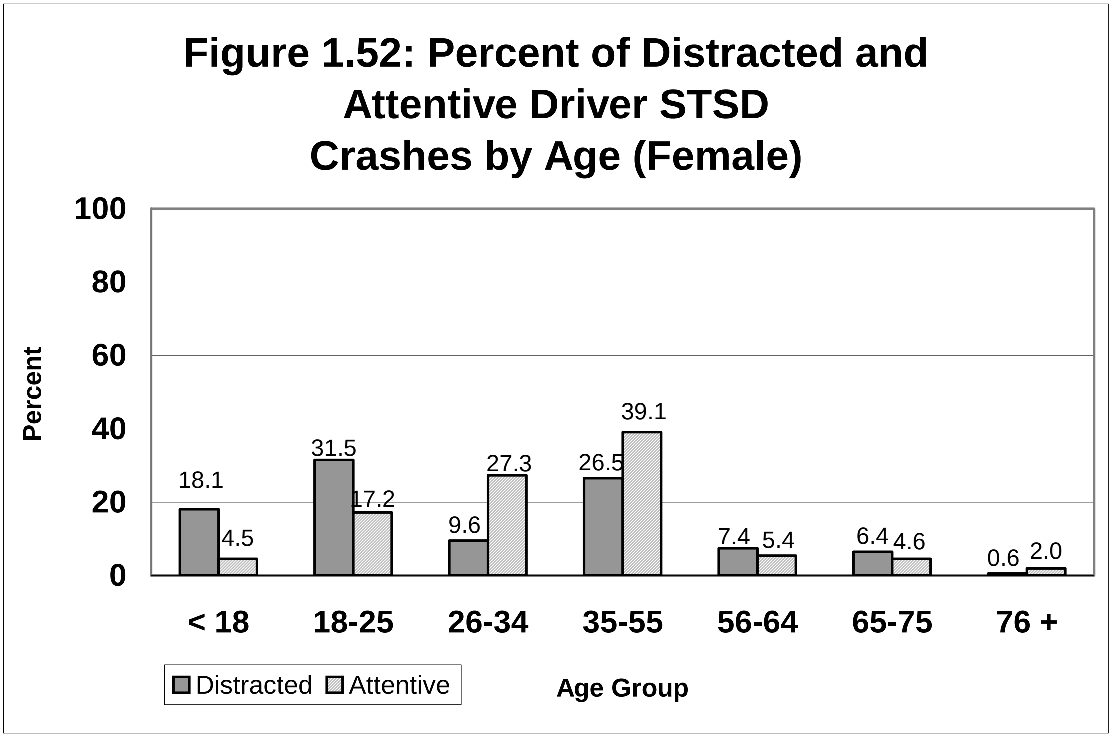


Figure 1.52: Percent of Distracted and Attentive Driver STSD Crashes by Age (Female)
100
80
60
40
20
0
Percent
18.1
4.5
31.5
17.2
9.6
27.3
26.5
39.1
7.4
5.4
6.4
4.6
0.6
2.0
< 18
18-25
26-34
35-55
56-64
65-75
76 +
Distracted
Attentive
Age Group

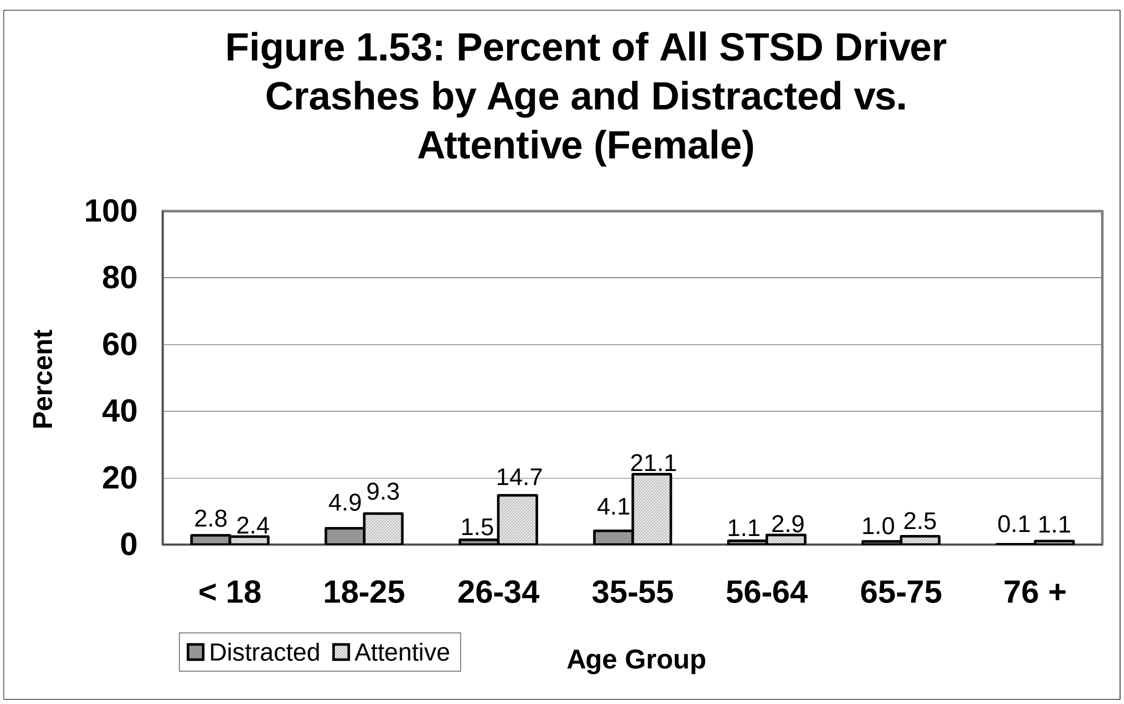


Figure 1.53: Percent of All STSD Driver Crashes by Age and Distracted vs. Attentive (Female)
100
80
60
40
20
0
Percent
2.8
2.4
4.9
9.3
1.5
14.7
4.1
21.1
1.1
2.9
1.0
2.5
0.1
1.1
< 18
18-25
26-34
35-55
56-64
65-75
76 +
Distracted
Attentive
Age Group

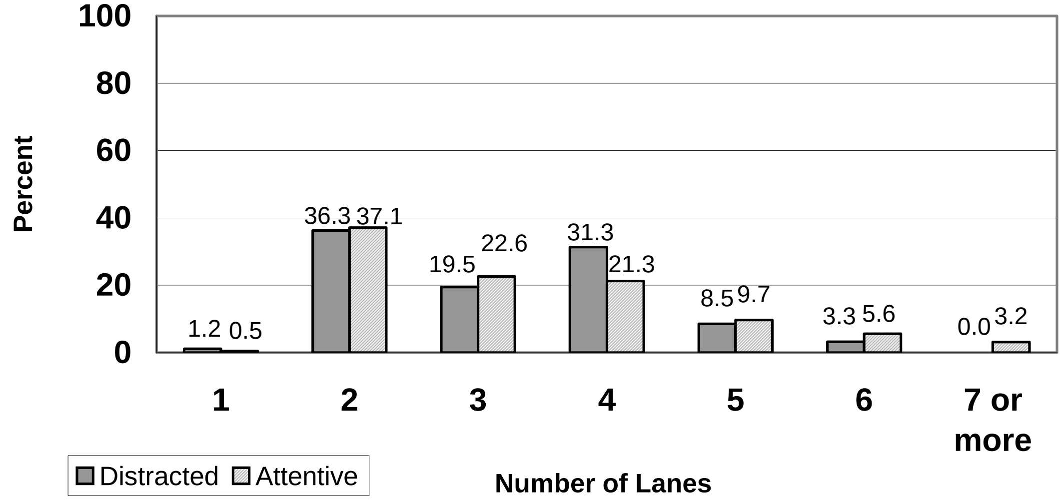


Figure 1.54: Perent Distracted and Attentive STSD Crashes by Number of Lanes

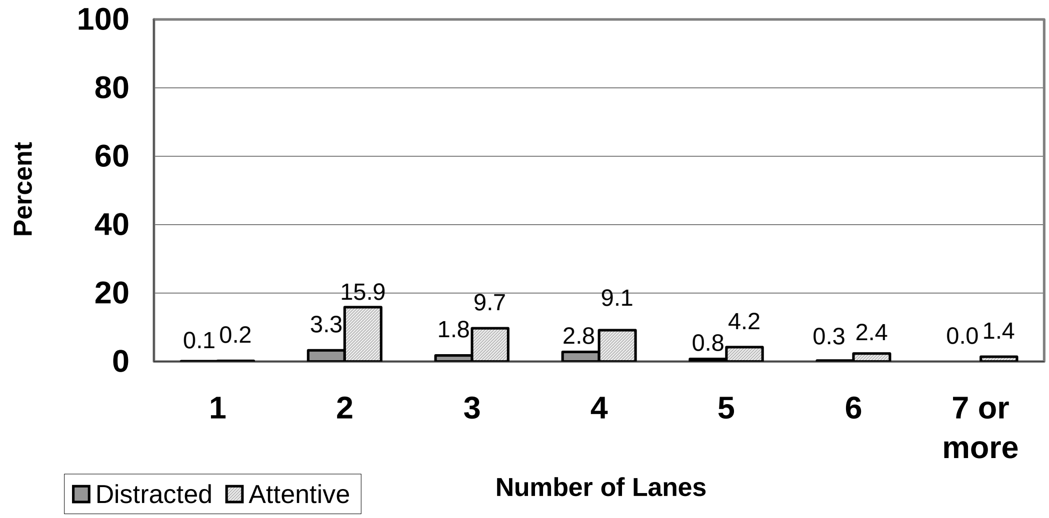


Figure 1.55: Percent of All STSD Crashes by Number of Lanes and Distracted vs Attentive

Figure 1.56: Percent Distracted and Attentive STSD Crashes by Roadway Profile

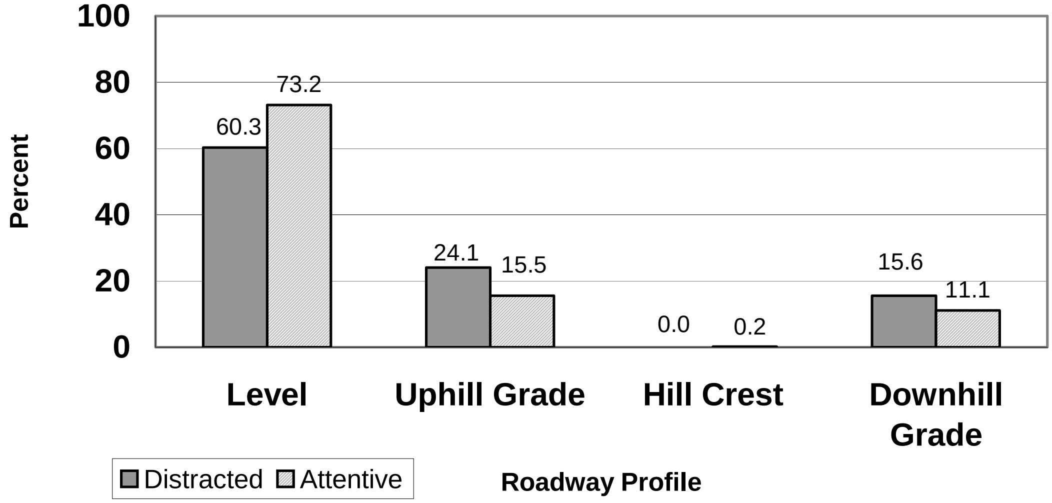


Figure 1.57: Percent of All STSD Crashes by Roadway Profile and Distracted vs. Attentive

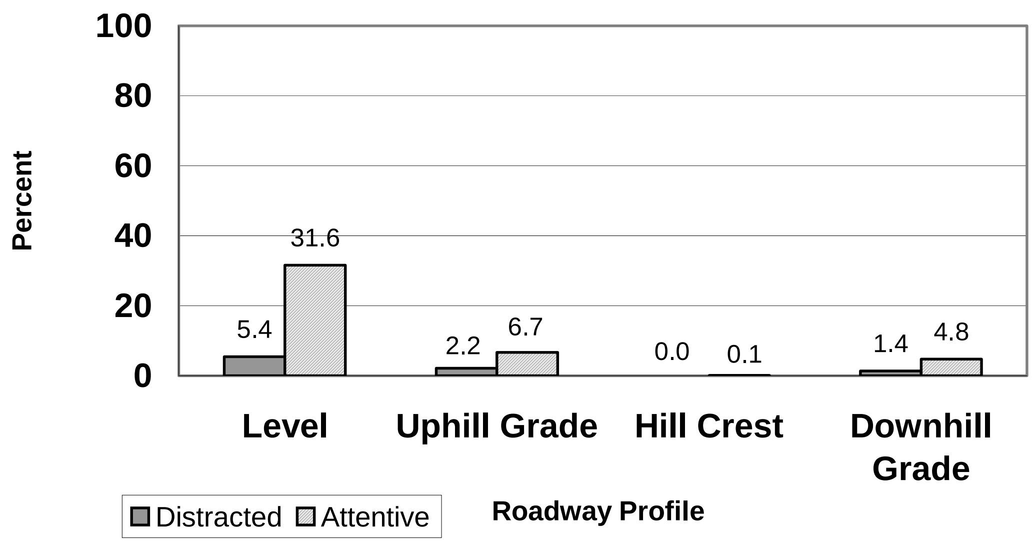


Figure 1.58: Percent Distracted and Attentive STSD Crashes by Relation to Junction

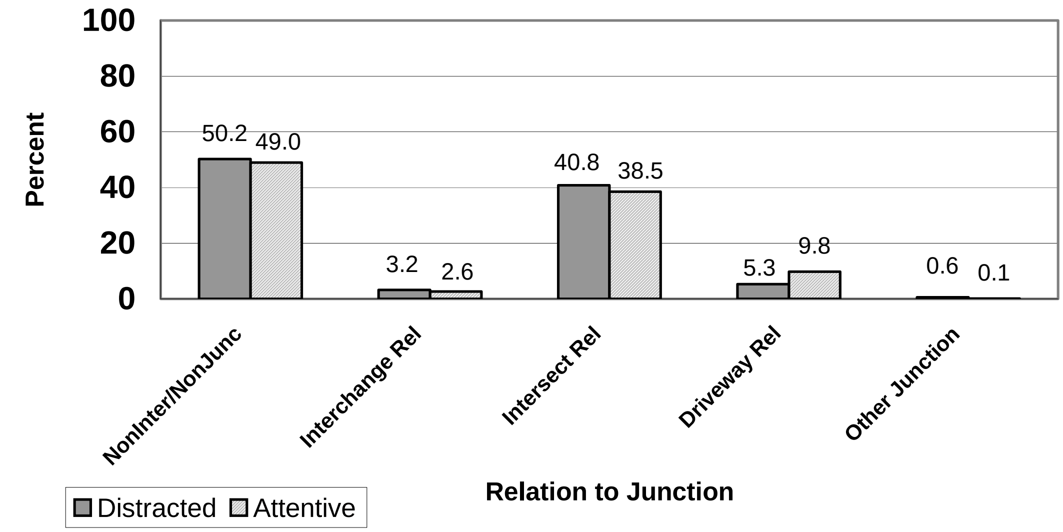
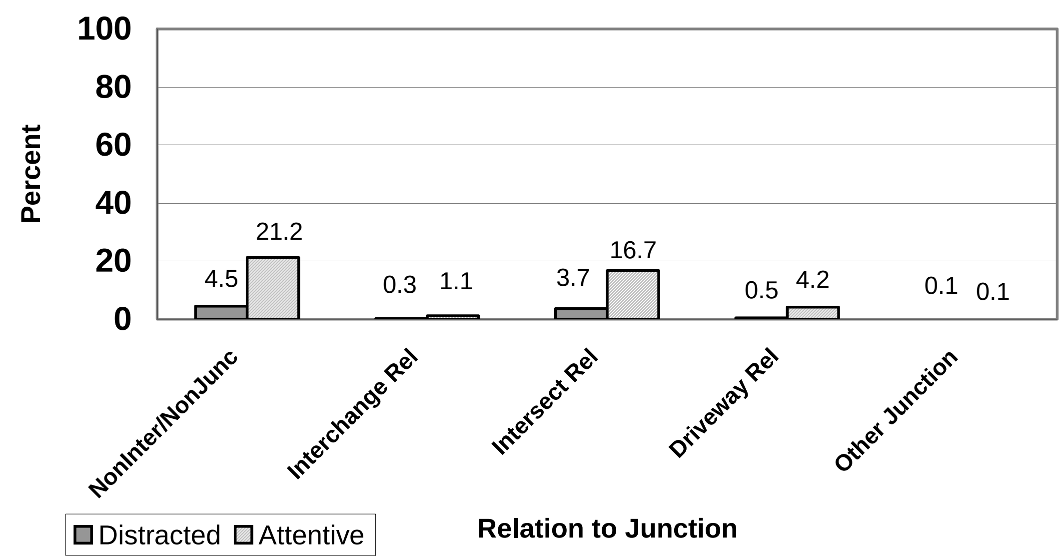


Figure 1.59: Percent of All STSD Crashes by Relation to Junction and Distracted vs. Attentive



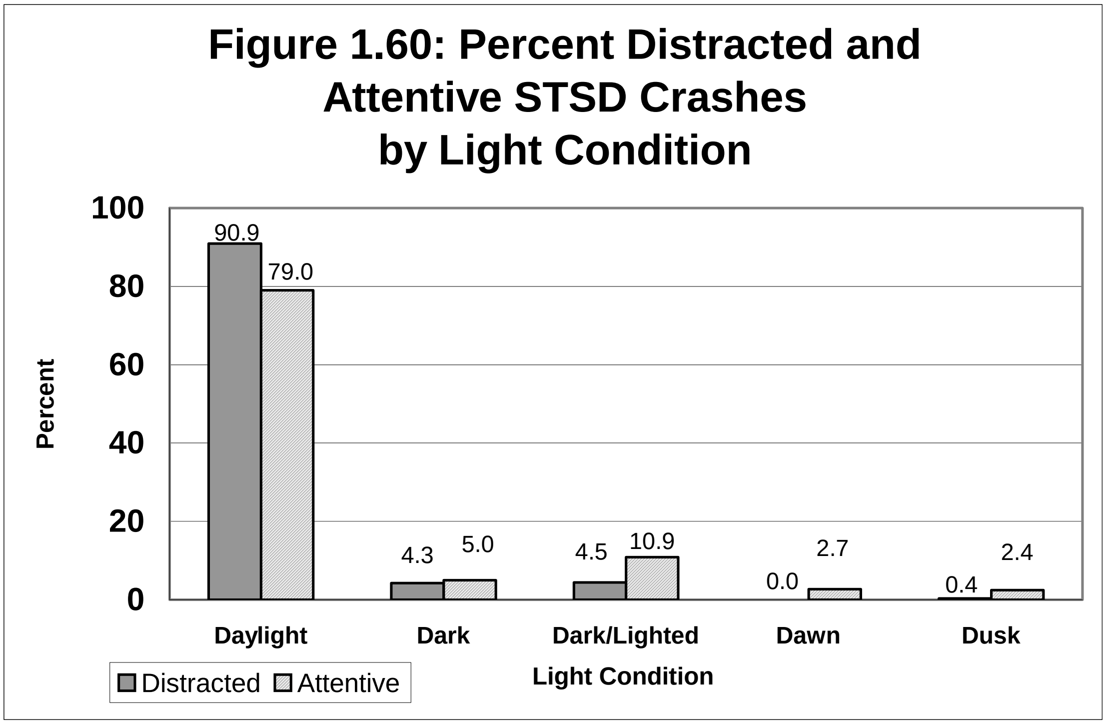


Figure 1.60: Percent Distracted and Attentive STSD Crashes by Light Condition
Percent
100
80
60
40
20
0
90.9
79.0
4.3
5.0
4.5
10.9
0.0
2.7
0.4
2.4
Daylight
Dark
Dark/Lighted
Dawn
Dusk
Light Condition
Distracted
Attentive

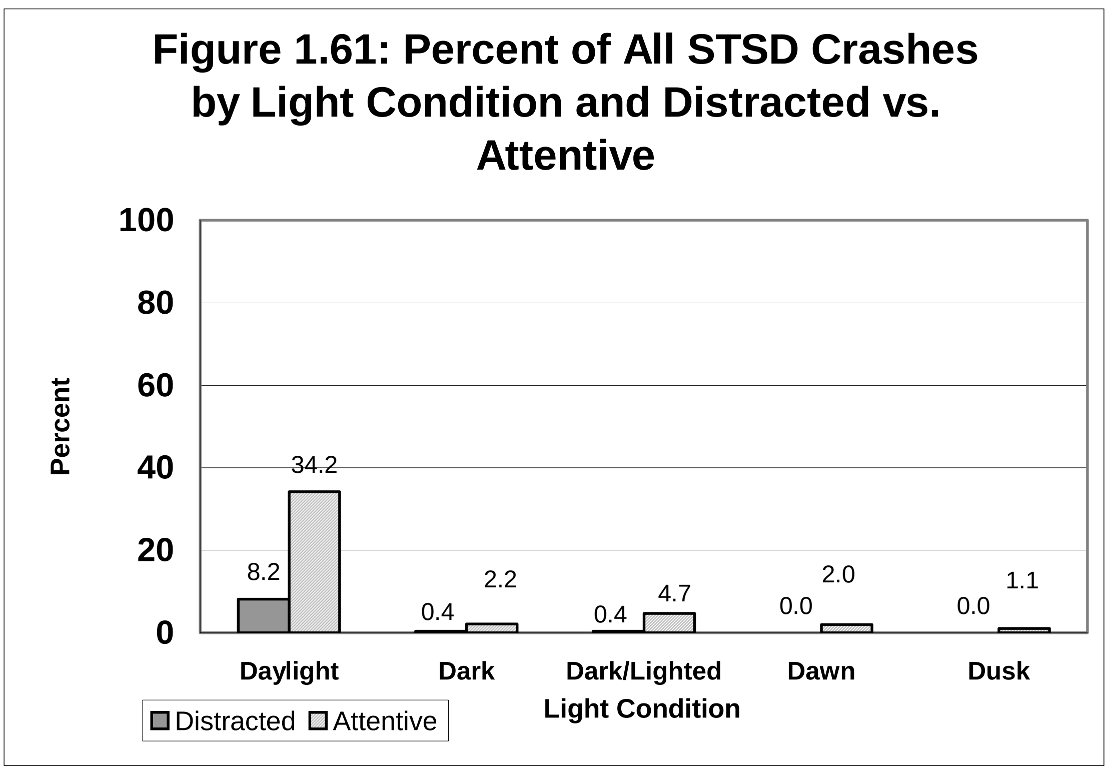


Figure 1.61: Percent of All STSD Crashes by Light Condition and Distracted vs. Attentive
Percent
100
80
60
40
20
0
8.2
34.2
0.4
2.2
0.4
4.7
0.0
2.0
0.0
1.1
Daylight
Dark
Dark/Lighted
Dawn
Dusk
Light Condition
Distracted
Attentive

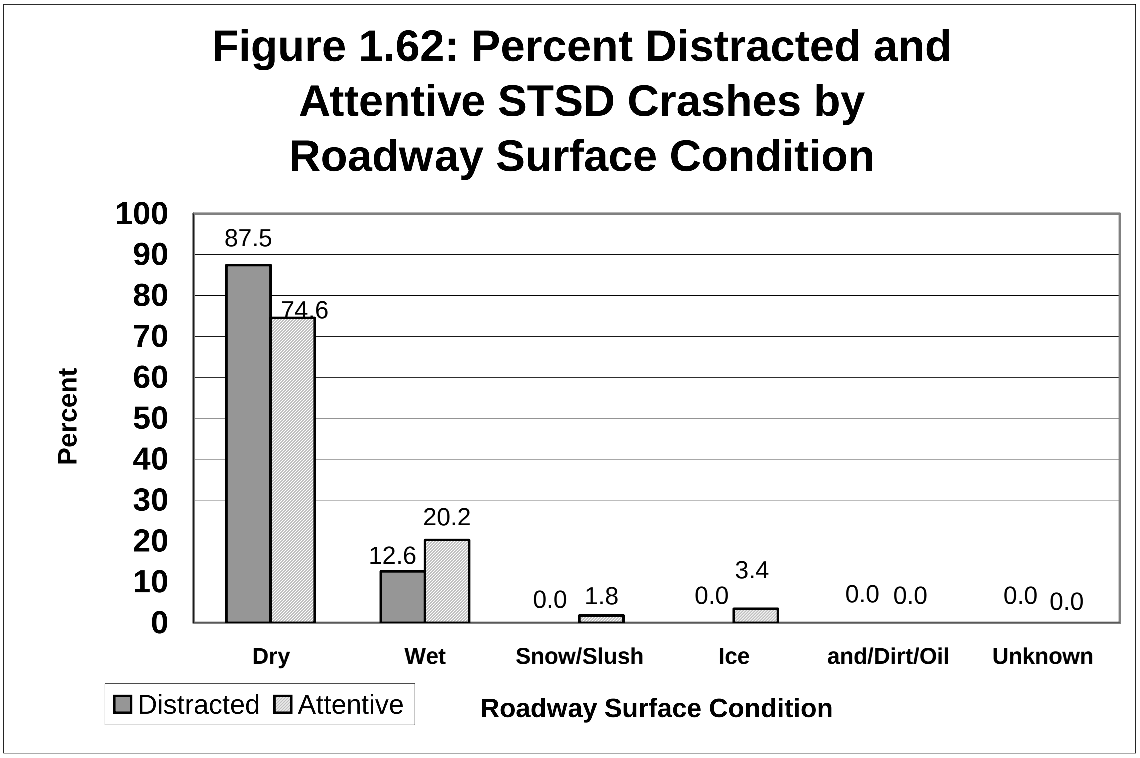


Figure 1.62: Percent Distracted and Attentive STSD Crashes by Roadway Surface Condition
Percent
100
90
80
70
60
50
40
30
20
10
0
87.5
74.6
12.6
20.2
0.0
1.8
0.0
3.4
0.0
0.0
0.0
0.0
Dry
Wet
Snow/Slush
Ice
and/Dirt/Oil
Unknown
Distracted
Attentive
Roadway Surface Condition

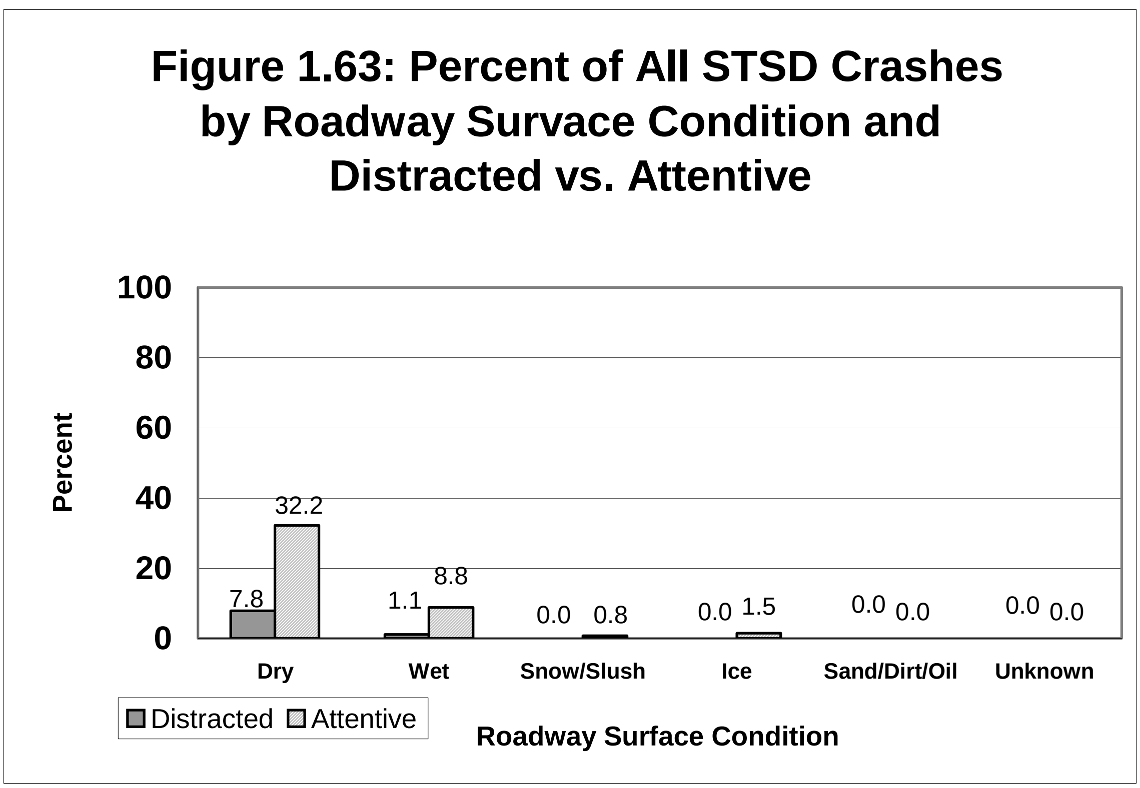


Figure 1.63: Percent of All STSD Crashes by Roadway Survace Condition and Distracted vs. Attentive
Percent
100
80
60
40
20
0
7.8
32.2
1.1
8.8
0.0
0.8
0.0
1.5
0.0
0.0
0.0
0.0
Dry
Wet
Snow/Slush
Ice
Sand/Dirt/Oil
Unknown
Distracted
Attentive
Roadway Surface Condition

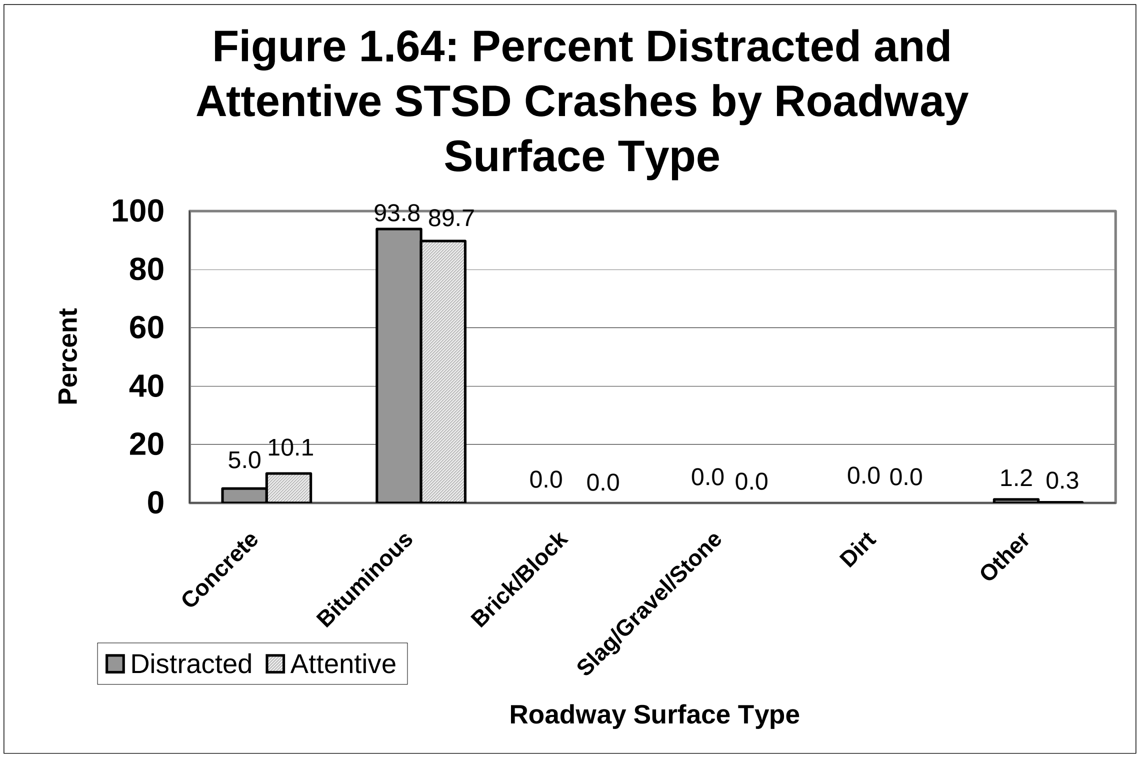


Figure 1.64: Percent Distracted and Attentive STSD Crashes by Roadway Surface Type
100
80
60
40
20
0
Percent
5.0
10.1
93.8
89.7
0.0
0.0
0.0
0.0
0.0
0.0
1.2
0.3
Concrete
Bituminous
Brick/Block
Slag/Gravel/Stone
Dirt
Other
Distracted
Attentive
Roadway Surface Type

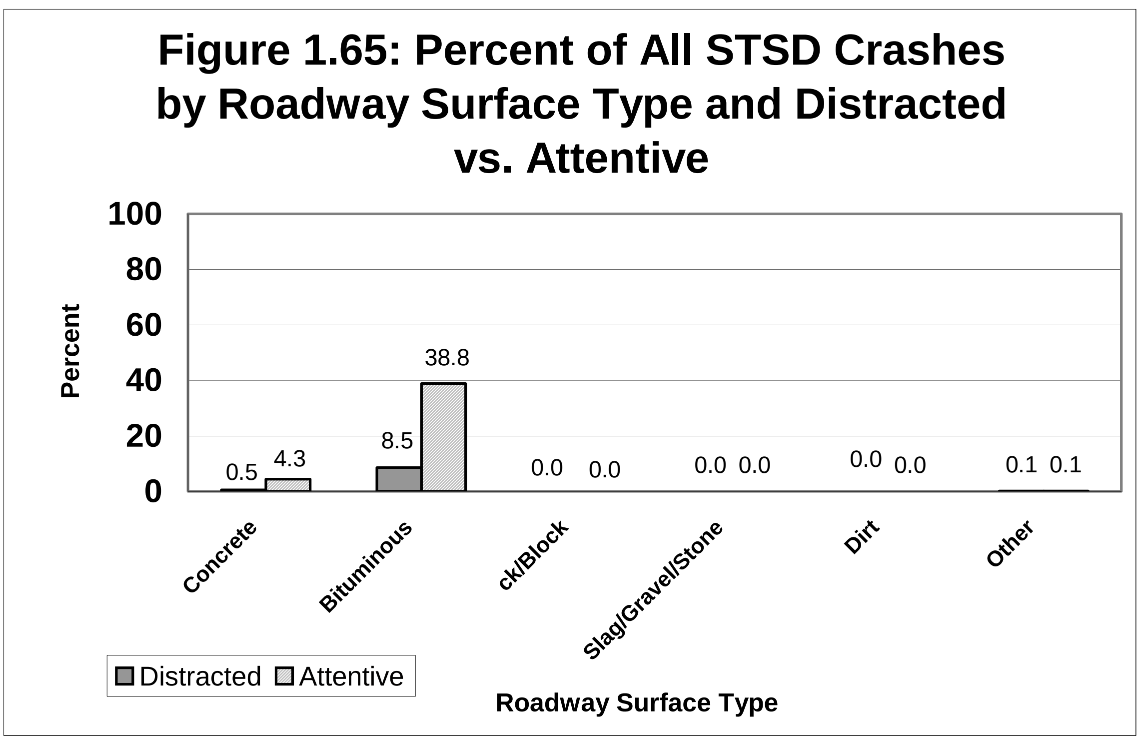


Figure 1.65: Percent of All STSD Crashes by Roadway Surface Type and Distracted vs. Attentive
100
80
60
40
20
0
Percent
0.5
4.3
8.5
38.8
0.0
0.0
0.0
0.0
0.0
0.0
0.1
0.1
Concrete
Bituminous
ck/Block
Slag/Gravel/Stone
Dirt
Other
Distracted
Attentive
Roadway Surface Type

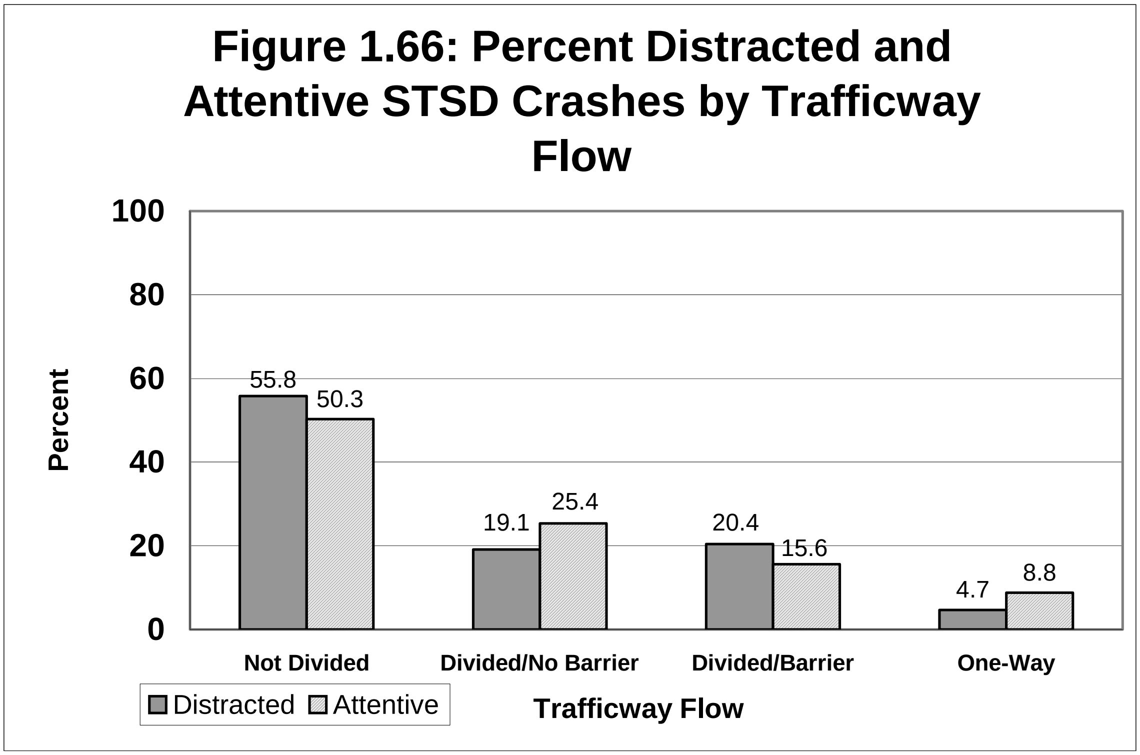


Figure 1.66: Percent Distracted and Attentive STSD Crashes by Trafficway Flow
100
80
60
40
20
0
Percent
55.8
50.3
19.1
25.4
20.4
15.6
4.7
8.8
Not Divided
Divided/No Barrier
Divided/Barrier
One-Way
Distracted
Attentive
Trafficway Flow

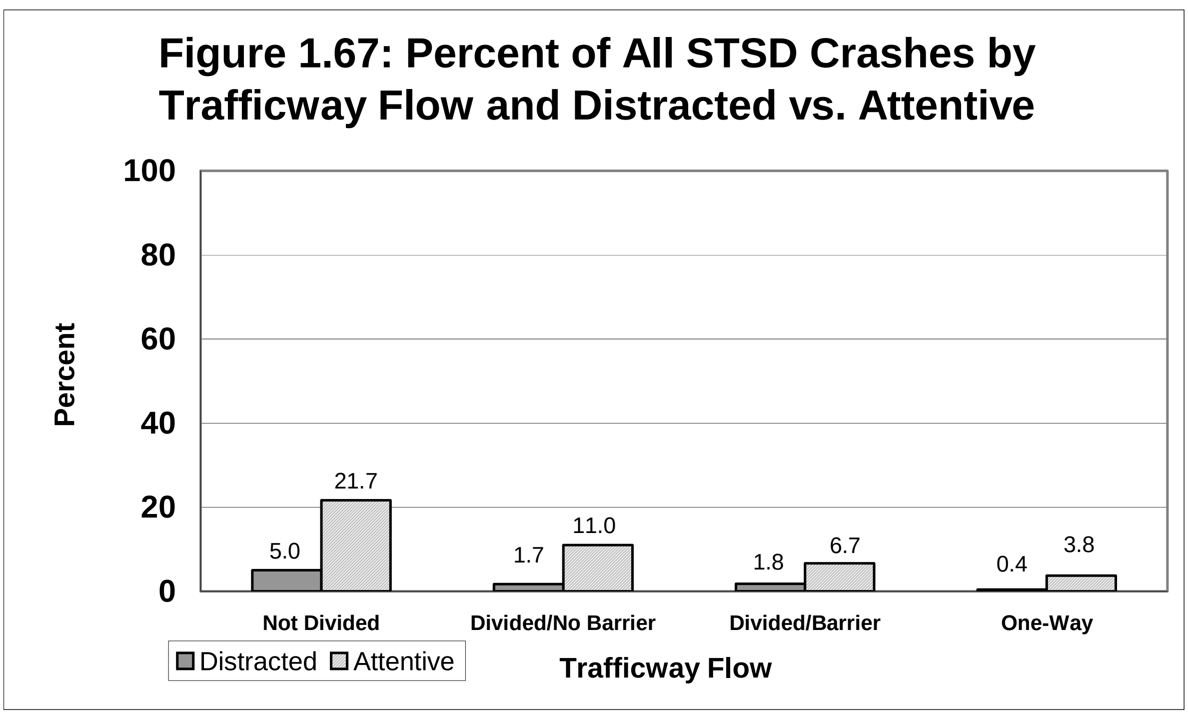


Figure 1.67: Percent of All STSD Crashes by Trafficway Flow and Distracted vs. Attentive
100
80
60
40
20
0
Percent
5.0
21.7
1.7
11.0
1.8
6.7
0.4
3.8
Not Divided
Divided/No Barrier
Divided/Barrier
One-Way
Distracted
Attentive
Trafficway Flow

Figure 1.68: Percent Distracted and Attentive STSD Crashes by Weather Condition

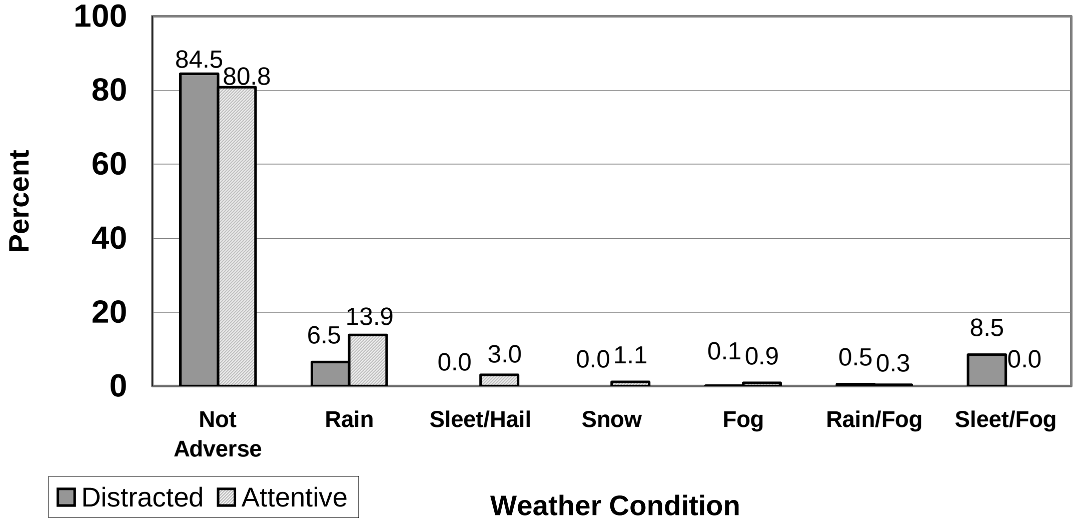


Figure 1.69: Percent of All STSD Crashes by Weather Condition and Distracted vs. Attentive

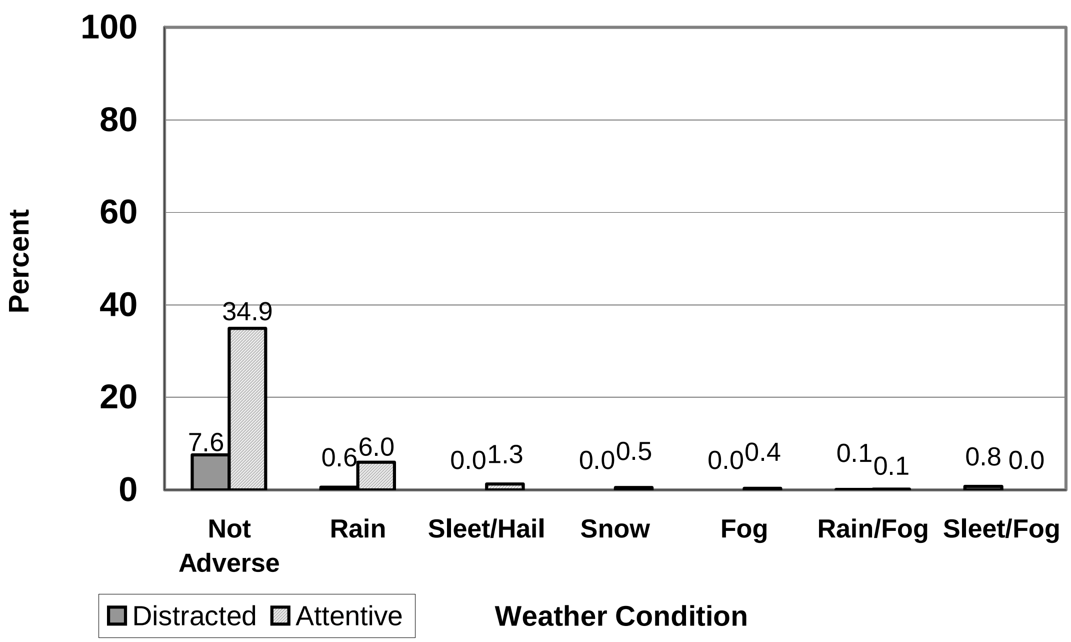


Figure 1.70: Percent Distracted and Attentive STSD Crashes by Number of Occupants

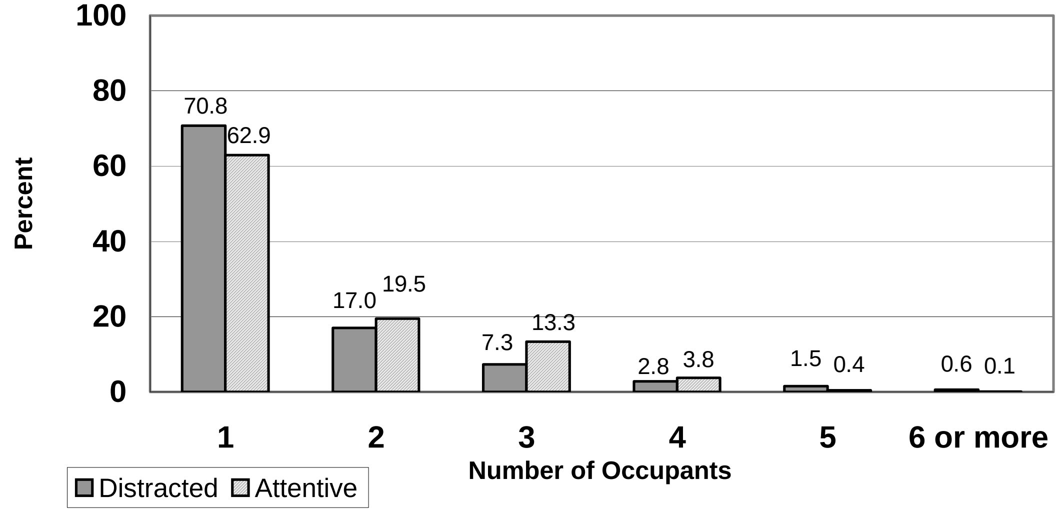
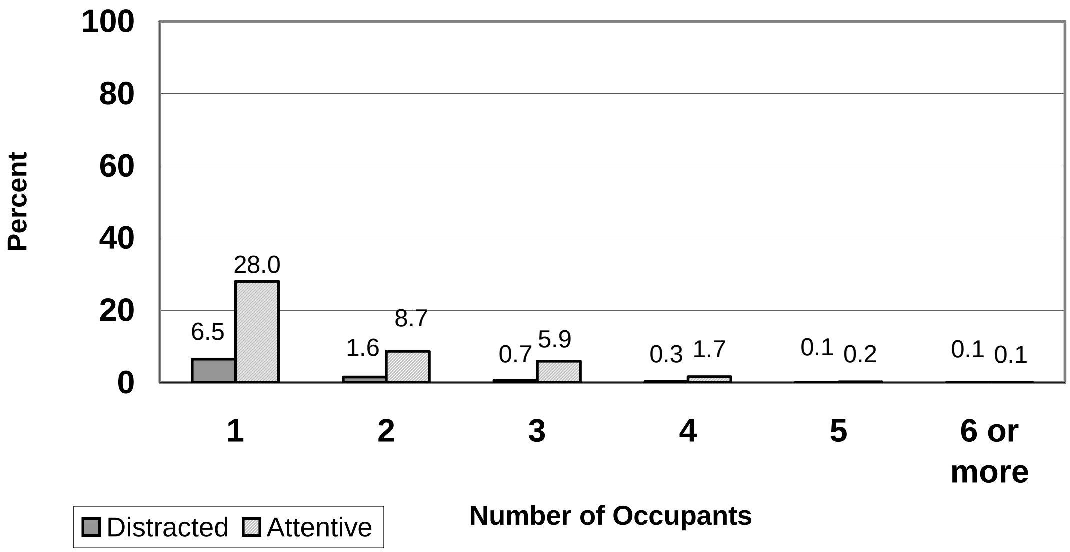


Figure 1.71: Percent of All STSD Crashes by Number of Occupants and Distracted vs. Attentive



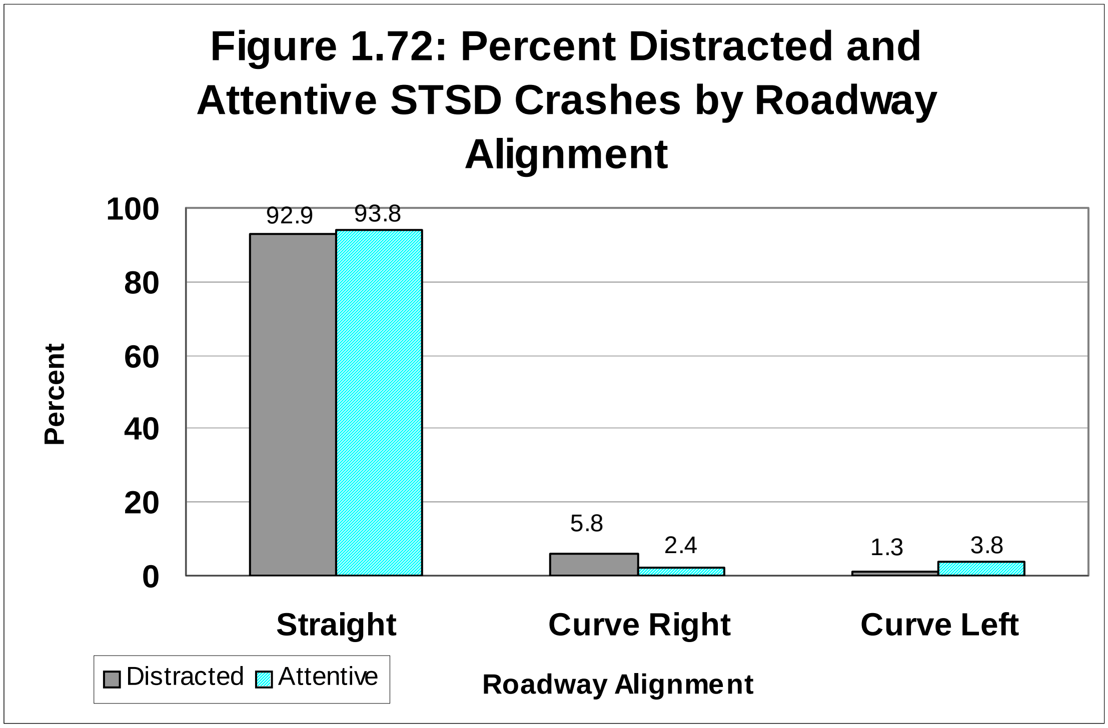


Figure 1.72: Percent Distracted and Attentive STSD Crashes by Roadway Alignment
Percent
100
80
60
40
20
0
92.9
93.8
5.8
2.4
1.3
3.8
Straight
Curve Right
Curve Left
Distracted
Attentive
Roadway Alignment

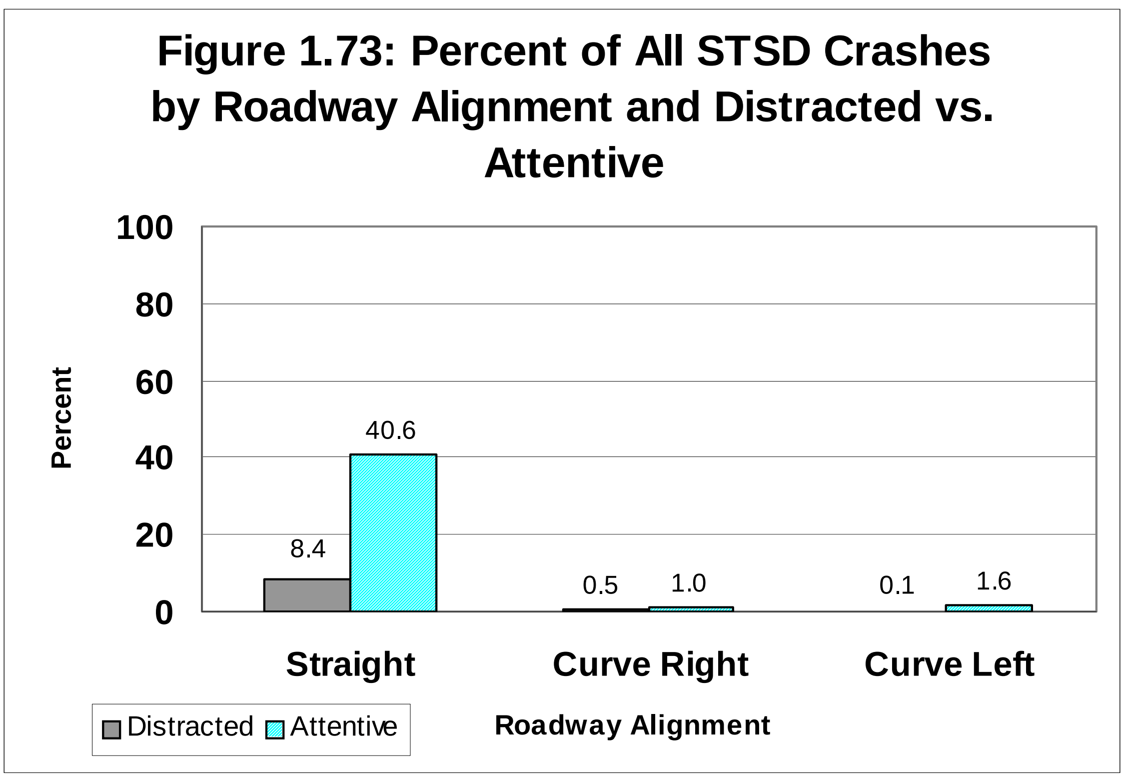
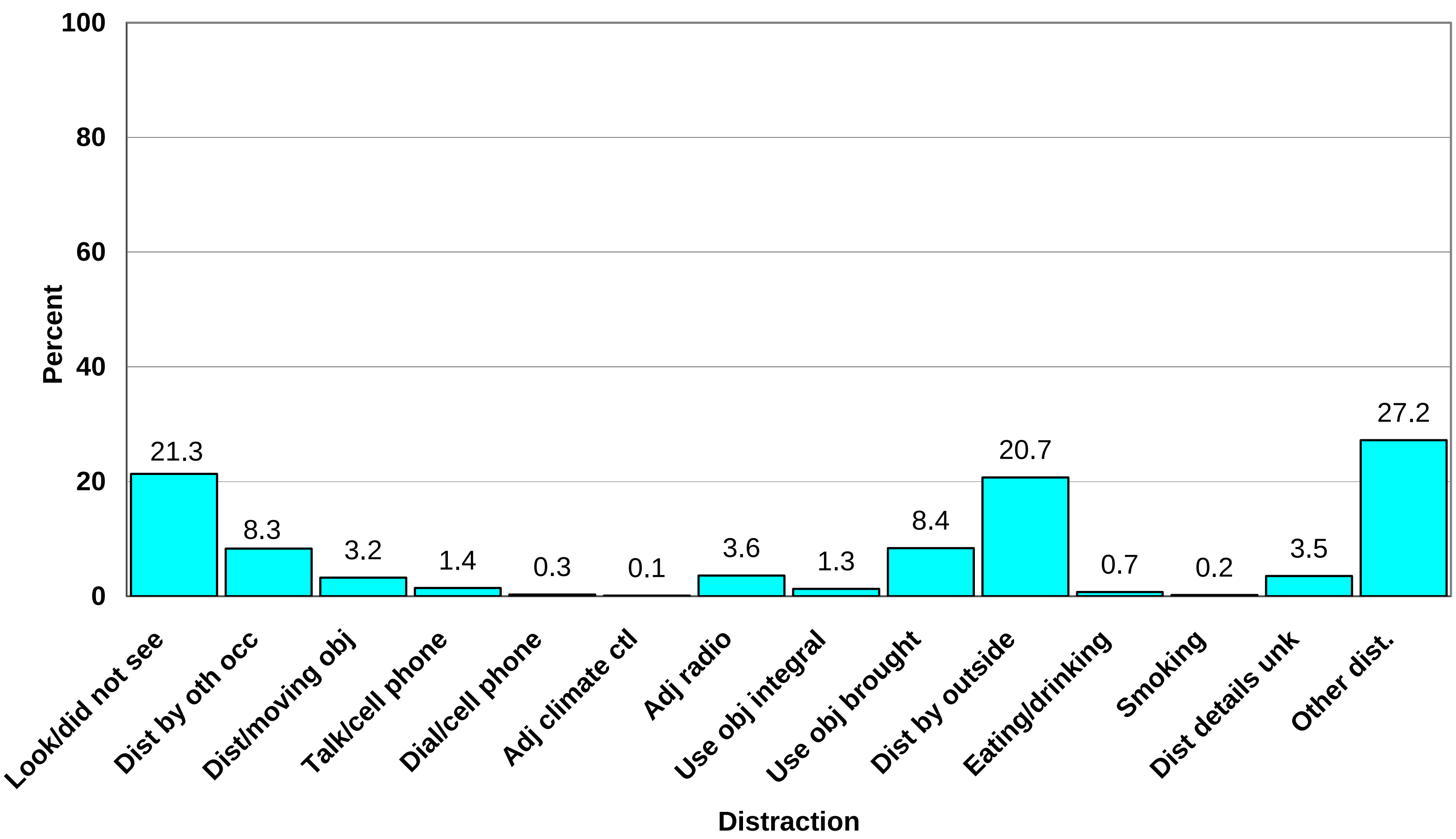


Figure 1.73: Percent of All STSD Crashes by Roadway Alignment and Distracted vs. Attentive
Percent
100
80
60
40
20
0
8.4
40.6
0.5
1.0
0.1
1.6
Straight
Curve Right
Curve Left
Distracted
Attentive
Roadway Alignment

Figure 1.74: Percent Recorded Distraction for Drivers in STSD Crashes



1.3.1.3.3. Intersecting Paths (IP)

Sex: Figures 1.75-1.76 show the proportion of all IP distracted and all IP attentive crashes (Figure 1.75) and the proportion of distracted and attentive IP crashes (Figure 1.76) by sex. A greater proportion of both distracted and attentive IP crashes were attributed to females. A large difference was found between attentive and distracted IP crashes when the proportion within the crash categories (attentive vs. distracted) were compared for females, with distracted crashes much more common. The opposite was found for males. Large differences were found when the proportions were determined as a function of all IP crashes, with distracted crashes much less frequent than attentive crashes for both sexes.

Age Group: The proportion of all distracted and all attentive IP crashes and the proportion of distracted and attentive crashes by all IP crashes by age group are shown in Figures 1.77 and 1.78. When proportions were compared within the crash categories (Figure 1.77), we found that distracted IP crashes were much more frequent for drivers aged 56-64 and drivers aged 76 or more. When compared among all IP crashes (Figure 1.78), similar results were found.

Age Group and Sex: Figures 1.79-1.82 show the proportions of IP by males and age (Figure 1.79-1.80) and by females and age (Figures 1.81-1.82). For males, IP distracted crashes were more common for drivers under age 18, drivers 35-55, and driver aged 65-75 when proportions were compared within crash categories. When compared among all IP crashes, distracted crashes for males were less common than attentive crashes for all age groups. For females, distracted IP crashes were more common for drivers aged 56-64 and aged 76 years or more when proportions were compared within crash categories. Comparing within all IP crashes, very similar results were found.

Number of Lanes: Figures 1.83 and 1.84 show IP crashes by the number of traffic lanes. Distracted IP crashes were much more common for two-lane, five-lane, and six-lanes roads when proportion were compared within crash categories (Figure 1.83), while attentive crashes were more frequent for all lane numbers (except six-lane roads) when proportions were compared among all IP crashes (Figure 1.84).

Roadway Profile: Figures 1.85 and 1.86 show the distributions of distracted and attentive IP crashes by the roadway profile. Comparisons within the crash categories showed that distracted IP crashes were much more frequent for downhill grades (Figure 1.85). Comparing proportions among all IP crashes showed that distracted IP crashes were also more frequent than attentive IP crashes for downhill grades.

Relation to Junction: Figures 1.87 and 1.88 show the distributions of distracted and attentive IP crashes by the relation to junctions. Comparison within the crash categories showed little difference by relation to junction, except that distracted crashes were more common at freeway interchanges (Figure 1.87), and attentive IP crashes were more common, or equal to, attentive crashes in all cases, when proportions were compared relative to all IP crashes (Figure 1.88).

Light Conditions: Figures 1.89 and 1.90 show the distributions of distracted and attentive IP crashes by the light conditions. Comparisons within the crash categories showed that distracted IP crashes were slightly more frequent during "daylight", "dark", and "dusk" conditions (Figure 1.89). Comparing proportions among all IP crashes showed that distracted IP crashes were less frequent than, or the same as, attentive crashes for all lighting conditions.

Roadway Surface Conditions: Figures 1.91 and 1.92 show the distributions of distracted and attentive IP crashes by the roadway surface conditions. Comparisons within the crash categories showed that distracted IP crashes were only slightly more frequent for dry road conditions (Figure 1.91). Comparing proportions among all IP crashes showed that distracted IP crashes were less frequent than, or equal to, attentive crashes for all roadway conditions (Figure 1.92).

Roadway Surface Type: Figures 1.93 and 1.94 show the distributions of distracted and attentive IP crashes by the roadway surface type. Comparisons within the crash categories showed that distracted IP crashes were more common for dirt roads only (Figure 1.93). Comparing proportions among all IP crashes showed that distracted IP crashes were less frequent then, or equal to, attentive crashes for all surface types (Figure 1.94).

Trafficway Flow: Figures 1.95 and 1.96 show the distributions of distracted and attentive IP crashes by the trafficway flow. Comparisons within the crash categories showed that distracted IP crashes were slightly more frequent for "divided with no barrier" and much more common for "one-way" roads (Figure 1.95). Comparing proportions among all IP crashes showed that distracted IP crashes were less frequent for all trafficway flow types (Figure 1.96).

Weather Conditions: Figures 1.97 and 1.98 show the distributions of distracted and attentive IP crashes by the prevailing weather condition. Comparisons within the crash categories showed that distracted IP crashes were more frequent only for rainy weather (Figure 1.97). Comparing proportions among all IP crashes showed that distracted IP crashes were less frequent than, or equal to, attentive crashes for all weather conditions (Figure 1.98).

Number of Occupants: Figures 1.99 and 1.100 show the distributions of distracted and attentive IP crashes by the number of occupants in the vehicle. Comparisons within the crash categories showed that distracted IP crashes were more frequent when there were two occupants in the vehicle (Figure 1.99). Comparing proportions among all IP crashes showed that distracted IP crashes were less frequent, or equal to, attentive crashes for all numbers of occupants (Figure 1.100).

Roadway Alignment: Figures 1.101 and 1.102 show the distributions of distracted and attentive IP crashes by the roadway alignment. Comparison within the crash categories showed that distracted IP crashes were slightly more frequent for curves to the left (Figure 1.101). Comparing proportions among all IP crashes showed that distracted IP crashes were also slightly more frequent for all curves to the left (Figure 1.102).

IP Crashes by Distraction Code: Figure 1.103 shows the distribution of the distraction codes for IP crashes. As shown in this figure, in about 60 percent of distracted IP crashes the cited distraction was “looked, but did not see.” The next most commonly cited distraction another occupant in the vehicle.

Figure 1.75: Percent of Distracted and Attentive Drivers in IP Crashes by Sex

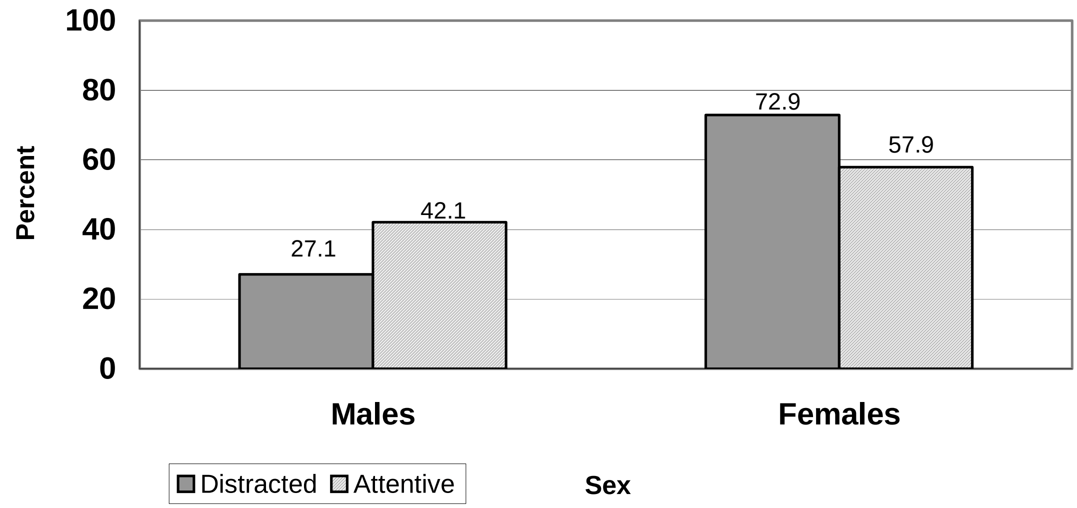
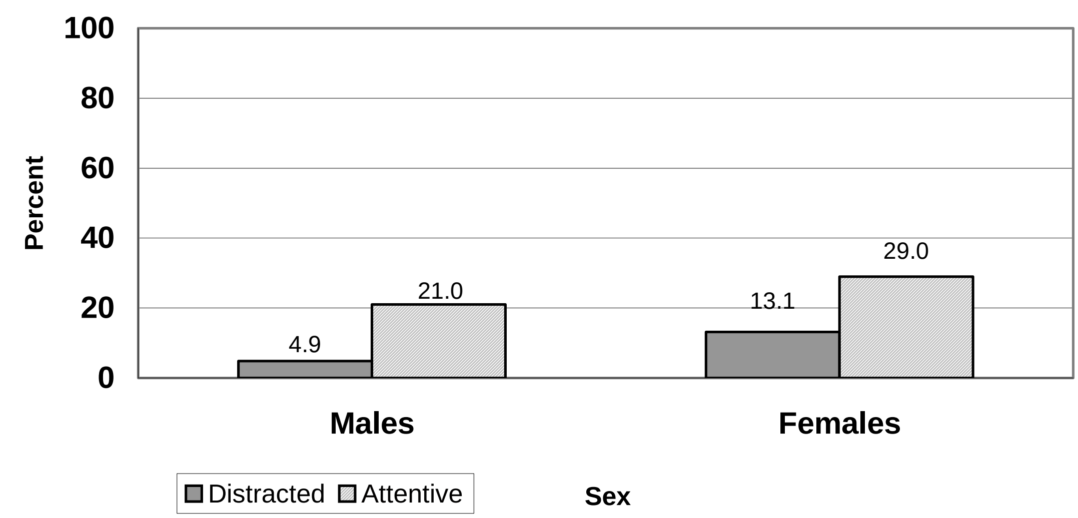


Figure 1.76: Percent of All IP Driver Crashes by Sex and Distracted vs. Attentive



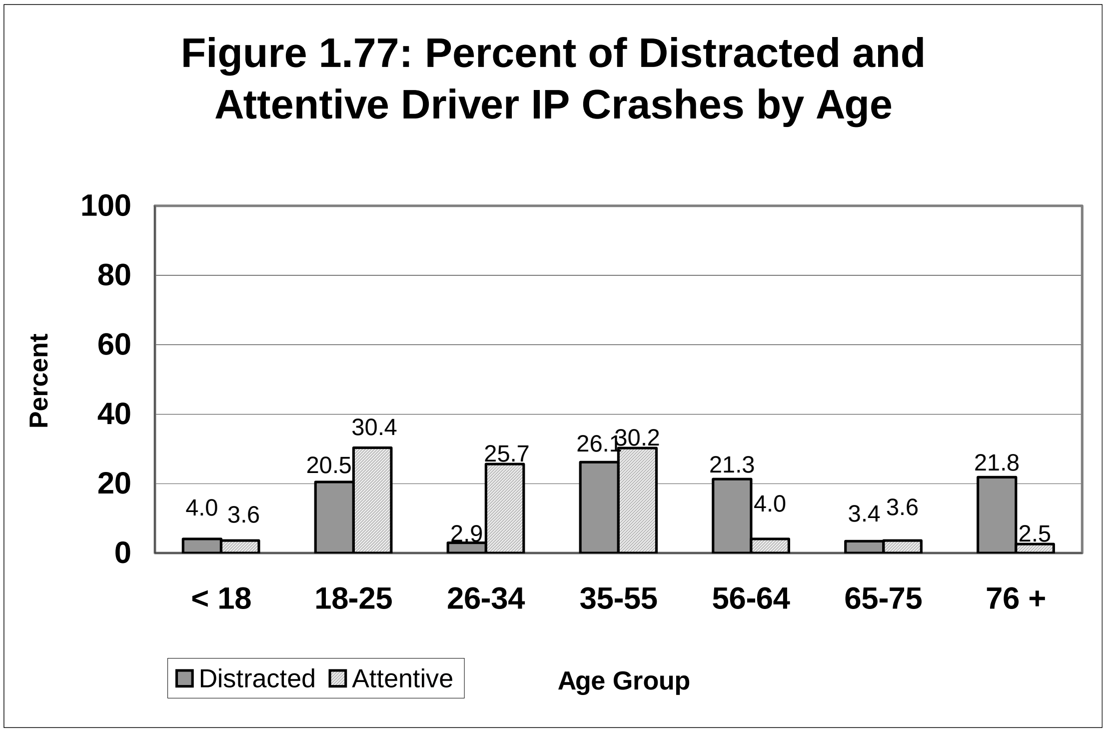


Figure 1.77: Percent of Distracted and Attentive Driver IP Crashes by Age
100
80
60
40
20
0
Percent
4.0
3.6
20.5
30.4
2.9
25.7
26.1
30.2
21.3
4.0
3.4
3.6
21.8
2.5
< 18
18-25
26-34
35-55
56-64
65-75
76 +
Distracted
Attentive
Age Group

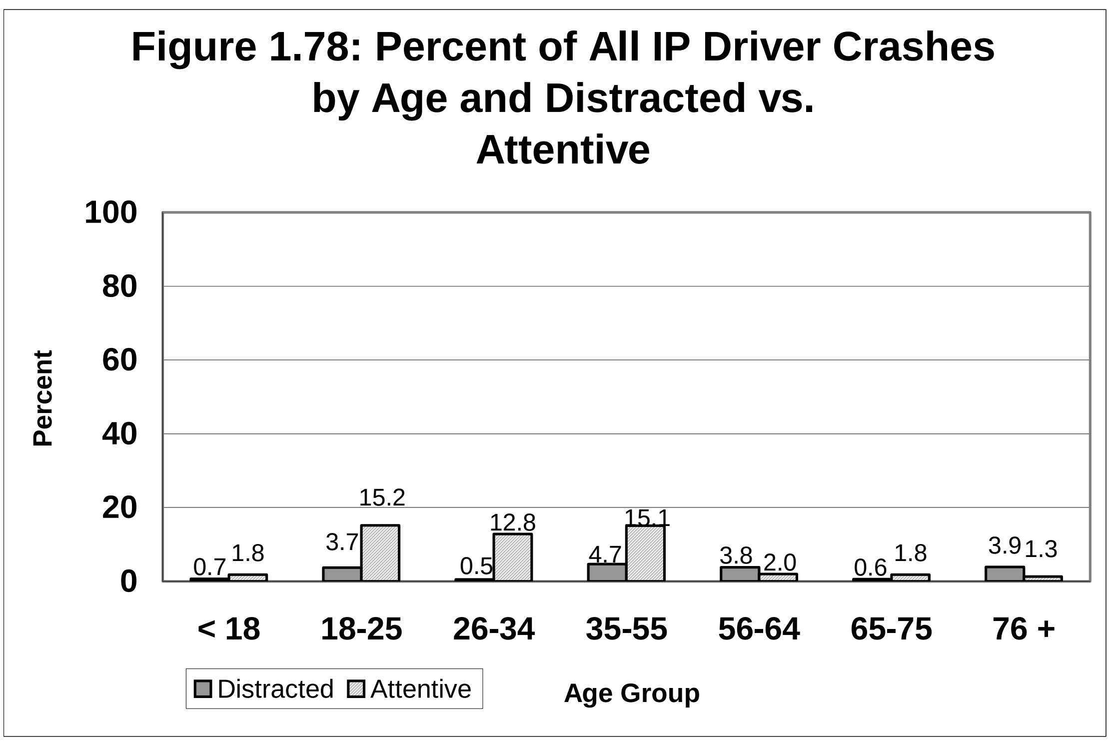


Figure 1.78: Percent of All IP Driver Crashes by Age and Distracted vs. Attentive
100
80
60
40
20
0
Percent
0.7
1.8
3.7
15.2
0.5
12.8
4.7
15.1
3.8
2.0
0.6
1.8
3.9
1.3
< 18
18-25
26-34
35-55
56-64
65-75
76 +
Distracted
Attentive
Age Group

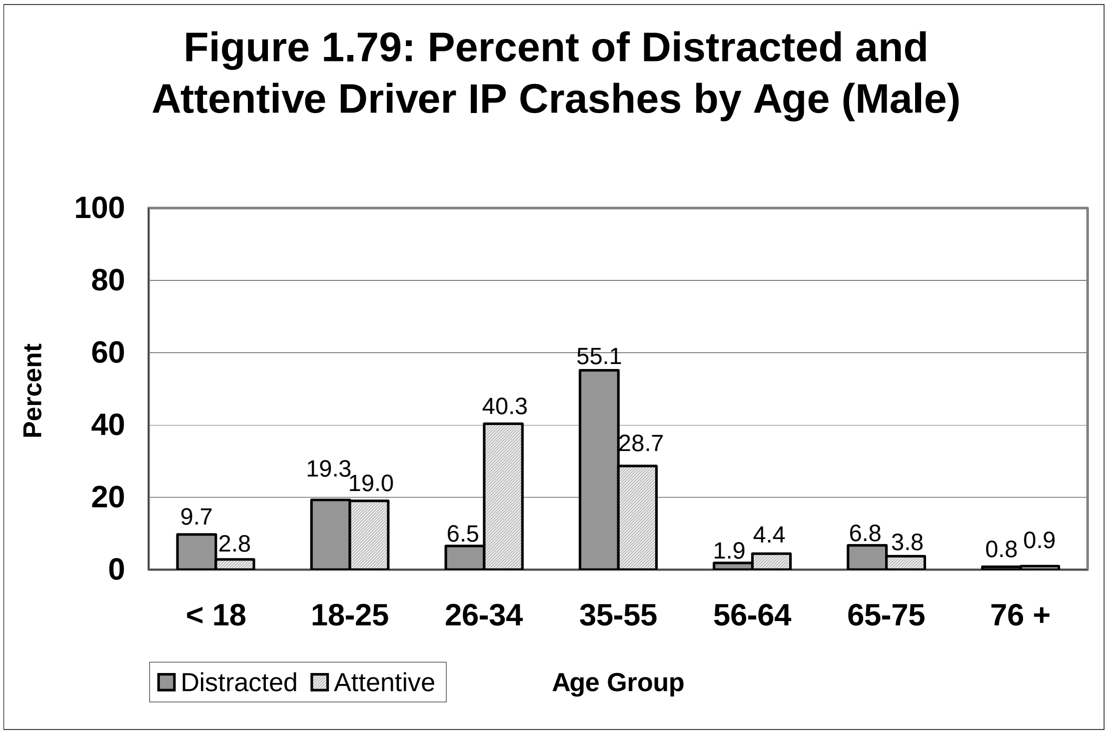


Figure 1.79: Percent of Distracted and Attentive Driver IP Crashes by Age (Male)
Percent
100
80
60
40
20
0
9.7
2.8
19.3
19.0
6.5
40.3
55.1
28.7
1.9
4.4
6.8
3.8
0.8
0.9
< 18
18-25
26-34
35-55
56-64
65-75
76 +
Distracted
Attentive
Age Group

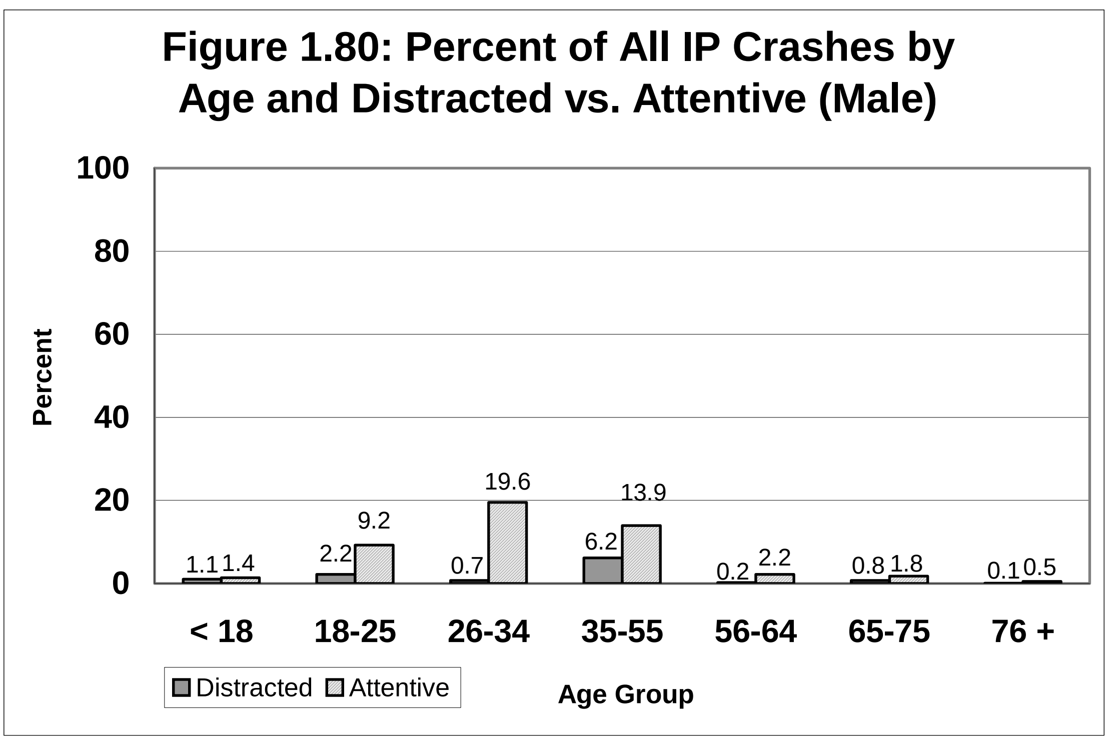


Figure 1.80: Percent of All IP Crashes by Age and Distracted vs. Attentive (Male)
Percent
100
80
60
40
20
0
1.1
1.4
2.2
9.2
0.7
19.6
6.2
13.9
0.2
2.2
0.8
1.8
0.1
0.5
< 18
18-25
26-34
35-55
56-64
65-75
76 +
Distracted
Attentive
Age Group

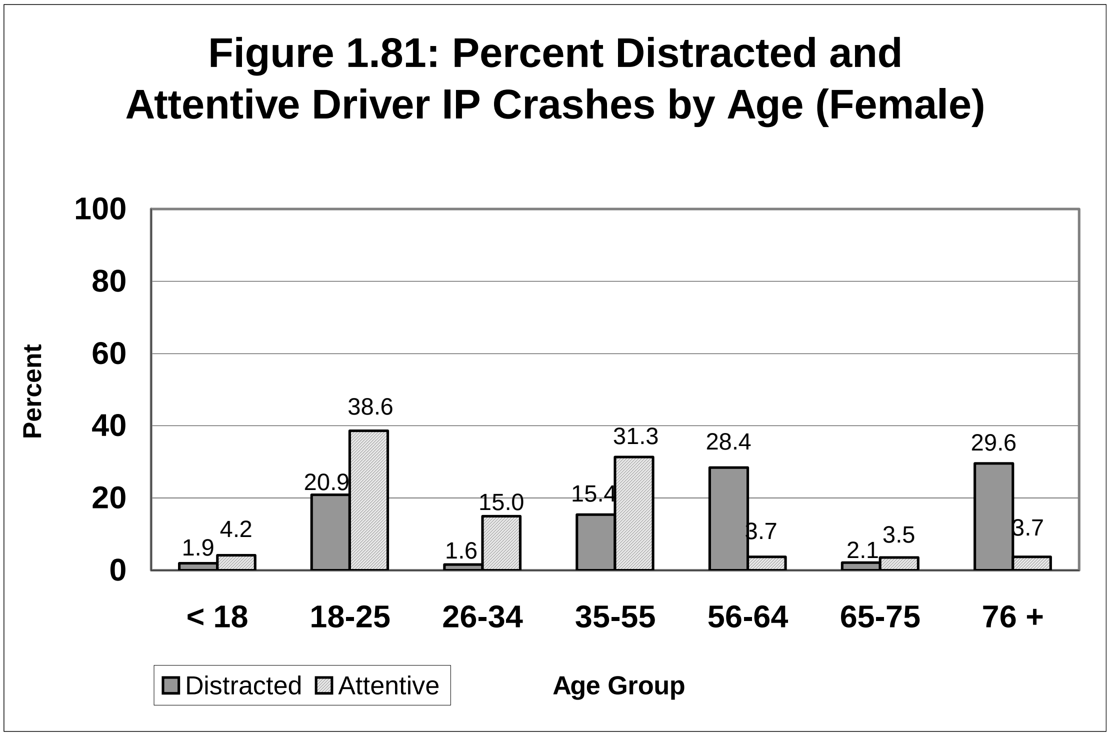


Figure 1.81: Percent Distracted and Attentive Driver IP Crashes by Age (Female)
100
80
60
40
20
0
Percent
1.9
4.2
20.9
38.6
1.6
15.0
15.4
31.3
28.4
3.7
2.1
3.5
29.6
3.7
< 18
18-25
26-34
35-55
56-64
65-75
76 +
Distracted
Attentive
Age Group

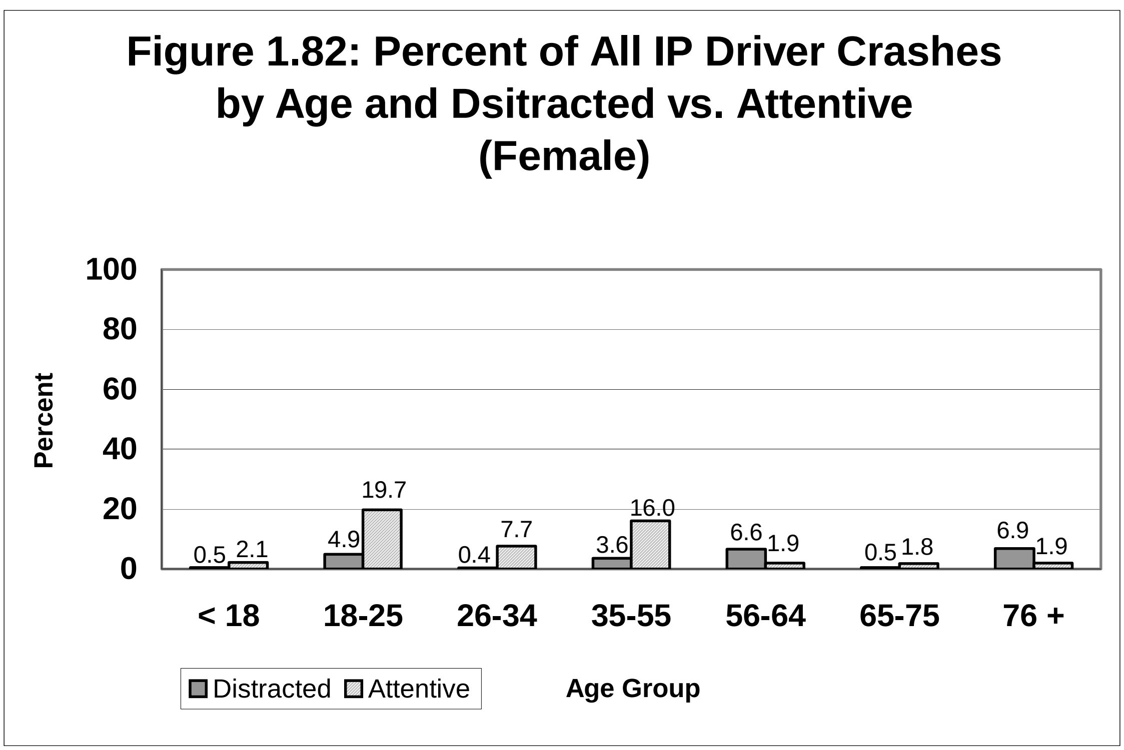


Figure 1.82: Percent of All IP Driver Crashes by Age and Dsitracted vs. Attentive (Female)
100
80
60
40
20
0
Percent
0.5
2.1
4.9
19.7
0.4
7.7
3.6
16.0
6.6
1.9
0.5
1.8
6.9
1.9
< 18
18-25
26-34
35-55
56-64
65-75
76 +
Distracted
Attentive
Age Group

Figure 1.83: Percent Distracted and Attentive IP Crashes by Number of Lanes

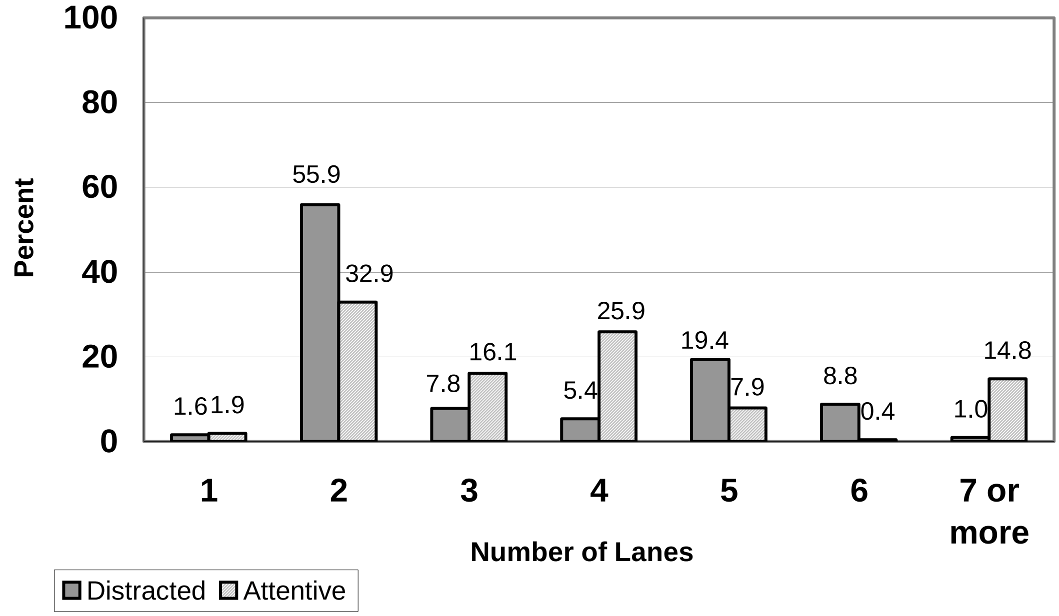


Figure 1.84: Percent of All IP Crashes by Number of Lanes and Distracted vs. Attentive

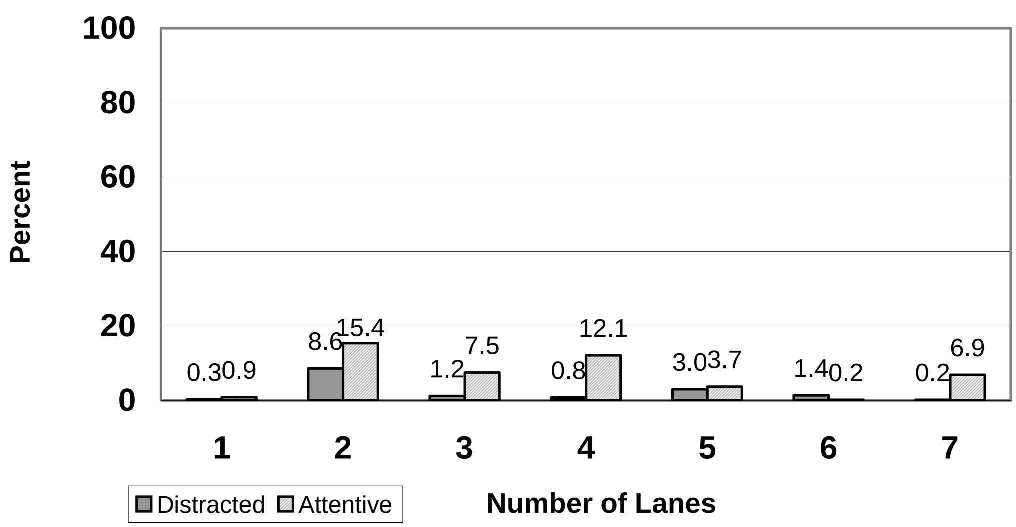


Figure 1.85: Percent Distracted and Atentive IP Crashes by Roadway Profile

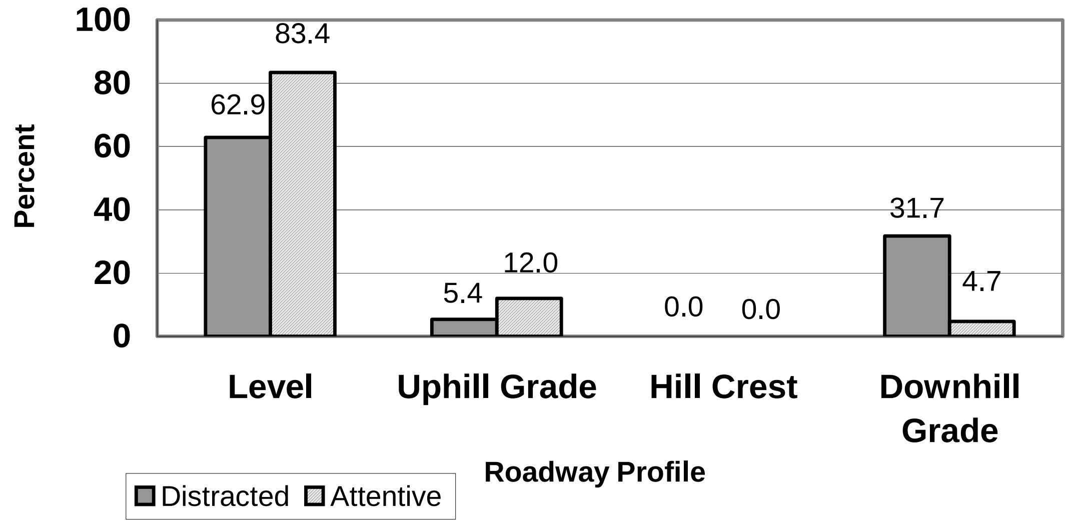


Figure 1.86: Percent of All IP Crashes by Roadway Profile and Distracted vs. Atentive

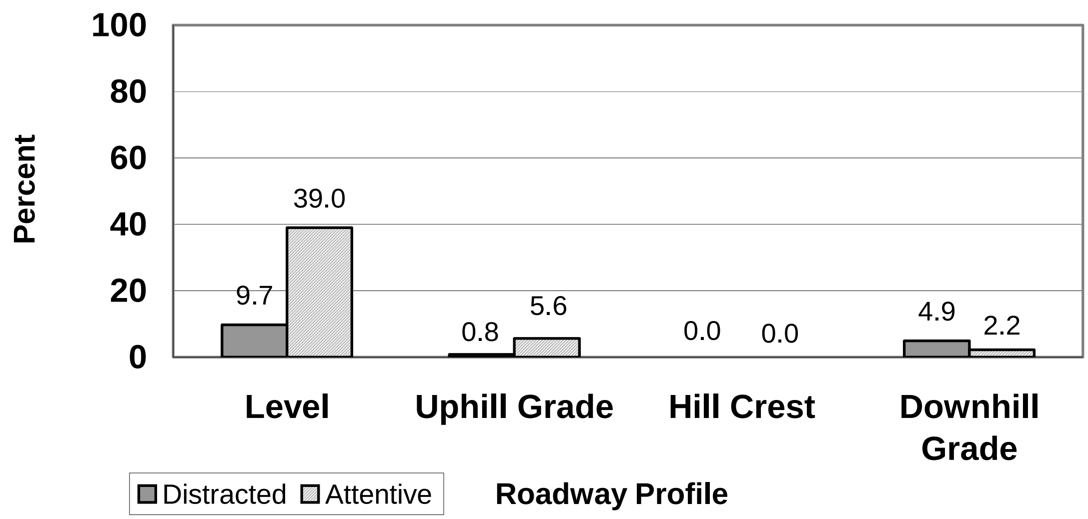


Figure 1.87: Percent Distracted and Attentive IP Crashes by Relation to Junction

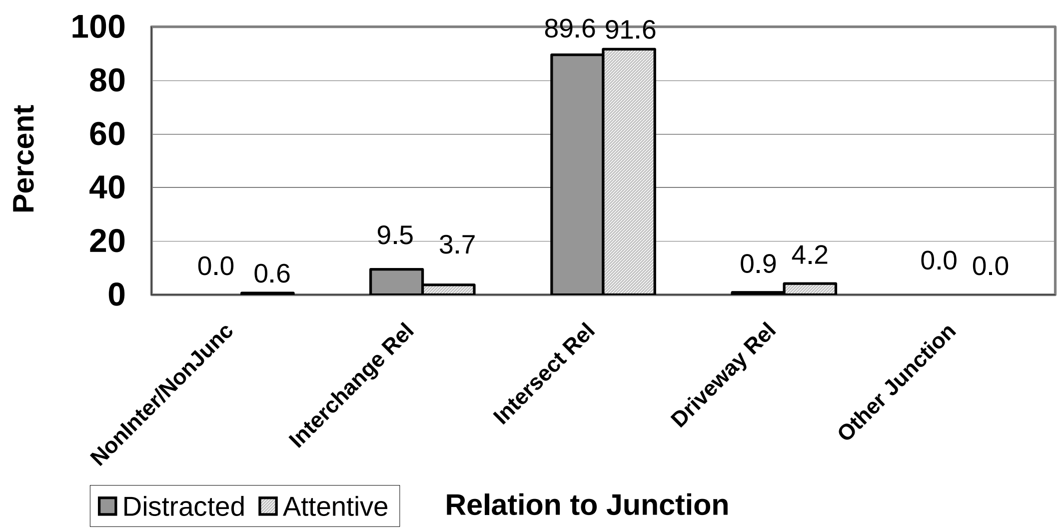
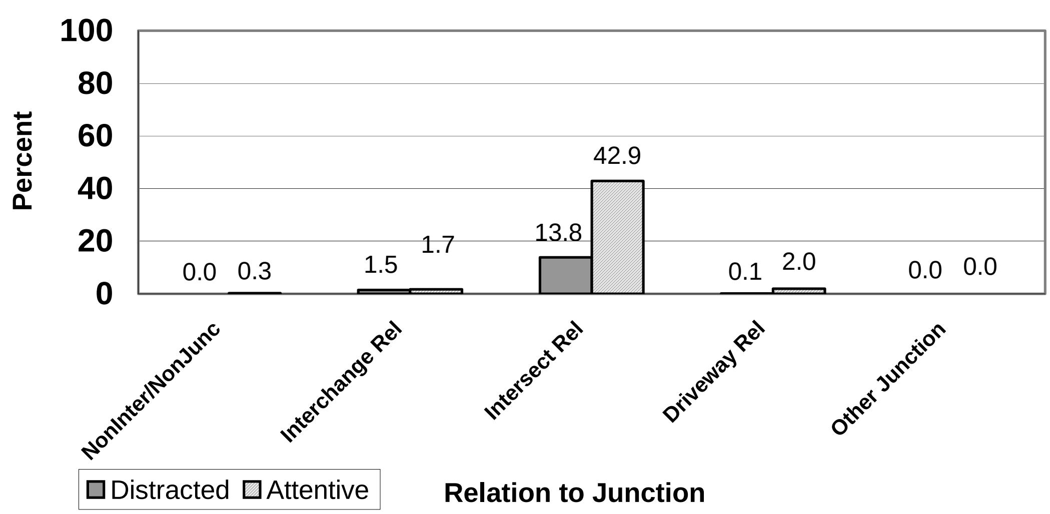


Figure 1.88: Percent of All IP Crashes by Relation to Junction and Distracted vs. Attentive



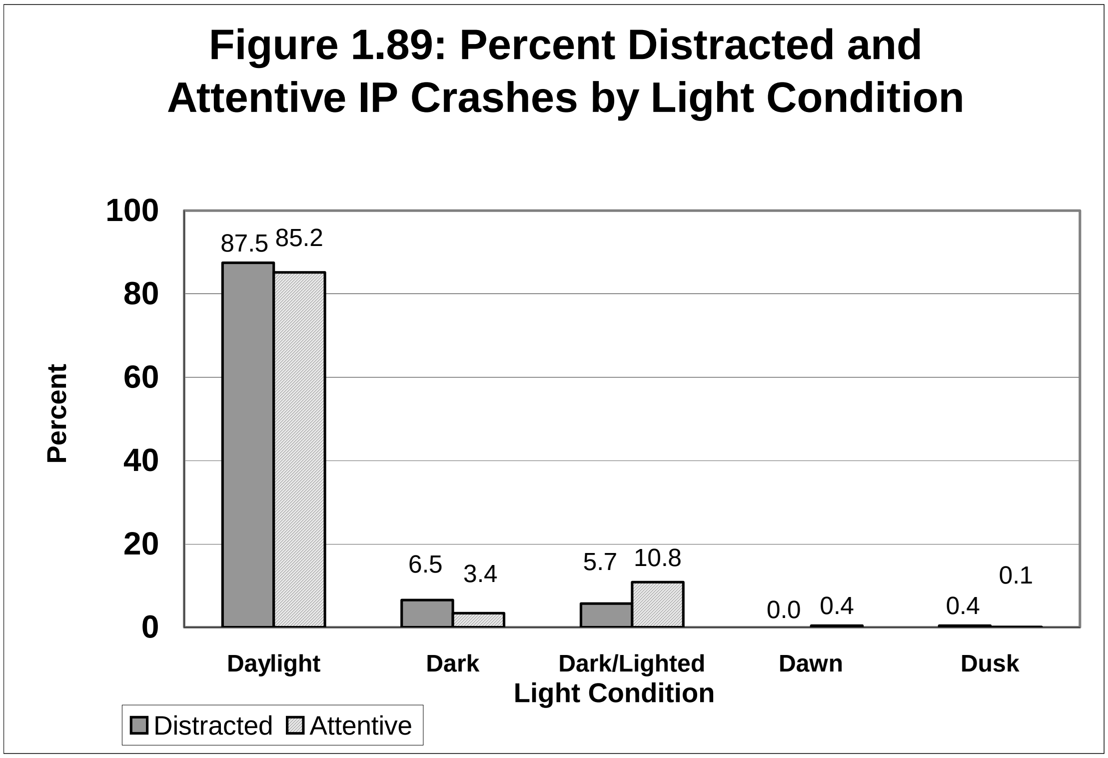


Figure 1.89: Percent Distracted and Attentive IP Crashes by Light Condition
100
80
60
40
20
0
Percent
87.5
85.2
6.5
3.4
5.7
10.8
0.0
0.4
0.4
0.1
Daylight
Dark
Dark/Lighted
Dawn
Dusk
Light Condition
Distracted
Attentive

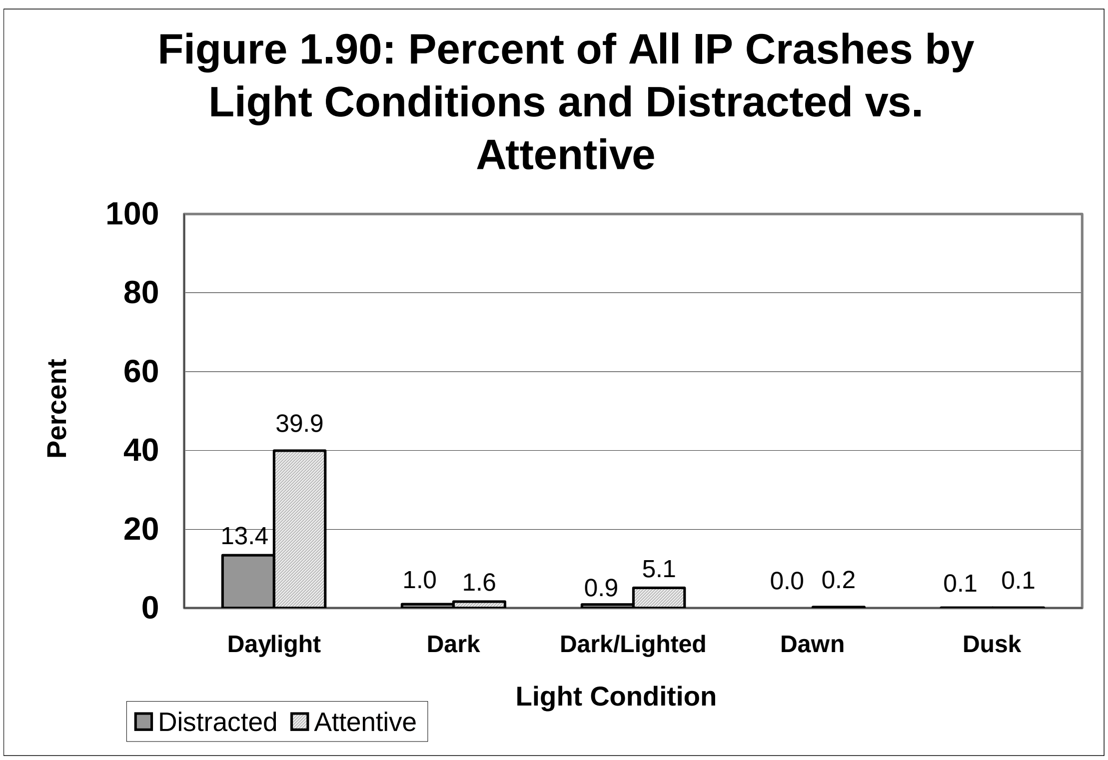


Figure 1.90: Percent of All IP Crashes by Light Conditions and Distracted vs. Attentive
100
80
60
40
20
0
Percent
13.4
39.9
1.0
1.6
0.9
5.1
0.0
0.2
0.1
0.1
Daylight
Dark
Dark/Lighted
Dawn
Dusk
Light Condition
Distracted
Attentive

Figure 1.91: Percent Distracted and Attentive IP Crashes by Roadway Surface Condition

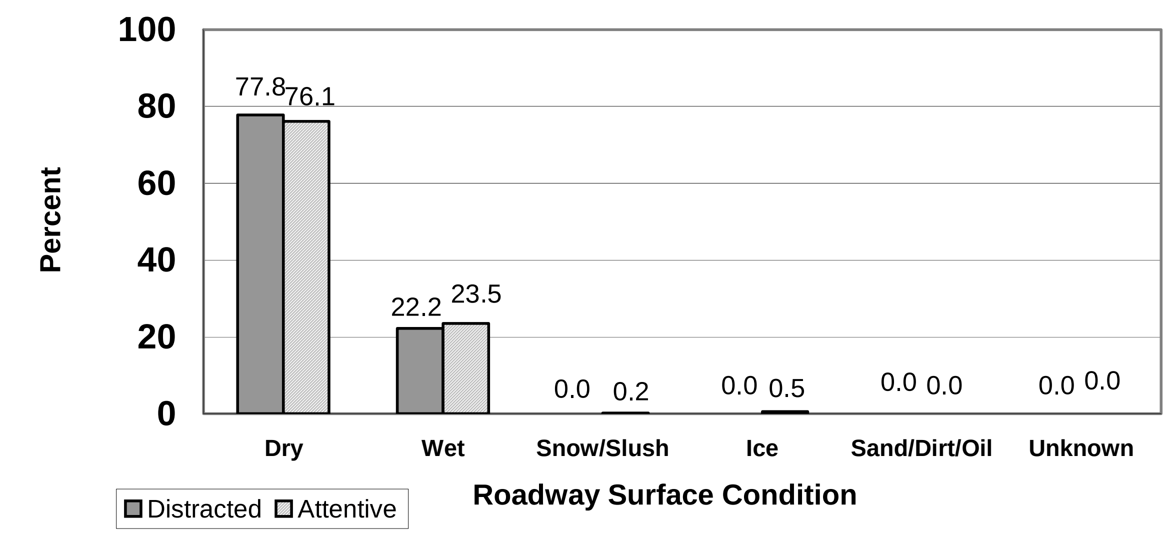
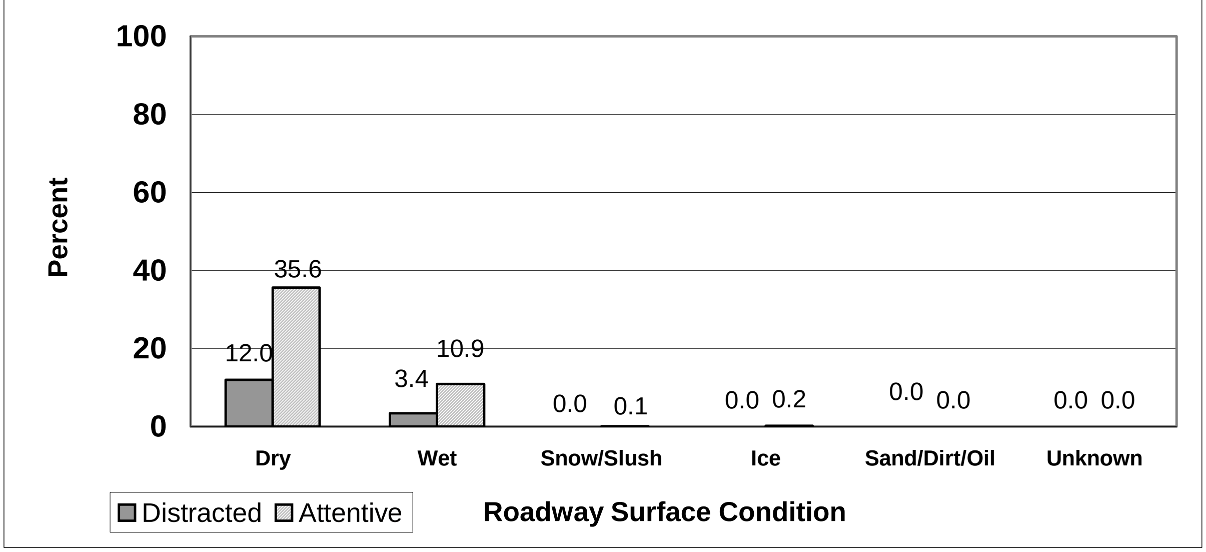


Figure 1.92: Percent of All IP Crashes by Roadway Surface Condition and Distracted vs. Attentive



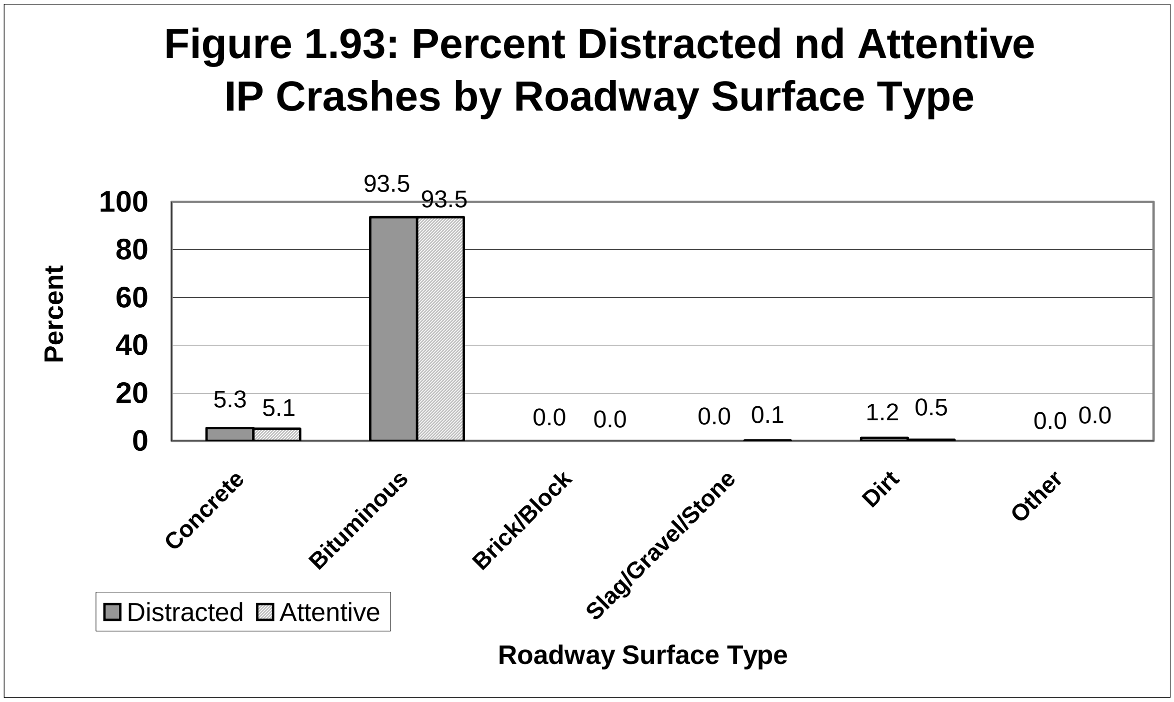


Figure 1.93: Percent Distracted nd Attentive
IP Crashes by Roadway Surface Type
Percent
100
80
60
40
20
0
5.3
5.1
93.5
93.5
0.0
0.0
0.0
0.1
1.2
0.5
0.0
0.0
Concrete
Bituminous
Brick/Block
Slag/Gravel/Stone
Dirt
Other
Distracted
Attentive
Roadway Surface Type

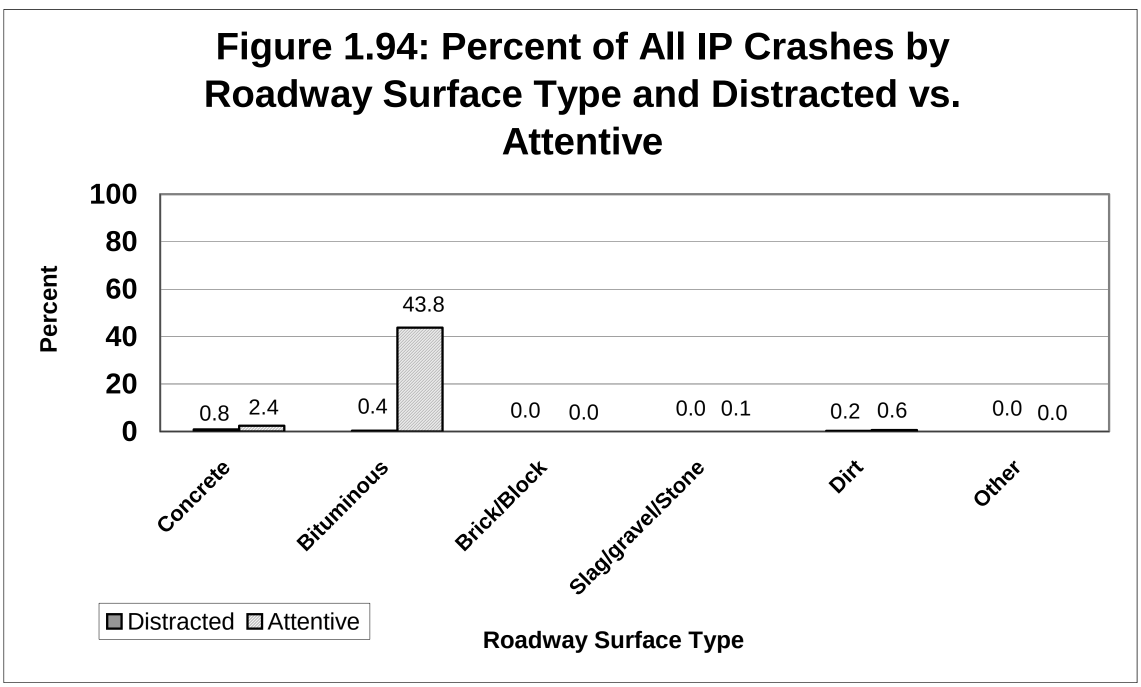


Figure 1.94: Percent of All IP Crashes by
Roadway Surface Type and Distracted vs.
Attentive
Percent
100
80
60
40
20
0
0.8
2.4
0.4
43.8
0.0
0.0
0.0
0.1
0.2
0.6
0.0
0.0
Concrete
Bituminous
Brick/Block
Slag/gravel/Stone
Dirt
Other
Distracted
Attentive
Roadway Surface Type

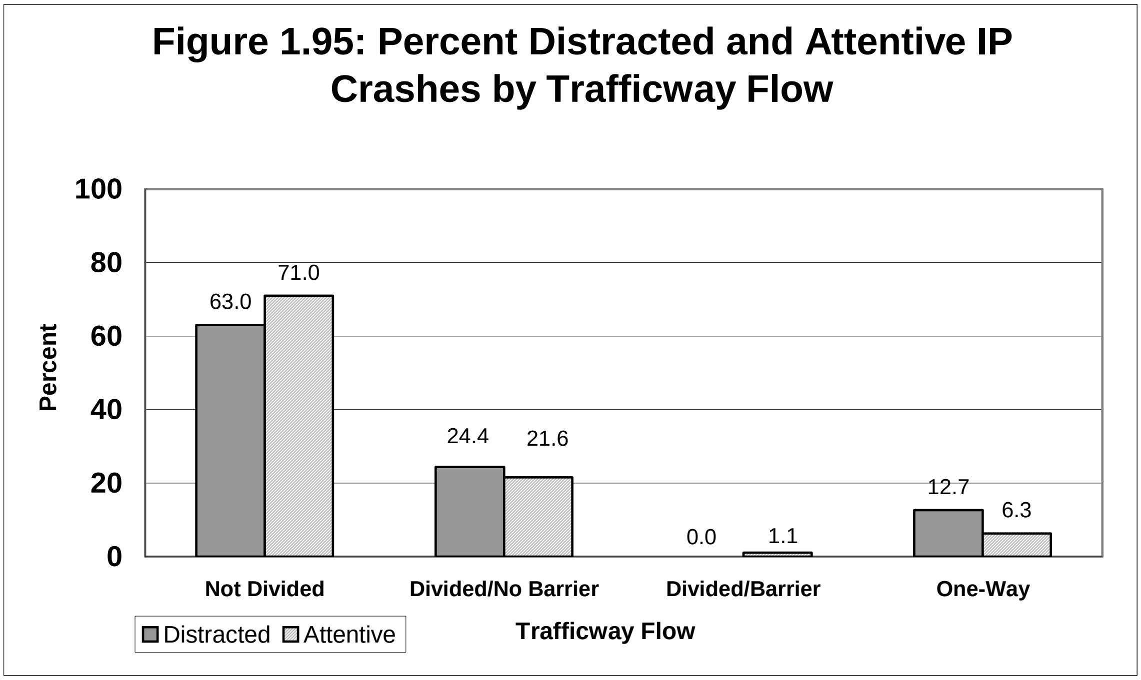


Figure 1.95: Percent Distracted and Attentive IP Crashes by Trafficway Flow
100
80
60
40
20
0
Percent
63.0
71.0
24.4
21.6
0.0
1.1
12.7
6.3
Not Divided
Divided/No Barrier
Divided/Barrier
One-Way
Distracted
Attentive
Trafficway Flow

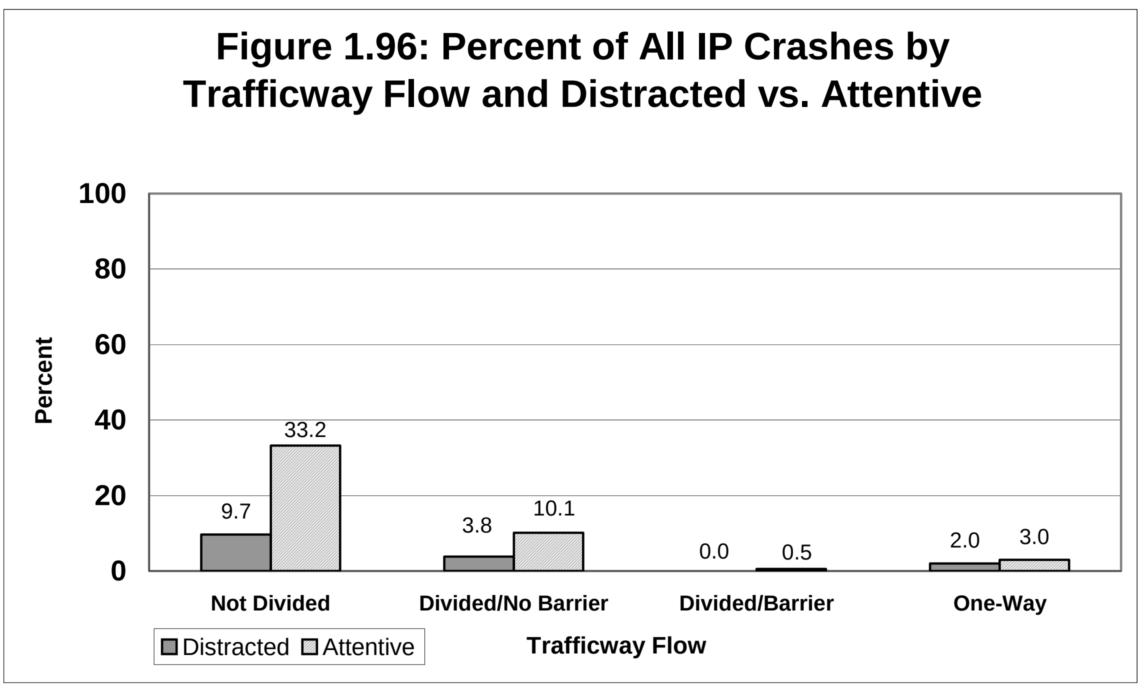


Figure 1.96: Percent of All IP Crashes by Trafficway Flow and Distracted vs. Attentive
100
80
60
40
20
0
Percent
9.7
33.2
3.8
10.1
0.0
0.5
2.0
3.0
Not Divided
Divided/No Barrier
Divided/Barrier
One-Way
Distracted
Attentive
Trafficway Flow

Figure 1.97: Percent Distracted and Attentive IP Crashes by Weather Condition

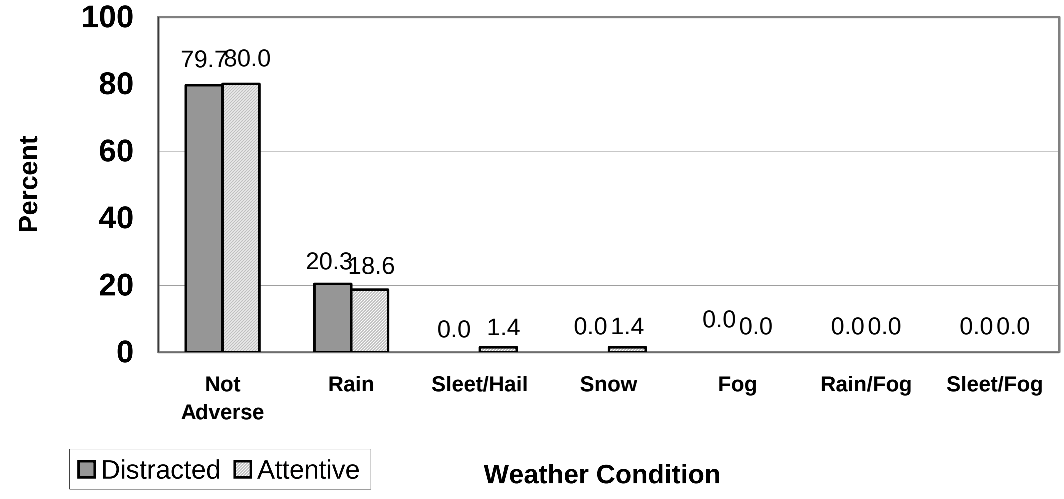


Figure 1.98: Percent of All IP Crashes by Weather Condition and Distracted vs. Attentive

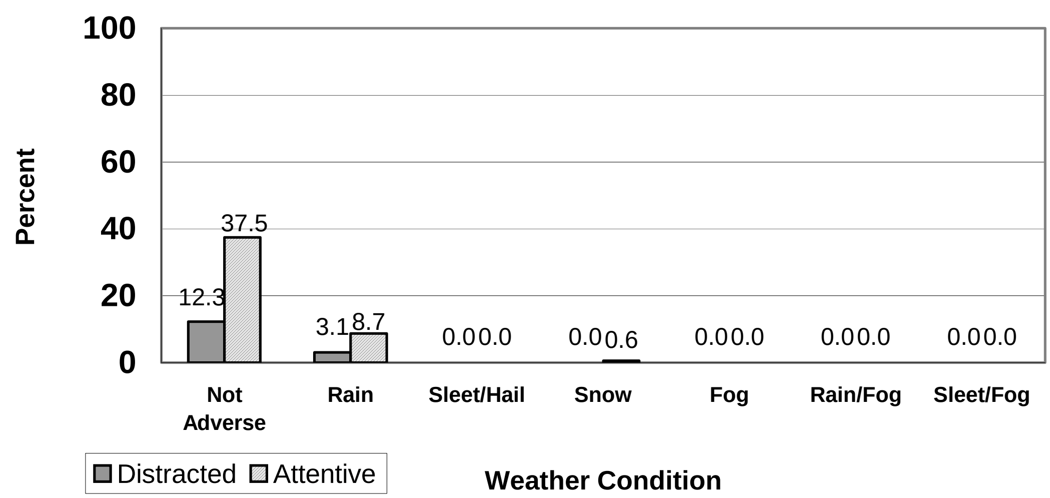


Figure 1.99: Percent Distracted and Attentive IP Crashes by Number of Occupants

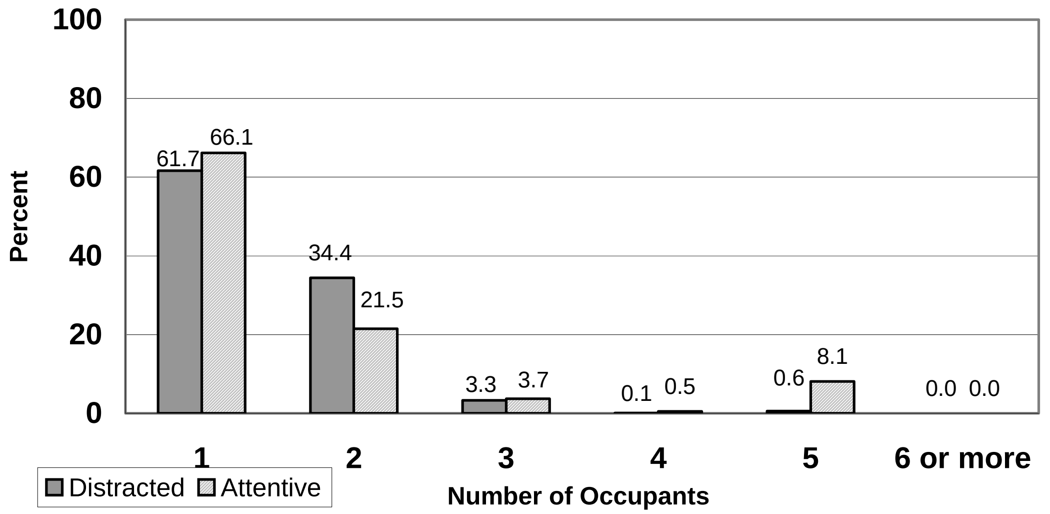


Figure 1.100: Percent of All IP Crashes by Number of Occupants and Distracted vs. Attentive

Figure 1.101: Percent Distracted and Attentive IP Crashes by Roadway Alignment

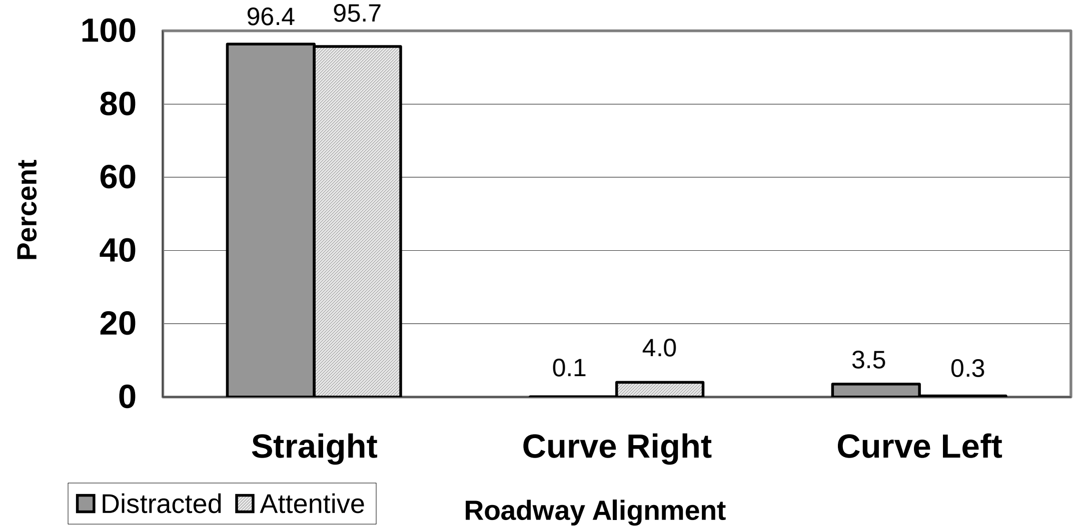
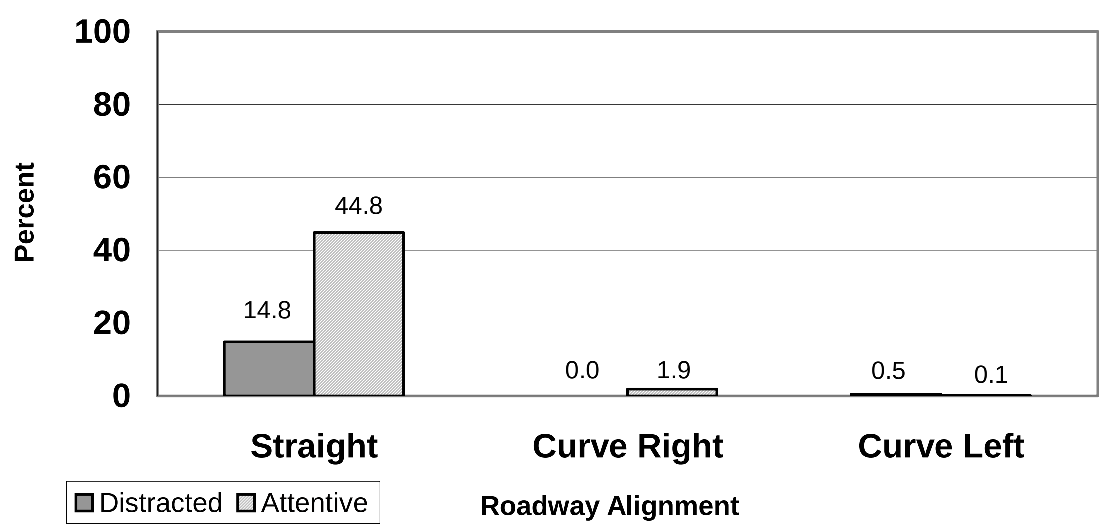


Figure 1.102: Percent of All IP Crashes by Roadway Alignment and Distracted vs. Attentive



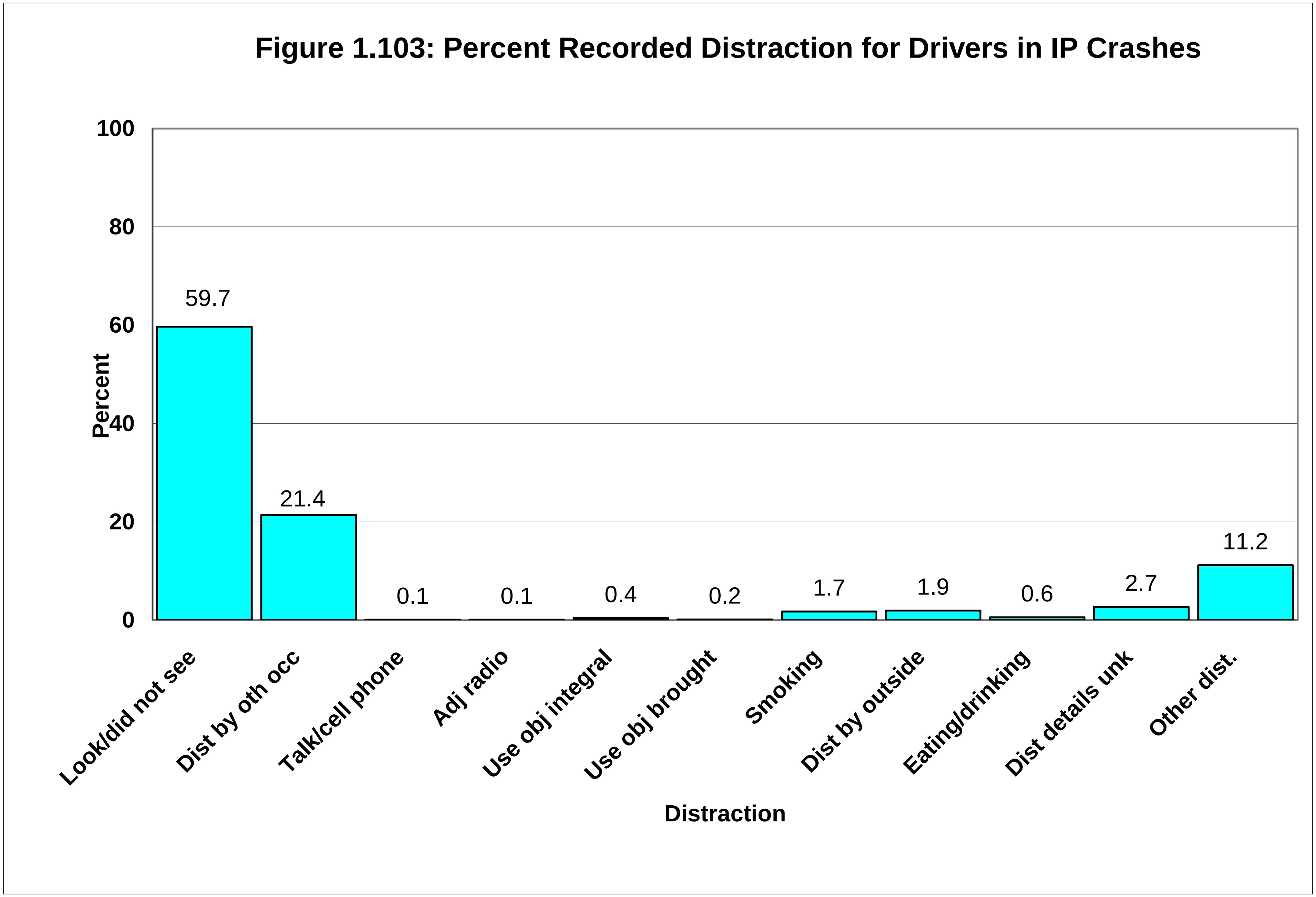


Figure 1.103: Percent Recorded Distraction for Drivers in IP Crashes
100
80
60
40
20
0
Percent
59.7
21.4
0.1
0.1
0.4
0.2
1.7
1.9
0.6
2.7
11.2
Look/did not see
Dist by oth occ
Talk/cell phone
Adj radio
Use obj integral
Use obj brought
Smoking
Dist by outside
Eating/drinking
Dist details unk
Other dist.
Distraction

1.3.1.3.4. Change Trafficway, Vehicle Turning (CTVT)

Sex: Figures 1.104-1.105 show the proportion of all CTVT distracted and all CTVT attentive crashes (Figure 1.104) and the proportion of distracted and attentive CTVT crashes (Figure 1.105) by sex. A greater proportion of both distracted and attentive CTVT crashes were attributed to males. No difference was found between attentive and distracted CTVT crashes when the proportion within the crash categories (attentive vs. distracted) were compared for males or females. Large differences were found when the proportions were determined as a function of all CTVT crashes, with distracted crashes much less frequent than attentive crashes for both sexes.

Age Group: The proportion of all distracted and all attentive CTVT crashes and the proportion of distracted and attentive CTVT crashes by age group are shown in Figures 1.106 and 1.107. When proportions were compared within the crash categories (Figure 1.106), we found that distracted CTVT crashes were more frequent for drivers aged 18-25 and drivers aged 65 years or more. When compared among all CTVT crashes (Figure 1.107), distracted CTVT crashes were less common for all age groups.

Age Group and Sex: Figures 1.108-1.111 show the proportions of CTVT crashes by males and age (Figure 1.108-1.109) and by females and age (Figures 1.110-1.111). For males, CTVT distracted crashes were common for drivers less than 26 years of age and drivers 65 years of age or older, when proportions were compared within crash categories. When compared among all CTVT crashes, distracted crashes for males were more common than attentive crashes for only the youngest age group. For females, distracted CTVT crashes were more common for drivers aged 18-34 and drivers aged 56 years or more, when proportions were compared within crash categories. Comparing within all CTVT crashes, we found that distracted CTVT crashes were less frequent than, or equal to, attentive crashes for all age groups.

Number of Lanes: Figures 1.112 and 1.113 show CTVT crashes by the number of traffic lanes. Comparing proportions within crash categories, we found that distracted crashes were more frequent for two-, three-, and five-lane roads (Figure 1.112) while distracted crashes are less frequent for all lane numbers when proportions were compared among all CTVT crashes.

Roadway Profile: Figures 1.114 and 1.115 show the distributions of distracted and attentive CTVT crashes by the roadway profile. Comparisons within the crash categories showed that distracted CTVT crashes were more frequent only for level profiles (Figure 1.114). Comparing proportions among all CTVT crashes showed that distracted CTVT crashes were less frequent than, or equal to, attentive crashes for all roadway profiles.

Relation to Junction: Figures 1.116 and 1.117 show the distributions of distracted and attentive CTVT crashes by the relation to junctions. Comparison within the crash categories showed that distracted CTVT crashes were more common at interchanges and driveways (Figure 1.116), and attentive CTVT crashes were more common or equal in all cases when proportions were compared relative to all CTVT crashes (Figure 1.117).

Light Conditions: Figures 1.118 and 1.119 show the distributions of distracted and attentive CTVT crashes by the light conditions. Comparison within the crash categories showed little difference by lighting conditions, except that distracted crashes were slightly more common for "dark/lighted" conditions (Figure 1.118). Comparing proportions among all CTVT crashes showed that distracted CTVT crashes were less frequent than attentive crashes for all lighting conditions.

Roadway Surface Conditions: Figures 1.120 and 1.121 show the distributions of distracted and attentive CTVT crashes by the roadway surface conditions. Comparison within the crash categories showed that distracted CTVT crashes were more frequent only for dry roads (Figure 1.120). Comparing proportions among all CTVT crashes showed that distracted CTVT crashes were less frequent than, or equal to, attentive crashes for all roadway conditions (Figure 1.121).

Roadway Surface Type: Figures 1.122 and 1.123 show the distributions of distracted and attentive CTVT crashes by the roadway surface type. Comparison within the crash categories showed no difference by type of roadway surface (Figure 1.122). Comparing proportions among all CTVT crashes showed that distracted CTVT crashes were less frequent than, or equal to, attentive crashes for all surface types (Figure 1.123).

Trafficway Flow: Figures 1.124 and 1.125 show the distributions of distracted and attentive CTVT crashes by the trafficway flow. Comparisons within the crash categories showed that distracted CTVT crashes were slightly more frequent for all trafficway flow, except "divided with no barrier" (Figure 1.124). Comparing proportions among all CTVT crashes showed that distracted IP crashes were less frequent for all trafficway flow types, except for "divided with a barrier" (Figure 1.125).

Weather Conditions: Figures 1.126 and 1.127 show the distributions of distracted and attentive CTVT crashes by the prevailing weather condition. Comparisons within the crash categories showed that distracted CTVT crashes were slightly more frequent only for "not adverse" and "foggy" weather (Figure 1.126). Comparing proportions among all CTVT crashes showed that distracted CTVT crashes were less frequent than, or equal to, attentive crashes for all weather conditions (Figure 1.127).

Number of Occupants: Figures 1.128 and 1.129 show the distributions of distracted and attentive CTVT crashes by the number of occupants in the vehicle. Comparisons within the crash categories showed that distracted CTVT crashes were slightly more frequent when there were three occupants (Figure 1.128). Comparing proportions among all CTVT crashes showed that distracted CTVT crashes were less frequent for all numbers of occupants (Figure 1.129).

Roadway Alignment: Figures 1.130 and 1.131 show the distributions of distracted and attentive CTVT crashes by the roadway alignment. Comparisons within the crash categories showed that distracted CTVT crashes were more frequent for curves to the right (Figure 1.130). Comparing proportions among all CTVT crashes showed that distracted

CTVT crashes were less frequent than attentive crashes for all alignments (Figure 1.131).

CTVT Crashes by Distraction Code: Figure 1.132 shows the distribution of the distraction codes for CTVT crashes. As shown in this figure, nearly all CTVT distracted crashes were coded as “looked, but did not see.” The second most common cited distractor was “another occupant.”

Figure 1.104: Percent of Distracted and Attentive Drivers in CTVT Crashes by Sex

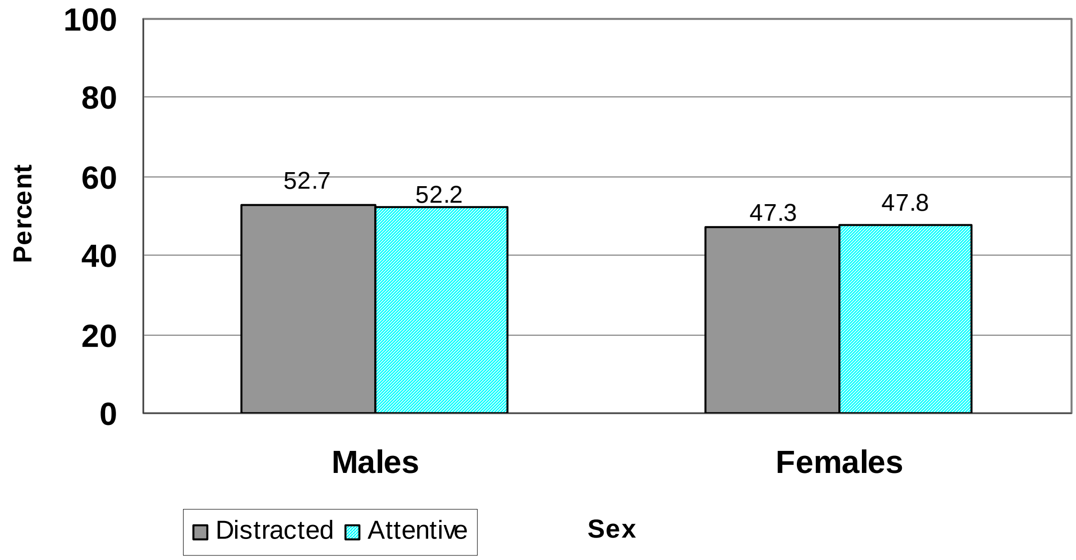
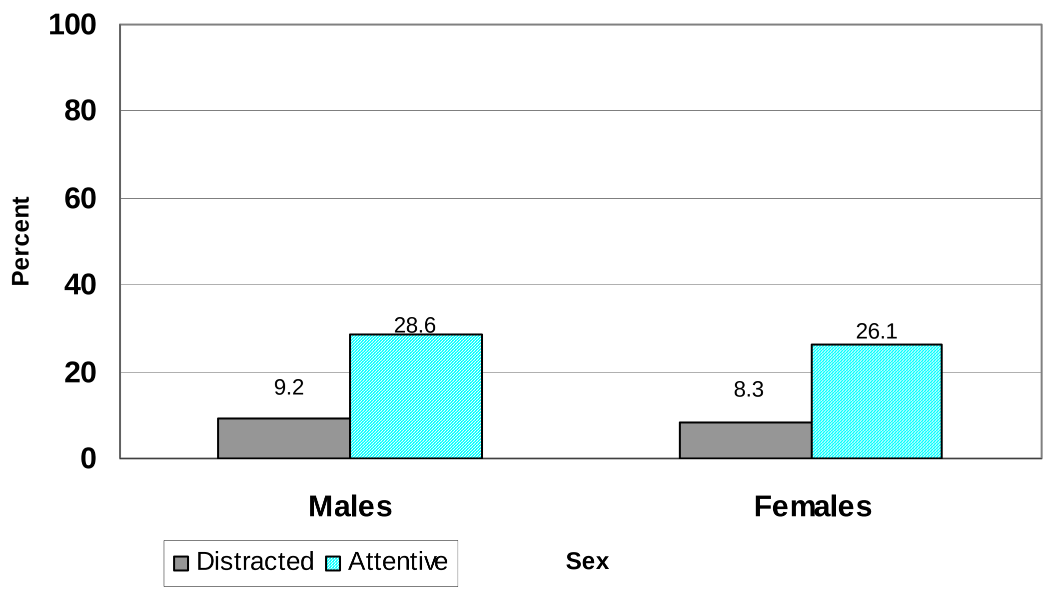


Figure 1.105: Percent of All CTVT Driver Crashes By Sex and Distracted vs. Attentive



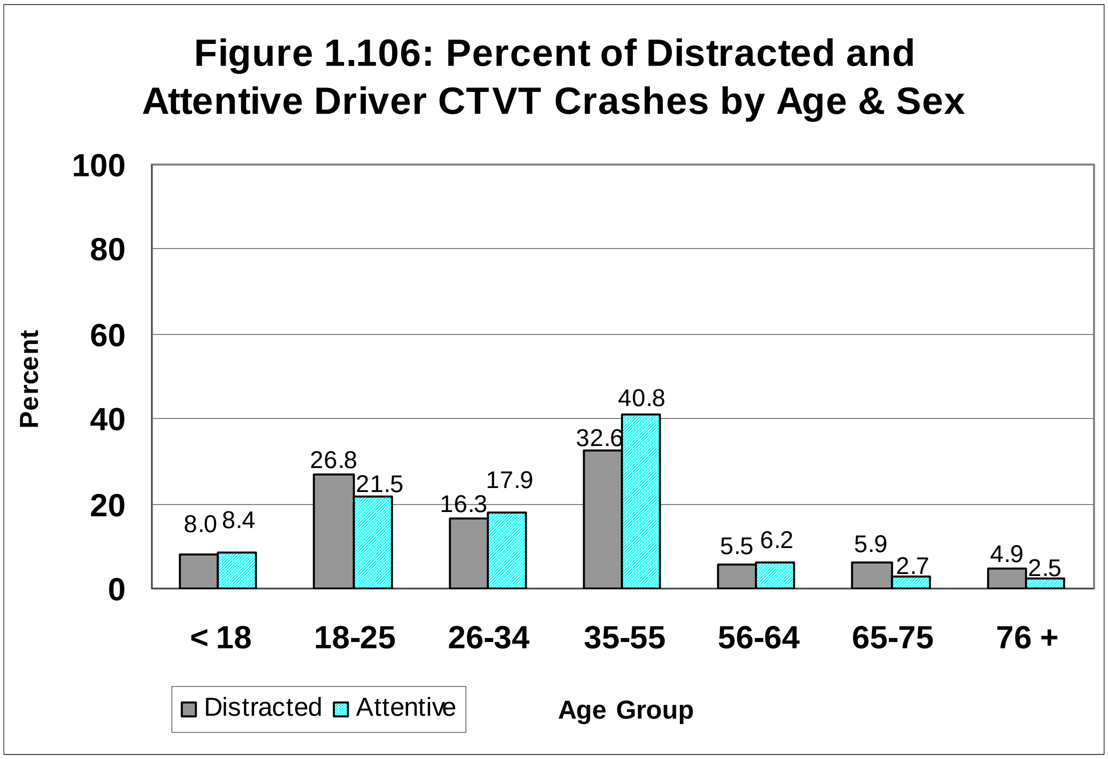


Figure 1.106: Percent of Distracted and Attentive Driver CTVT Crashes by Age & Sex
Percent
100
80
60
40
20
0
8.0
8.4
26.8
21.5
16.3
17.9
32.6
40.8
5.5
6.2
5.9
2.7
4.9
2.5
< 18
18-25
26-34
35-55
56-64
65-75
76 +
Distracted
Attentive
Age Group

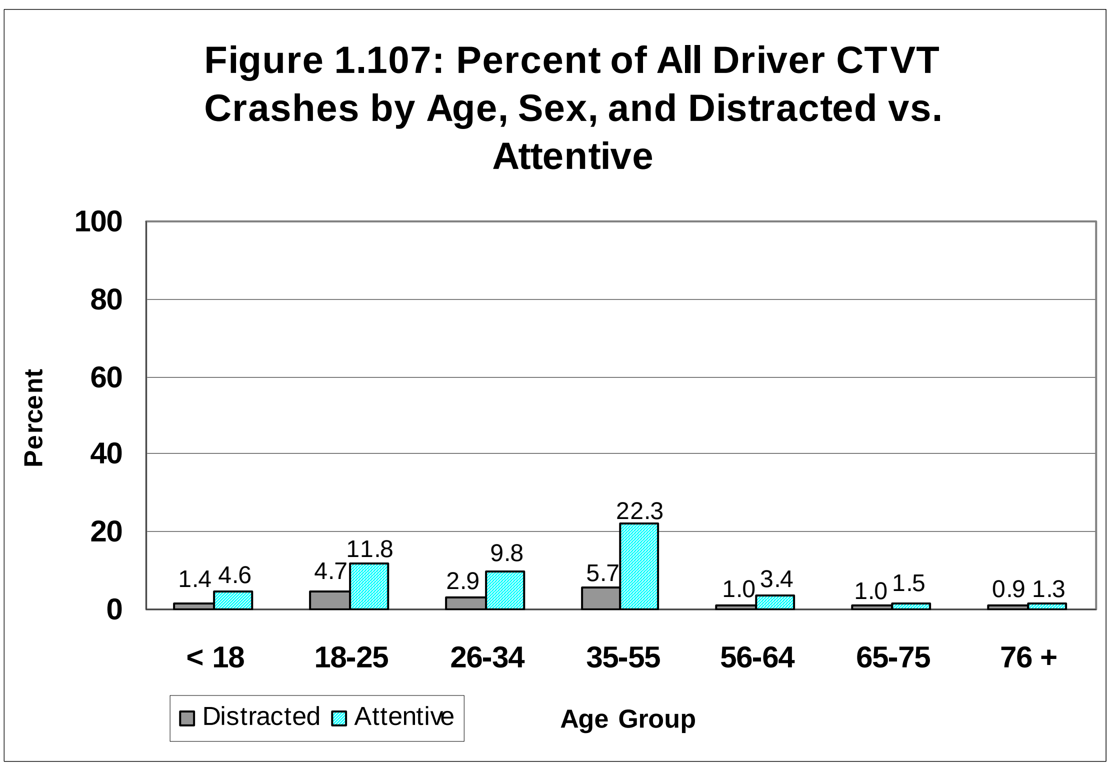


Figure 1.107: Percent of All Driver CTVT Crashes by Age, Sex, and Distracted vs. Attentive
Percent
100
80
60
40
20
0
1.4
4.6
4.7
11.8
2.9
9.8
5.7
22.3
1.0
3.4
1.0
1.5
0.9
1.3
< 18
18-25
26-34
35-55
56-64
65-75
76 +
Distracted
Attentive
Age Group

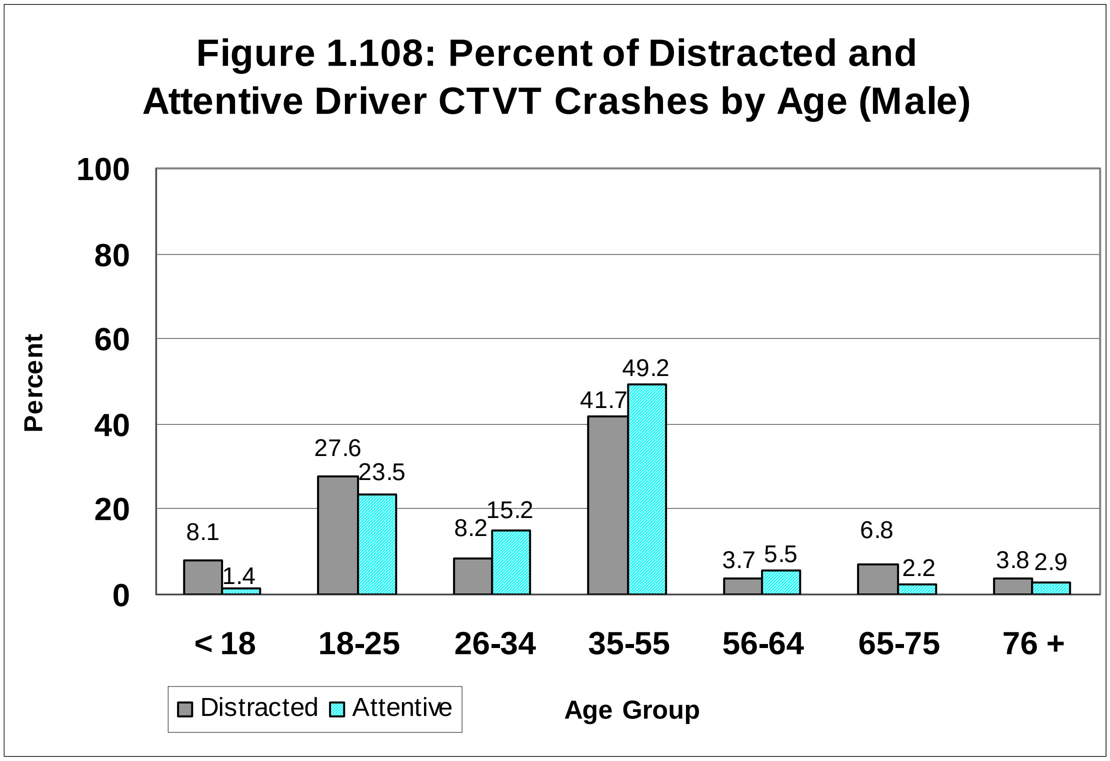


Figure 1.108: Percent of Distracted and Attentive Driver CTVT Crashes by Age (Male)
Percent
100
80
60
40
20
0
8.1
1.4
27.6
23.5
8.2
15.2
41.7
49.2
3.7
5.5
6.8
2.2
3.8
2.9
< 18
18-25
26-34
35-55
56-64
65-75
76 +
Distracted
Attentive
Age Group

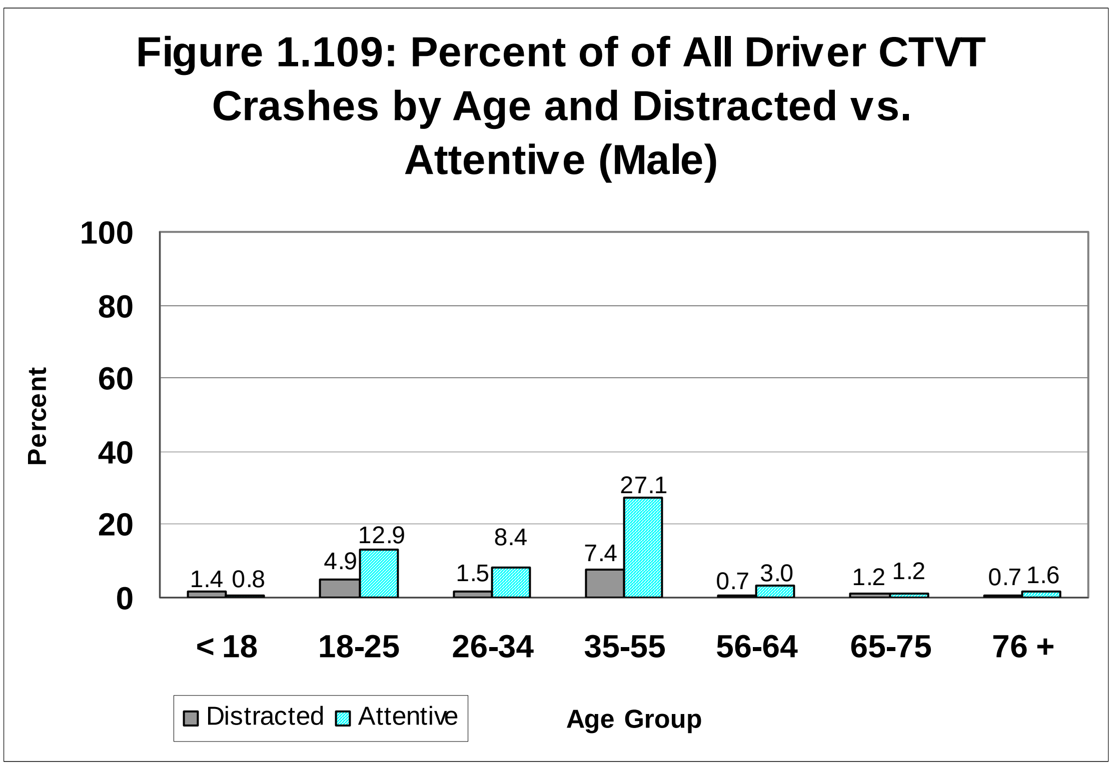


Figure 1.109: Percent of of All Driver CTVT Crashes by Age and Distracted vs. Attentive (Male)
Percent
100
80
60
40
20
0
1.4
0.8
4.9
12.9
1.5
8.4
7.4
27.1
0.7
3.0
1.2
1.2
0.7
1.6
< 18
18-25
26-34
35-55
56-64
65-75
76 +
Distracted
Attentive
Age Group

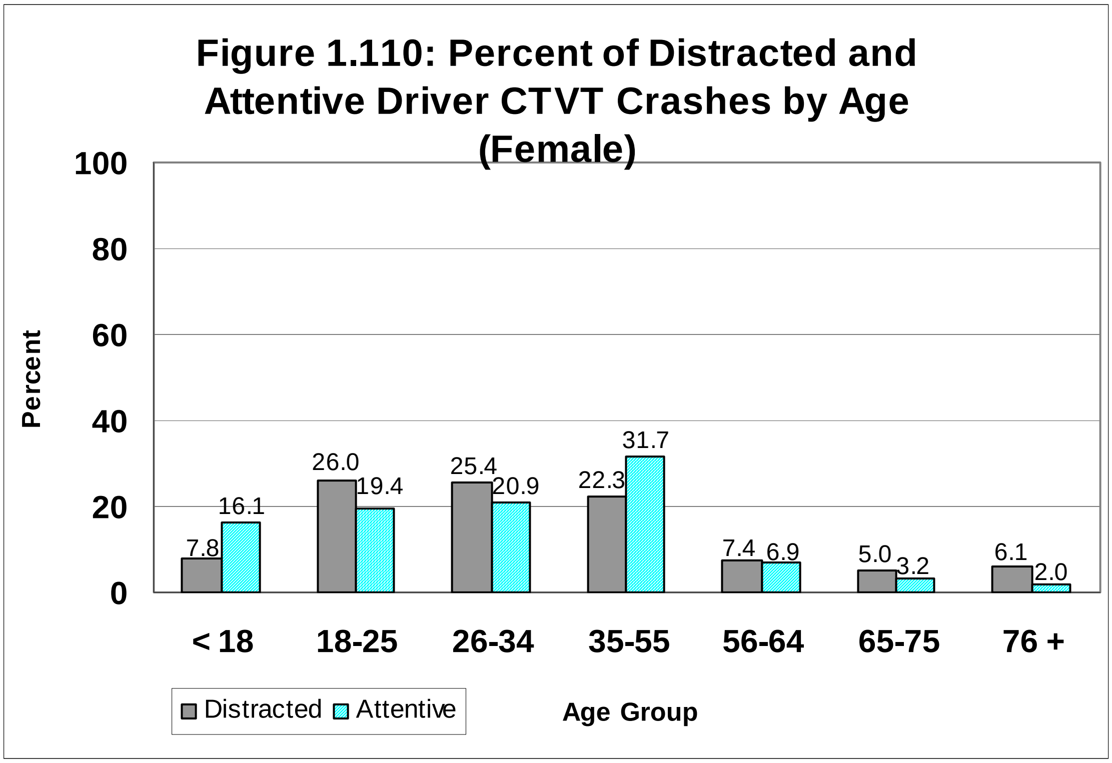


Figure 1.110: Percent of Distracted and Attentive Driver CTVT Crashes by Age (Female)
Percent
100
80
60
40
20
0
7.8
16.1
26.0
19.4
25.4
20.9
22.3
31.7
7.4
6.9
5.0
3.2
6.1
2.0
< 18
18-25
26-34
35-55
56-64
65-75
76 +
Distracted
Attentive
Age Group

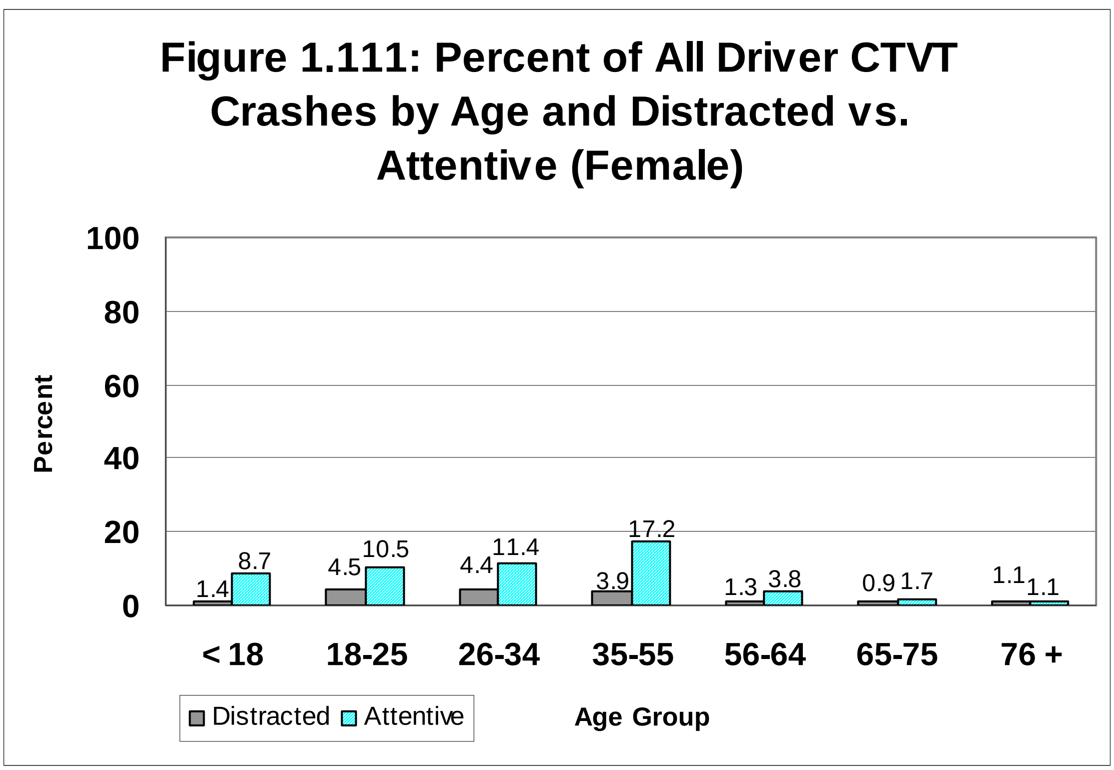


Figure 1.111: Percent of All Driver CTVT Crashes by Age and Distracted vs. Attentive (Female)
Percent
100
80
60
40
20
0
1.4
8.7
4.5
10.5
4.4
11.4
3.9
17.2
1.3
3.8
0.9
1.7
1.1
1.1
< 18
18-25
26-34
35-55
56-64
65-75
76 +
Distracted
Attentive
Age Group

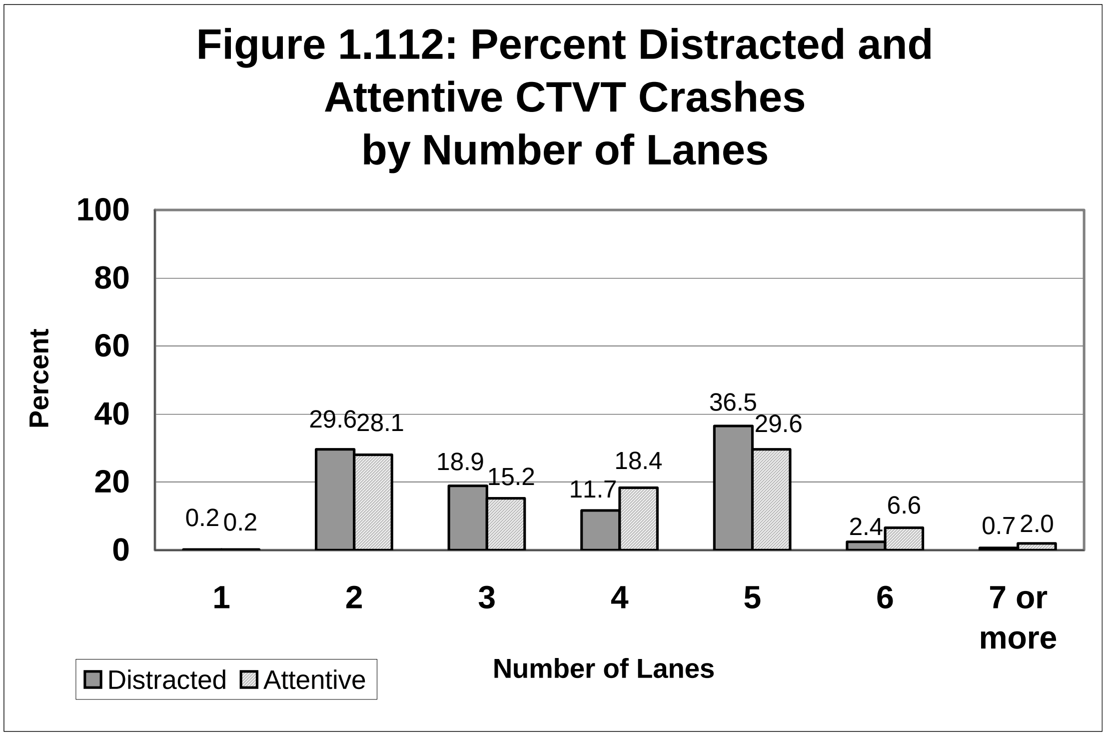


Figure 1.112: Percent Distracted and Attentive CTVT Crashes by Number of Lanes
Percent
100
80
60
40
20
0
0.2
0.2
29.6
28.1
18.9
15.2
11.7
18.4
36.5
29.6
2.4
6.6
0.7
2.0
1
2
3
4
5
6
7 or more
Number of Lanes
Distracted
Attentive

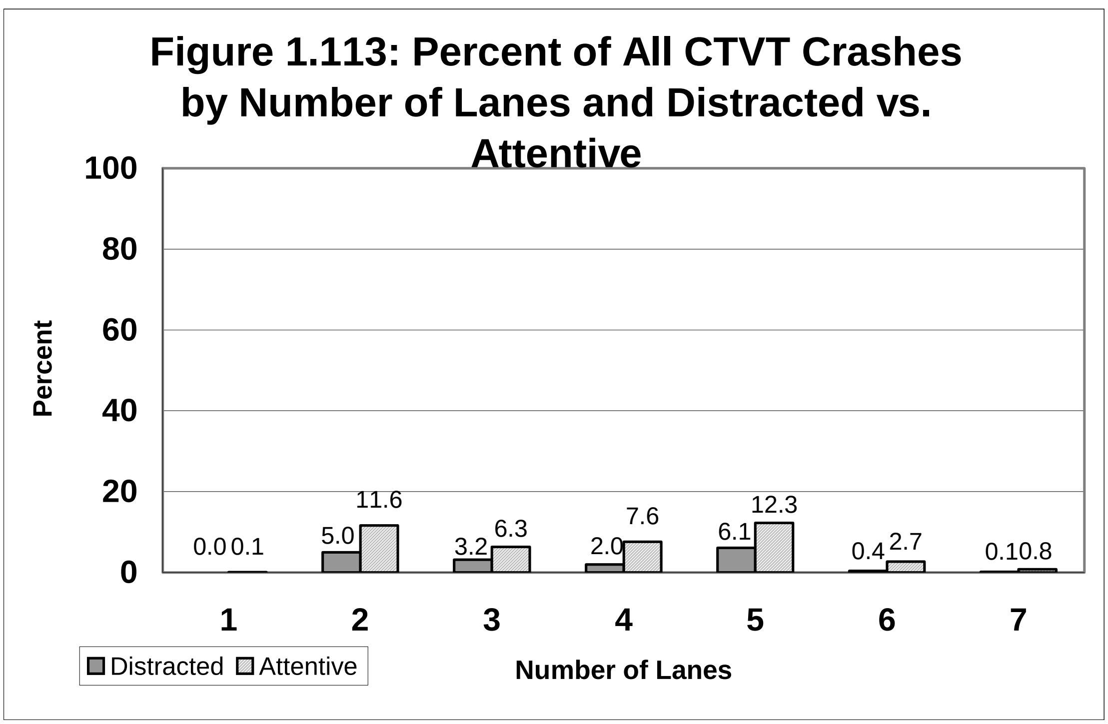


Figure 1.113: Percent of All CTVT Crashes by Number of Lanes and Distracted vs. Attentive
Percent
100
80
60
40
20
0
0.0
0.1
5.0
11.6
3.2
6.3
2.0
7.6
6.1
12.3
0.4
2.7
0.1
0.8
1
2
3
4
5
6
7
Number of Lanes
Distracted
Attentive

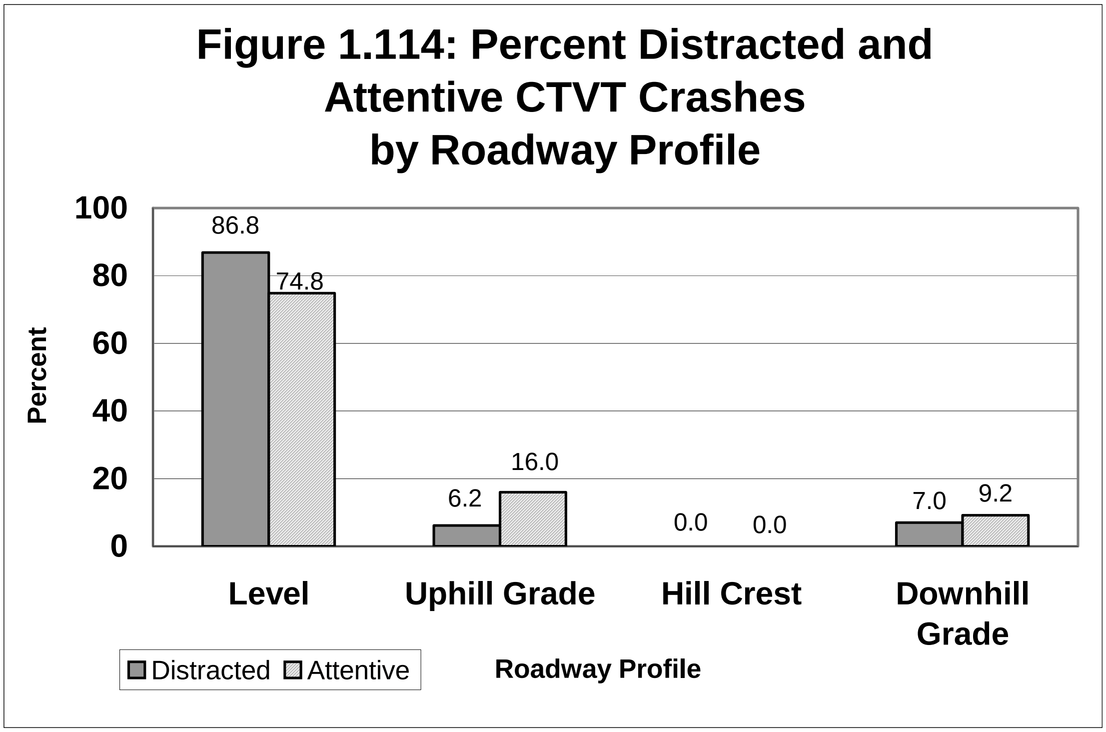


Figure 1.114: Percent Distracted and Attentive CTVT Crashes by Roadway Profile
Percent
100
80
60
40
20
0
86.8
74.8
6.2
16.0
0.0
0.0
7.0
9.2
Level
Uphill Grade
Hill Crest
Downhill Grade
Distracted
Attentive
Roadway Profile

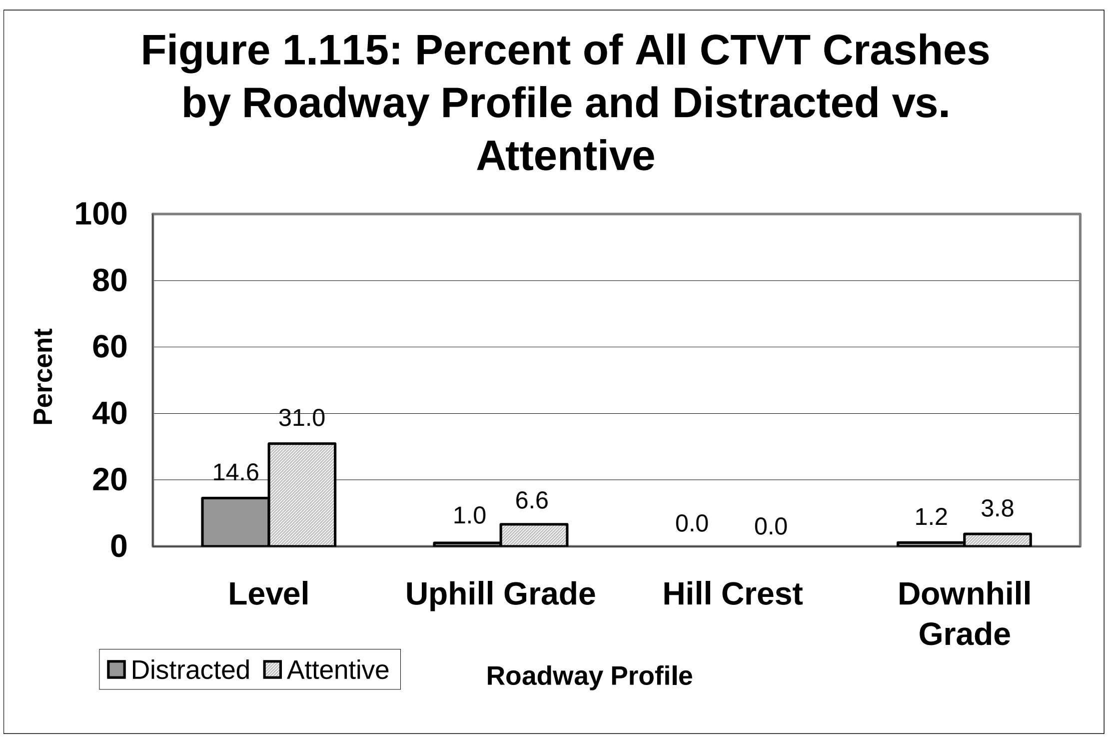


Figure 1.115: Percent of All CTVT Crashes by Roadway Profile and Distracted vs. Attentive
Percent
100
80
60
40
20
0
14.6
31.0
1.0
6.6
0.0
0.0
1.2
3.8
Level
Uphill Grade
Hill Crest
Downhill Grade
Distracted
Attentive
Roadway Profile

Figure 1.116: Percent Distracted and Attentive CTVT Crashes by Relation to Junction

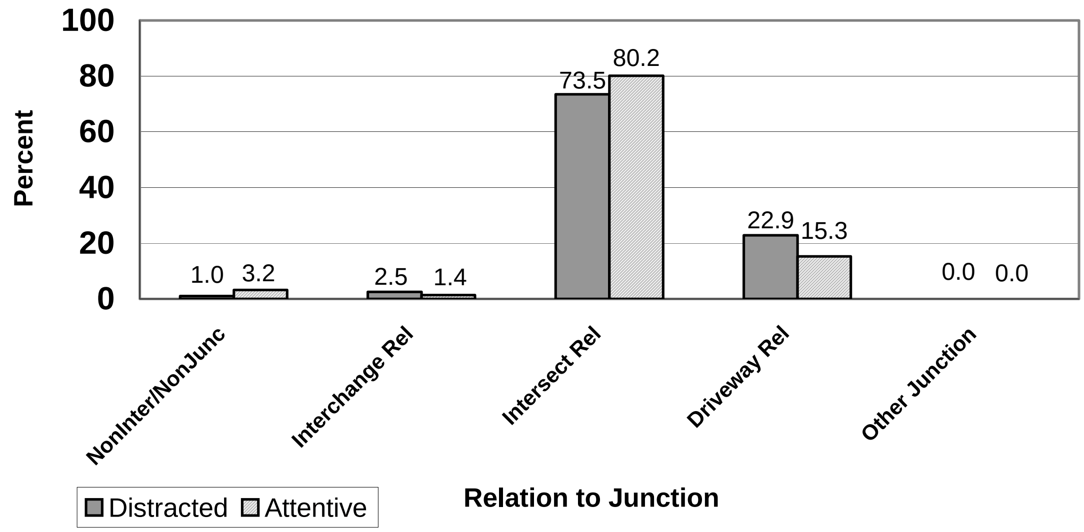
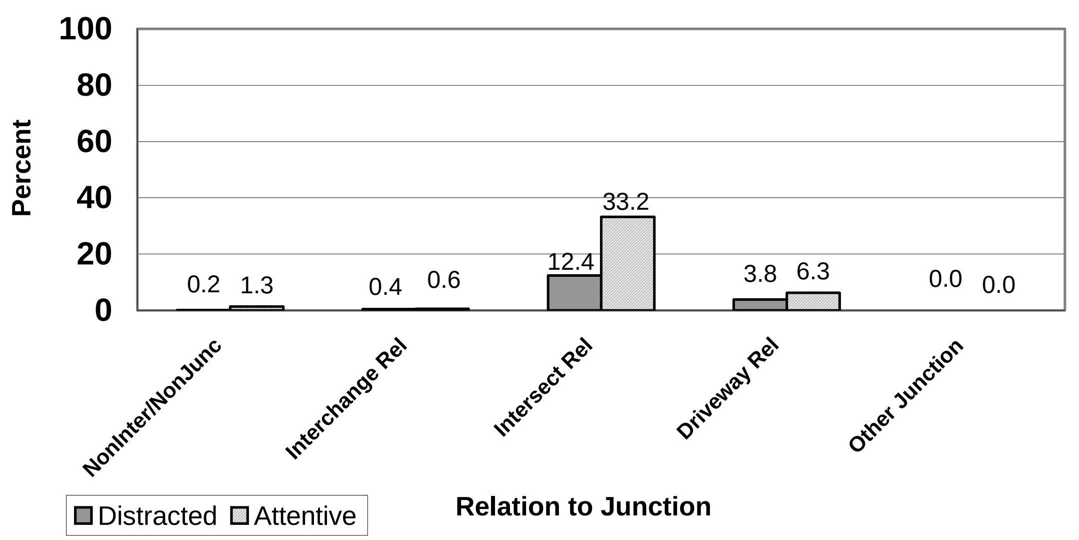


Figure 1.117: Percent of All CTVT Crashes by Relation to Junction and Distracted vs. Attentive



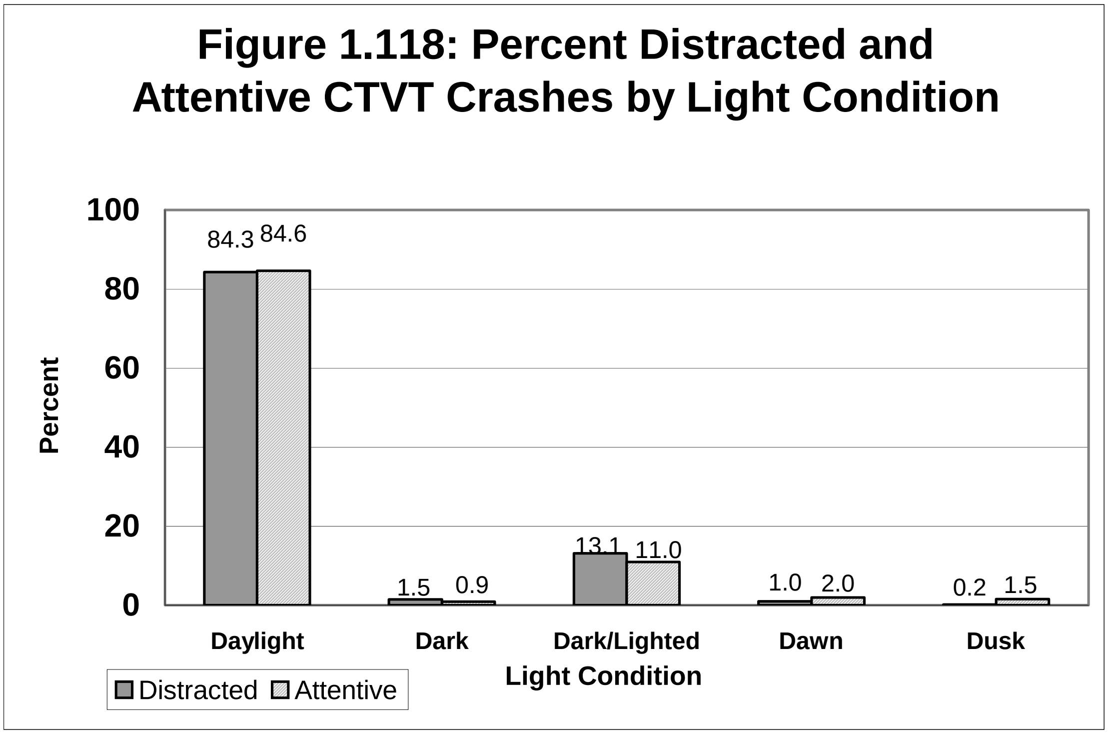


Figure 1.118: Percent Distracted and Attentive CTVT Crashes by Light Condition
100
80
60
40
20
0
Percent
84.3
84.6
1.5
0.9
13.1
11.0
1.0
2.0
0.2
1.5
Daylight
Dark
Dark/Lighted
Dawn
Dusk
Light Condition
Distracted
Attentive

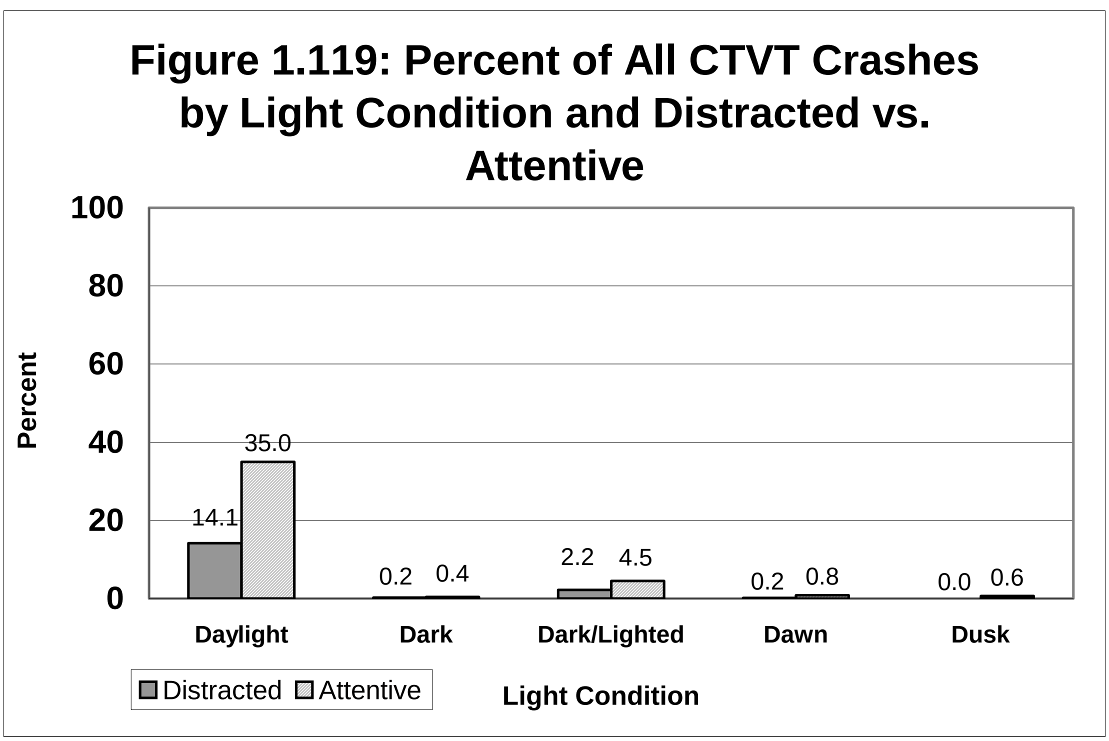


Figure 1.119: Percent of All CTVT Crashes by Light Condition and Distracted vs. Attentive
100
80
60
40
20
0
Percent
14.1
35.0
0.2
0.4
2.2
4.5
0.2
0.8
0.0
0.6
Daylight
Dark
Dark/Lighted
Dawn
Dusk
Distracted
Attentive
Light Condition

Figure 1.120: Percent Distracted and Attentive CTVT Crashes by Roadway Surface Condition

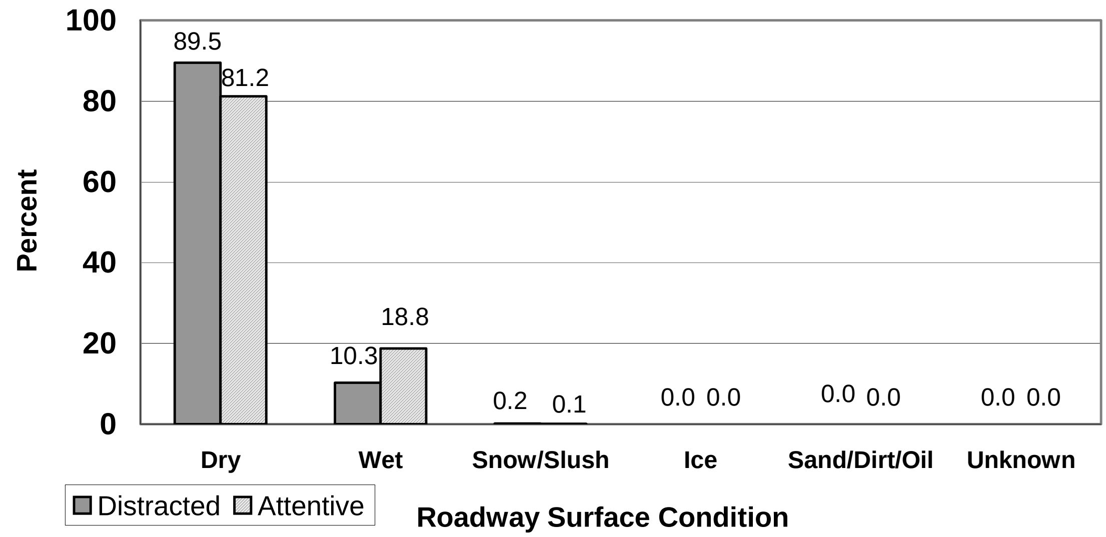
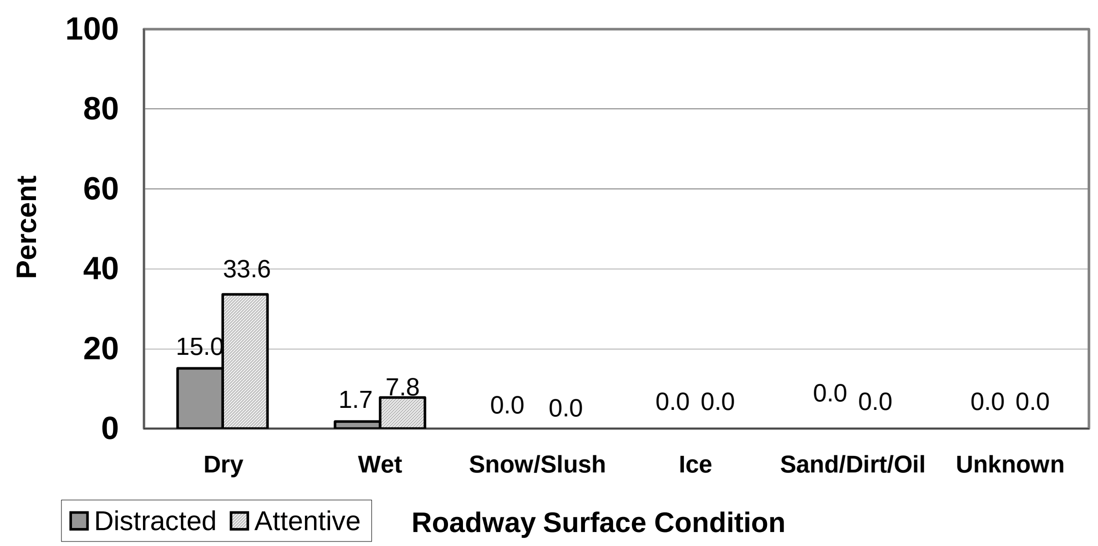


Figure 1.121: Percent of All CTVT Crashes by Roadway Surface Condition and Distracted vs. Attentive



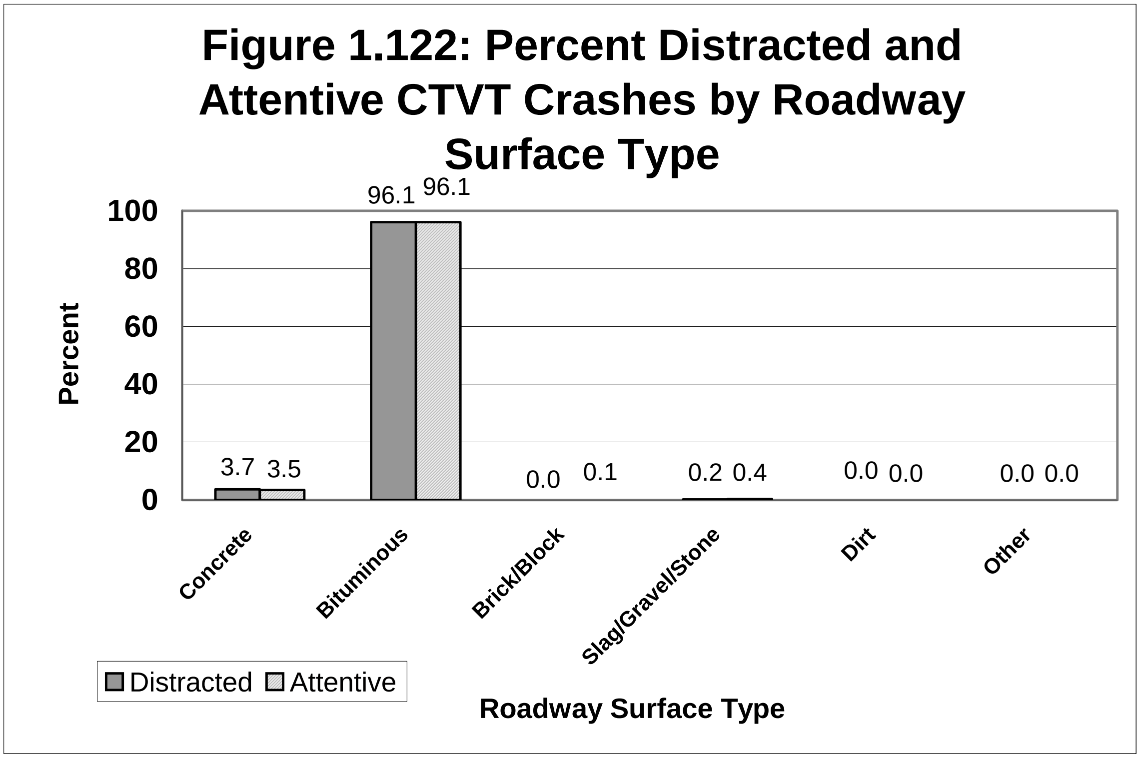


Figure 1.122: Percent Distracted and Attentive CTVT Crashes by Roadway Surface Type
Percent
100
80
60
40
20
0
3.7
3.5
96.1
96.1
0.0
0.1
0.2
0.4
0.0
0.0
0.0
0.0
Concrete
Bituminous
Brick/Block
Slag/Gravel/Stone
Dirt
Other
Distracted
Attentive
Roadway Surface Type

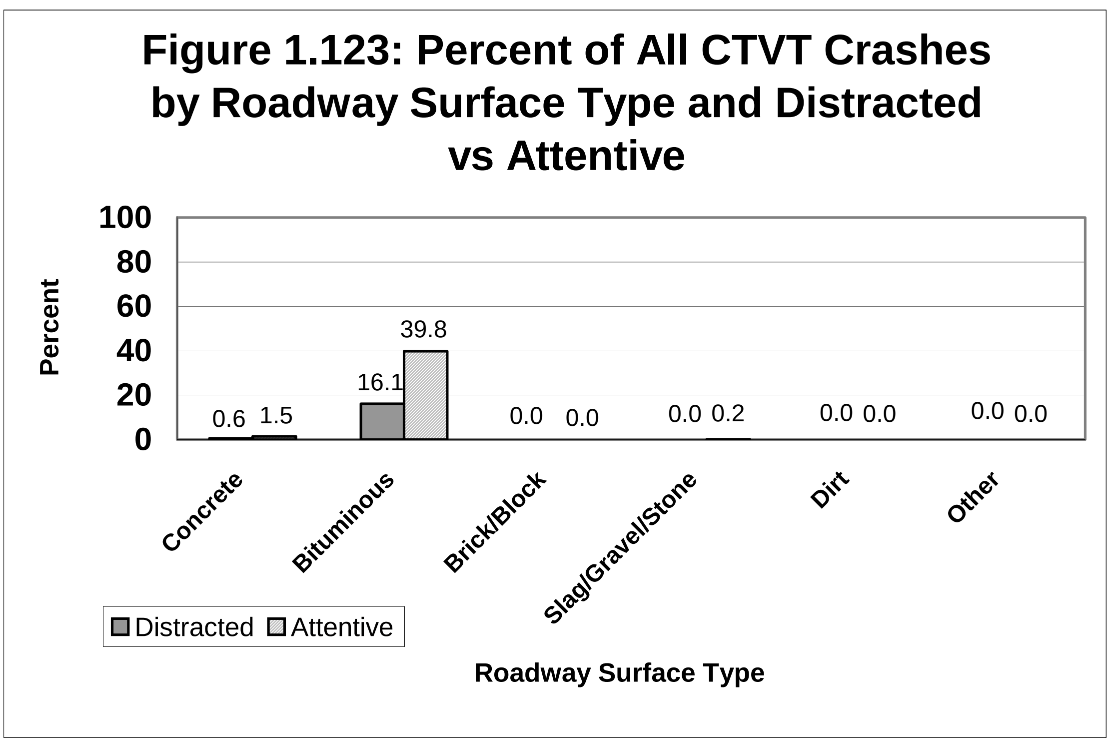


Figure 1.123: Percent of All CTVT Crashes by Roadway Surface Type and Distracted vs Attentive
Percent
100
80
60
40
20
0
0.6
1.5
16.1
39.8
0.0
0.0
0.0
0.2
0.0
0.0
0.0
0.0
Concrete
Bituminous
Brick/Block
Slag/Gravel/Stone
Dirt
Other
Distracted
Attentive
Roadway Surface Type

Figure 1.124: Percent Distracted and Attentive CTVT Crashes by Trafficway Flow

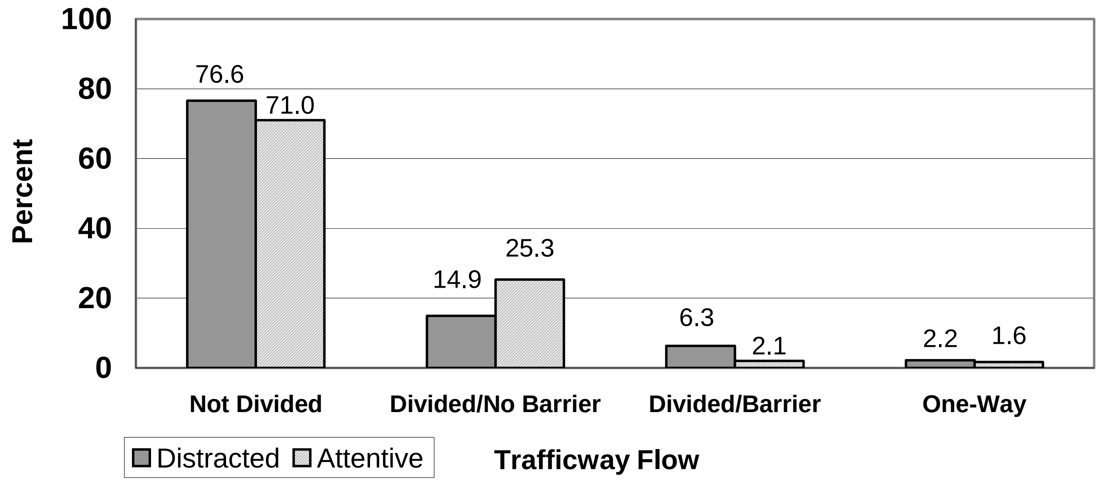
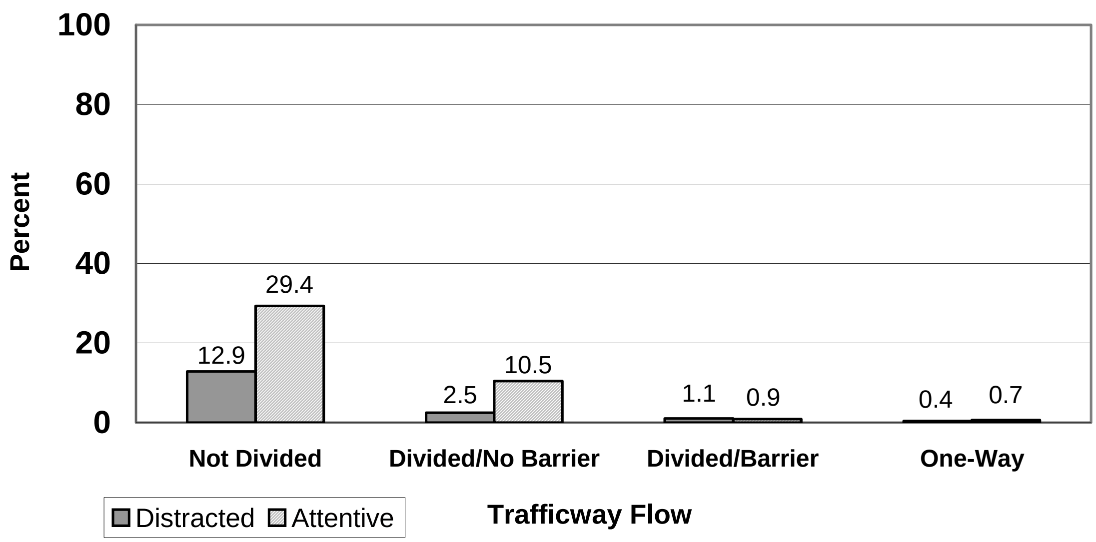


Figure 1.125: Percent of All CTVT Crashes by Trafficway Flow and Distracted vs. Attentive



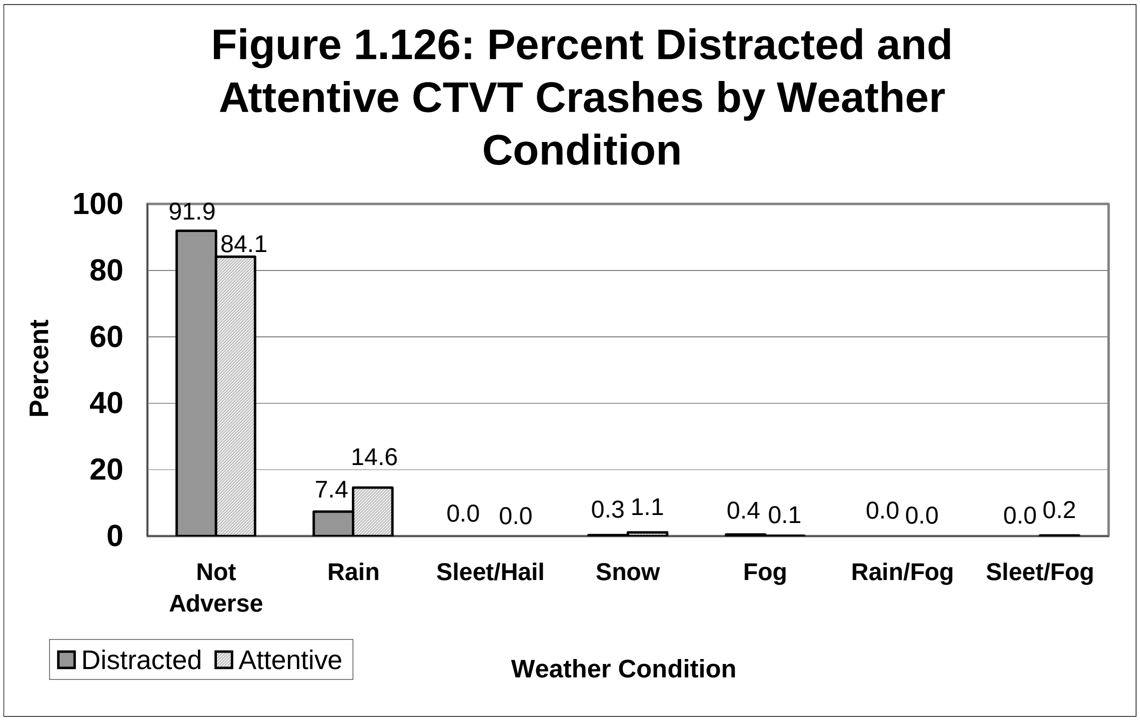


Figure 1.126: Percent Distracted and Attentive CTVT Crashes by Weather Condition
100
80
60
40
20
0
Percent
91.9
84.1
7.4
14.6
0.0
0.0
0.3
1.1
0.4
0.1
0.0
0.0
0.0
0.2
Not Adverse
Rain
Sleet/Hail
Snow
Fog
Rain/Fog
Sleet/Fog
Distracted
Attentive
Weather Condition

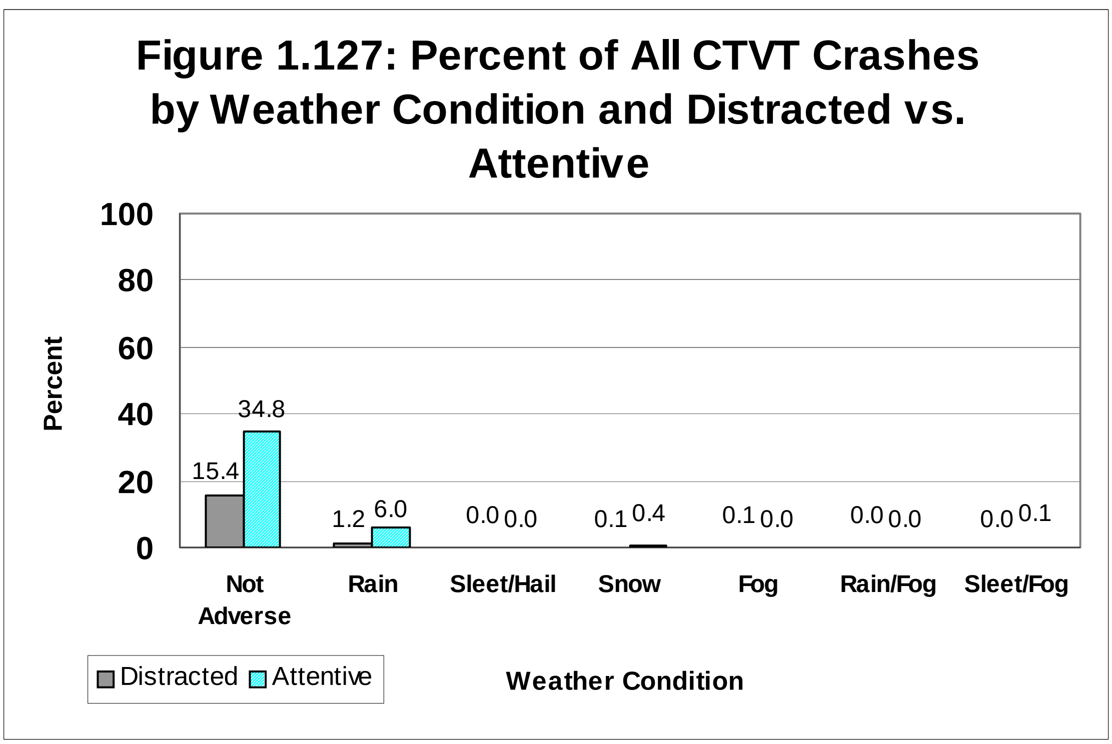


Figure 1.127: Percent of All CTVT Crashes by Weather Condition and Distracted vs. Attentive
100
80
60
40
20
0
Percent
15.4
34.8
1.2
6.0
0.0
0.0
0.1
0.4
0.1
0.0
0.0
0.0
0.0
0.1
Not Adverse
Rain
Sleet/Hail
Snow
Fog
Rain/Fog
Sleet/Fog
Distracted
Attentive
Weather Condition

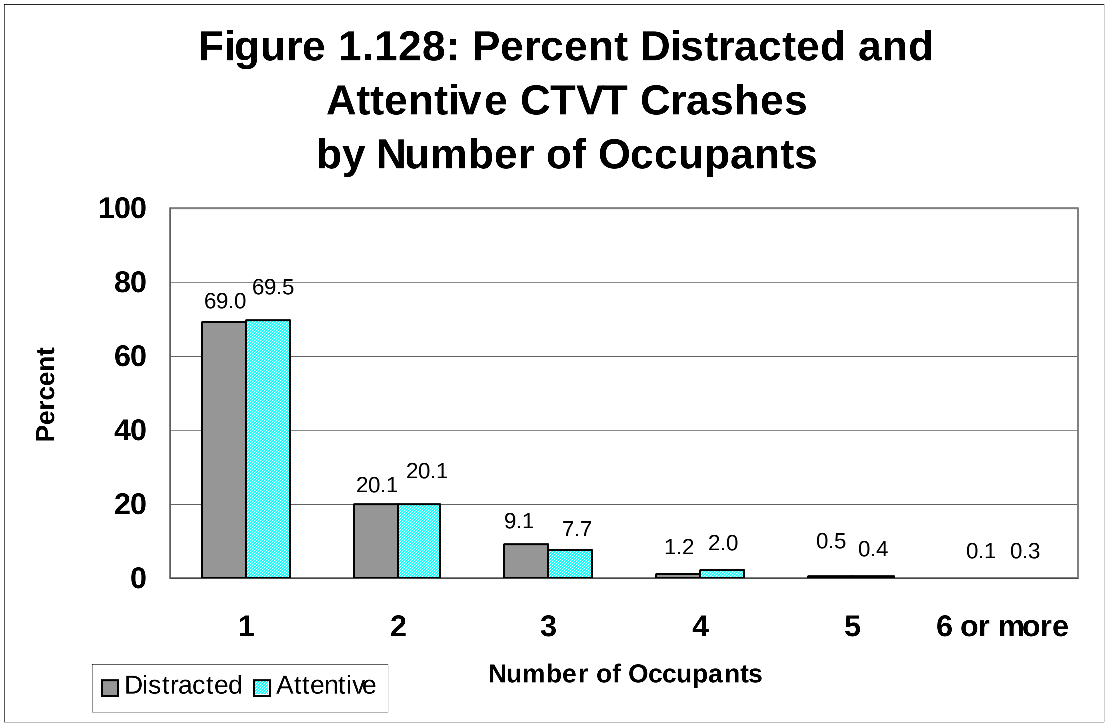


Figure 1.128: Percent Distracted and Attentive CTVT Crashes by Number of Occupants
100
80
60
40
20
0
Percent
69.0
69.5
20.1
20.1
9.1
7.7
1.2
2.0
0.5
0.4
0.1
0.3
1
2
3
4
5
6 or more
Number of Occupants
Distracted
Attentive

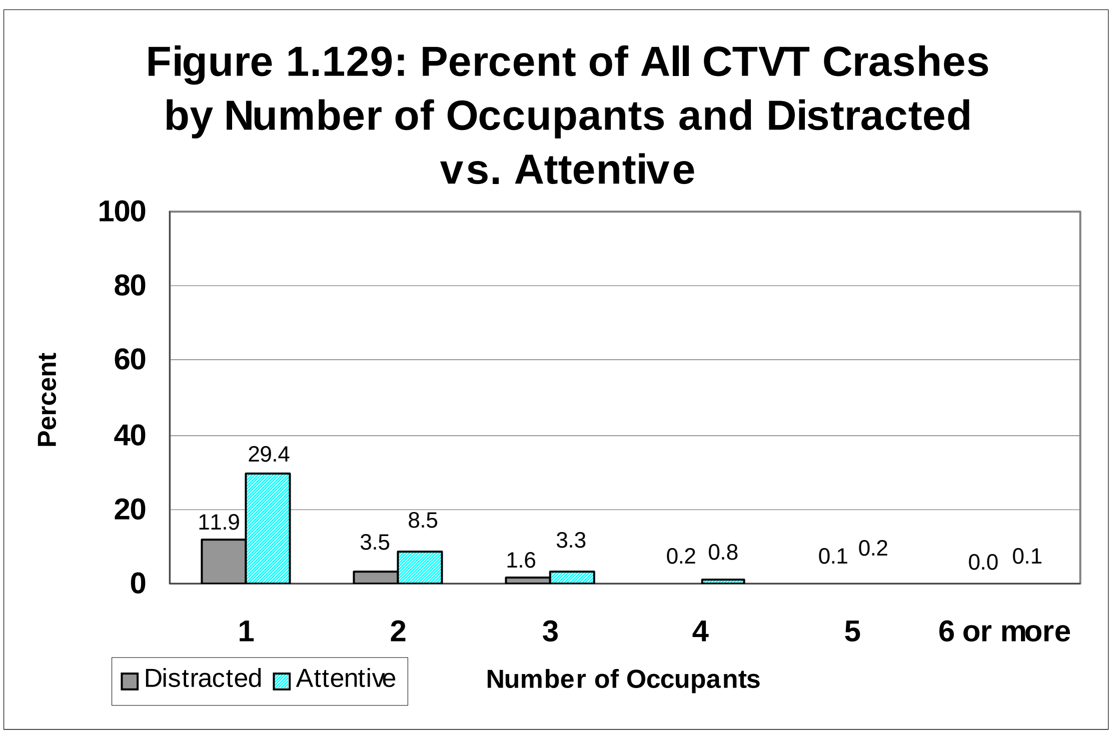


Figure 1.129: Percent of All CTVT Crashes by Number of Occupants and Distracted vs. Attentive
100
80
60
40
20
0
Percent
11.9
29.4
3.5
8.5
1.6
3.3
0.2
0.8
0.1
0.2
0.0
0.1
1
2
3
4
5
6 or more
Number of Occupants
Distracted
Attentive

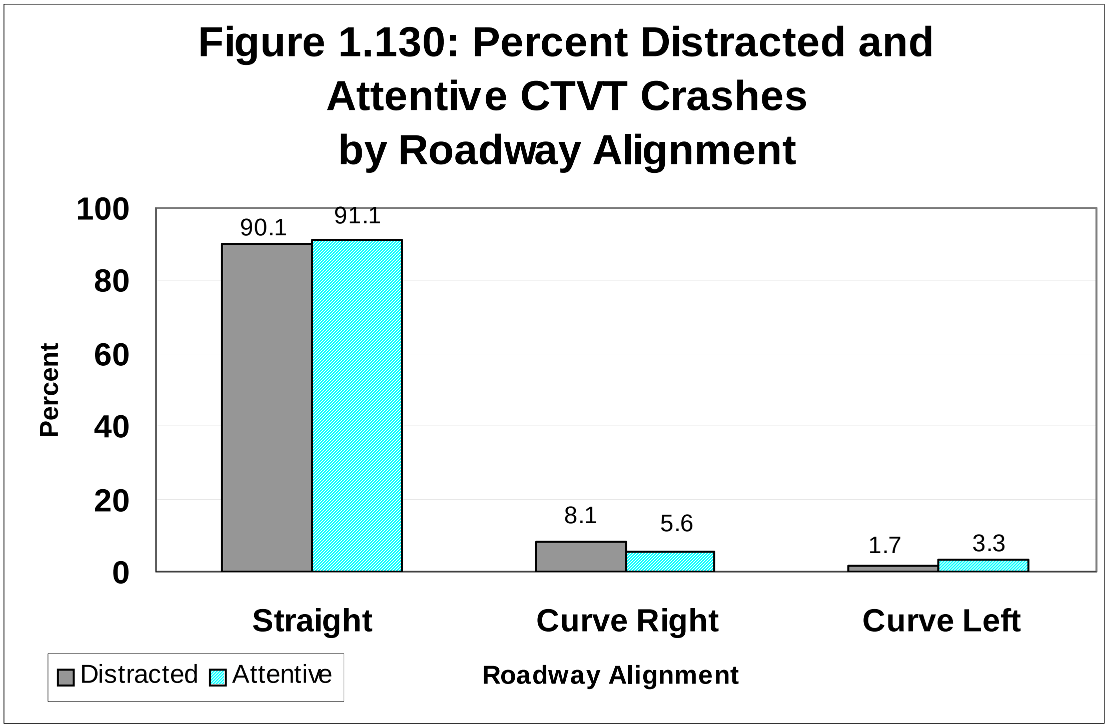


Figure 1.130: Percent Distracted and Attentive CTVT Crashes by Roadway Alignment
Percent
100
80
60
40
20
0
90.1
91.1
8.1
5.6
1.7
3.3
Straight
Curve Right
Curve Left
Distracted
Attentive
Roadway Alignment

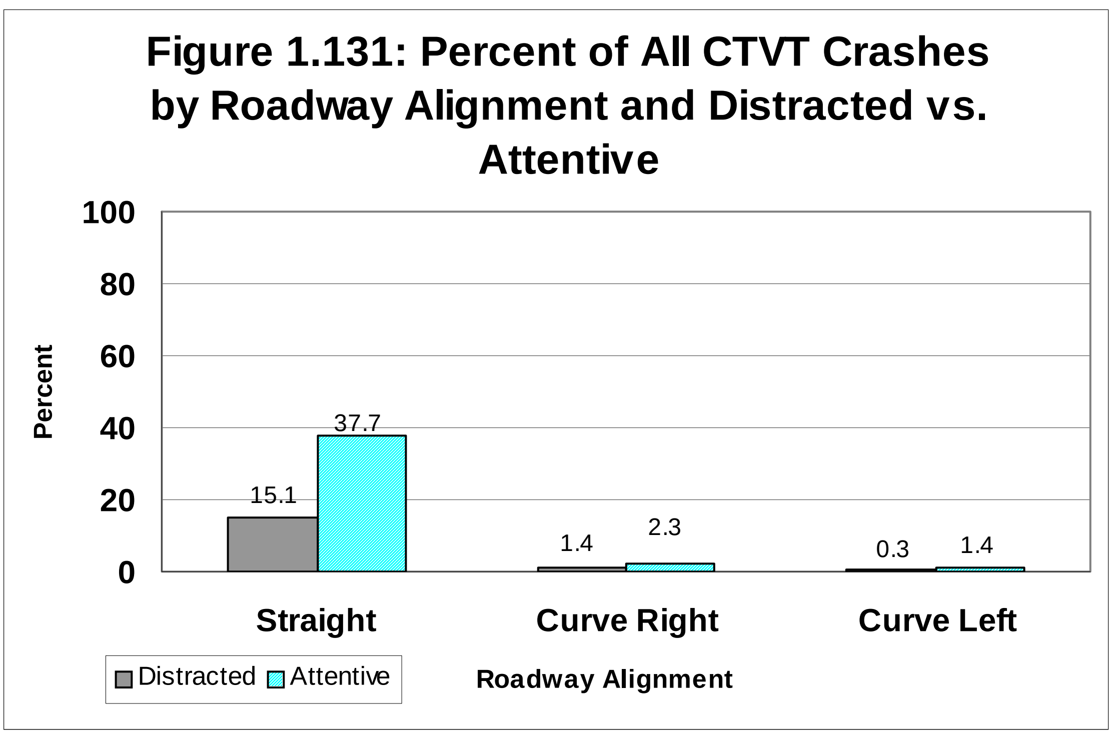


Figure 1.131: Percent of All CTVT Crashes by Roadway Alignment and Distracted vs. Attentive
Percent
100
80
60
40
20
0
15.1
37.7
1.4
2.3
0.3
1.4
Straight
Curve Right
Curve Left
Distracted
Attentive
Roadway Alignment

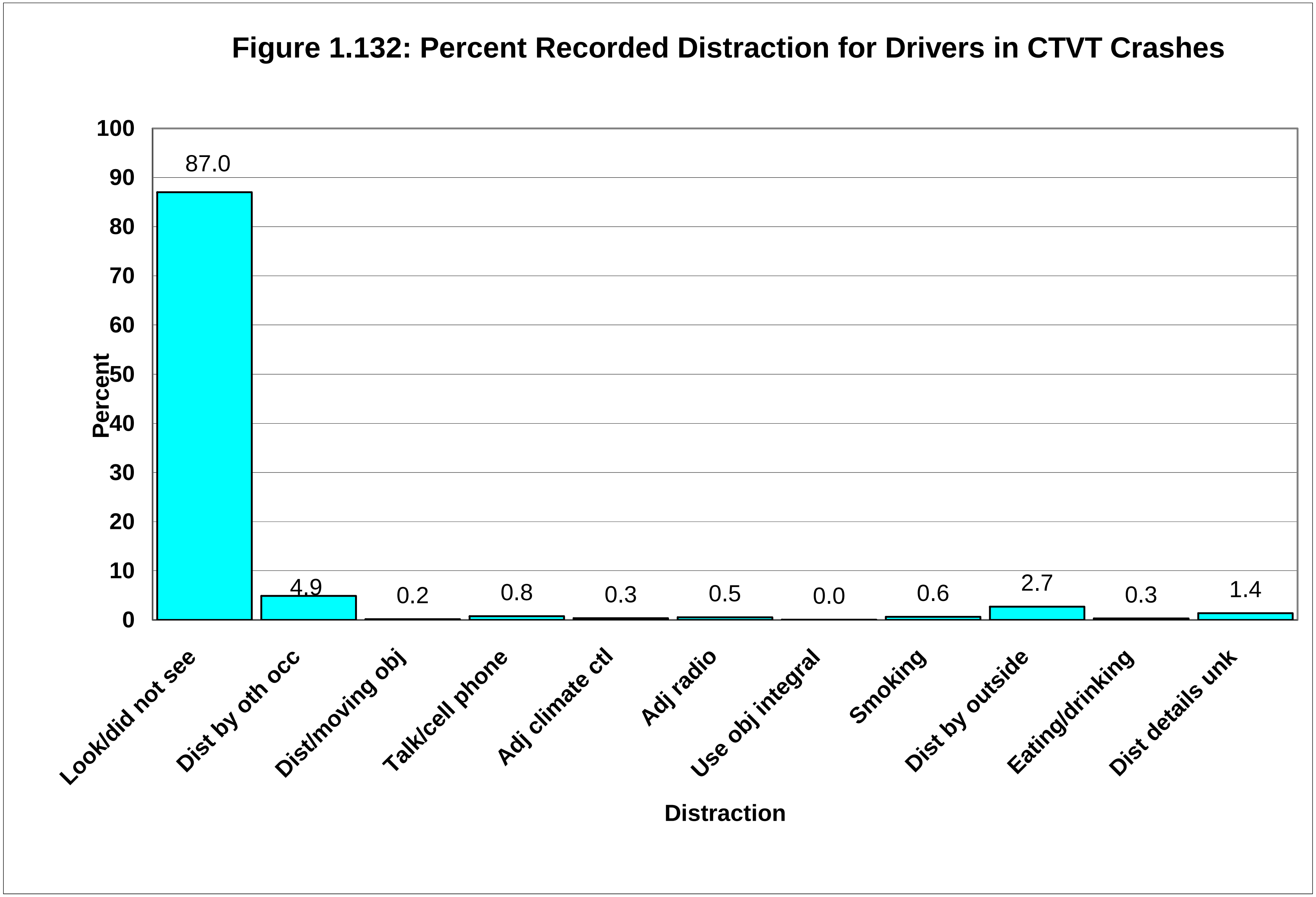


Figure 1.132: Percent Recorded Distraction for Drivers in CTVT Crashes
Percent
100
90
80
70
60
50
40
30
20
10
0
87.0
4.9
0.2
0.8
0.3
0.5
0.0
0.6
2.7
0.3
1.4
Look/did not see
Dist by oth occ
Dist/moving obj
Talk/cell phone
Adj climate ctl
Adj radio
Use obj integral
Smoking
Dist by outside
Eating/drinking
Dist details unk
Distraction

1.3.1.3.5. Same Trafficway, Opposite Direction (STOD)

Sex: Figures 1.133-1.134 show the proportion of all STOD distracted and all STOD attentive crashes (Figure 1.133) and the proportion of distracted and attentive STOD crashes (Figure 1.134) by sex. A greater proportion of both distracted and attentive STOD crashes were attributed to males. A large difference was found between attentive and distracted STOD crashes when the proportion within the crash categories (attentive vs. distracted) were compared for males, with distracted crashes much more common. The opposite result was found for females. Large differences were found when the proportions were determined as a function of all STOD crashes, with distracted crashes much less frequent than attentive crashes for both sexes.

Age Group: The proportion of all distracted and all attentive STOD crashes and the proportion of distracted and attentive crashes by all STOD crashes by age group are shown in Figures 1.135 and 1.136. When proportions were compared within the crash categories (Figure 1.135), we found that distracted STOD crashes were more frequent for drivers under age 18, drivers aged 26-34, and drivers aged 65-75. When compared among all STOD crashes (Figure 1.136), distracted STOD crashes were less common for all age groups.

Age Group and Sex: Figures 1.137-1.140 show the proportions of STOD crashes by males and age (Figure 1.137-1.138) and by females and age (Figures 1.139-1.140). For males, STOD distracted crashes were more common for drivers under age 18, drivers aged 26-34, and drivers aged 65-75, when proportions were compared within crash categories. When compared among all STOD crashes, distracted crashes for males were less common than. Or nearly equal to, attentive crashes for all age groups. For females, distracted STOD crashes were more common for drivers aged 35-75, with an extremely large difference found for the 65-75 age group, when proportions were compared within crash categories. Comparing within all STOD crashes, we found that distracted crashes were less frequent than attentive crashes for all female age groups.

Number of Lanes: Figures 1.141 and 1.142 show STOD crashes by the number of traffic lanes. Comparing proportions within crash categories, we found that distracted crashes were more frequent for one-, two-, four-, and 6-lane roads (Figure 1.141). Distracted STOD crashes were less frequent, or equal to, attentive crashes for all lane numbers, except one-lane roads, when proportions were compared among all STOD crashes.

Roadway Profile: Figures 1.143 and 1.144 show the distributions of distracted and attentive STOD crashes by the roadway profile. Comparisons within the crash categories showed that distracted STOD crashes were more frequent for hill crests and downhill grades (Figure 1.143). Comparing proportions among all STOD crashes showed that distracted were common than, or nearly equal to, attentive crashes for all profiles (Figure 1.144).

Relation to Junction: Figures 1.145 and 1.146 show the distributions of distracted and attentive STOD crashes by their relation to junctions. Comparisons within the crash categories showed that distracted STOD crashes were more common non-inersection/nonjunction areas (Figure 1.145). Attentive STOD crashes were more common than, or equal to, distracted crashes in all cases when proportions were compared relative to all STOD crashes (Figure 1.146).

Light Conditions: Figures 1.147 and 1.148 show the distributions of distracted and attentive STOD crashes by the light conditions. Comparison within the crash categories showed that distracted STOD crashes were more common for “daylight”, “dark/lighted” and “dawn” lighting conditions (Figure 1.147). Comparing proportions among all STOD crashes showed that distracted STOD crashes were less frequent than attentive crashes for all lighting conditions (Figure 1.148).

Roadway Surface Conditions: Figures 1.149 and 1.150 show the distributions of distracted and attentive STOD crashes by the roadway surface conditions. Comparisons within the crash categories showed that distracted STOD crashes were much more frequent for dry roads (Figure 1.149). Comparing proportions among all STOD crashes showed that distracted STOD crashes were less frequent than, or equal to, attentive crashes for all roadway conditions (Figure 1.150).

Roadway Surface Type: Figures 1.151 and 1.152 show the distributions of distracted and attentive STOD crashes by the roadway surface type. Comparisons within the crash categories showed that distracted STOD crashes were much more common for dirt roads, and slightly more common for concrete and slag/gravel/stone roads (Figure 1.151). Comparing proportions among all STOD crashes showed that distracted STOD crashes were equally or less frequent than attentive crashes for all surface types (Figure 1.152).

Trafficway Flow: Figures 1.153 and 1.154 show the distributions of distracted and attentive STOD crashes by the trafficway flow. Comparisons within the crash categories showed that distracted STOD crashes were more frequent for “divided with no barrier” and “divided/barrier” flows (Figure 1.153). Comparing proportions among all STOD crashes showed that distracted STOD crashes were less frequent than, or nearly equal to, attentive crashes for all trafficway flow types (Figure 1.154).

Weather Conditions: Figures 1.155 and 1.156 show the distributions of distracted and attentive STOD crashes by the prevailing weather conditions. Comparison within the crash categories showed that distracted STOD crashes were much more common for “not adverse” weather only (Figure 1.155). Comparing proportions among all STOD crashes showed that distracted STOD crashes were equally or less frequent than distracted crashes for all weather conditions (Figure 1.156).

Number of Occupants: Figures 1.157 and 1.158 show the distributions of distracted and attentive STOD crashes by the number of occupants in the vehicle. Comparisons within the crash categories showed that distracted STOD crashes were more frequent for one, three, and four passengers (Figure 1.157). Comparing proportions among all STOD crashes showed that distracted STOD crashes were equally or less frequent than distracted crashes for all numbers of occupants (Figure 1.158).

Roadway Alignment: Figures 1.159 and 1.160 show the distributions of distracted and attentive STOD crashes by the roadway alignment. Comparisons within the crash categories showed that distracted STOD crashes were much more frequent for curves to the right (Figure 1.159). Comparing proportions among all STOD crashes showed that distracted STOD crashes were slightly more frequent than attentive crashes for curves to the right (Figure 1.160).

STOD Crashes by Distraction Code: Figure 1.161 shows the distribution of the distraction codes for STOD crashes. As shown in this figure, about 40 percent of all STOD distracted crashes were coded as being distracted by another occupant. In another 25 percent of these crashes, adjusting-the-climate-controls was listed as the distraction. Ten percent of these crashes were coded as the driver being distracted by an outside event.

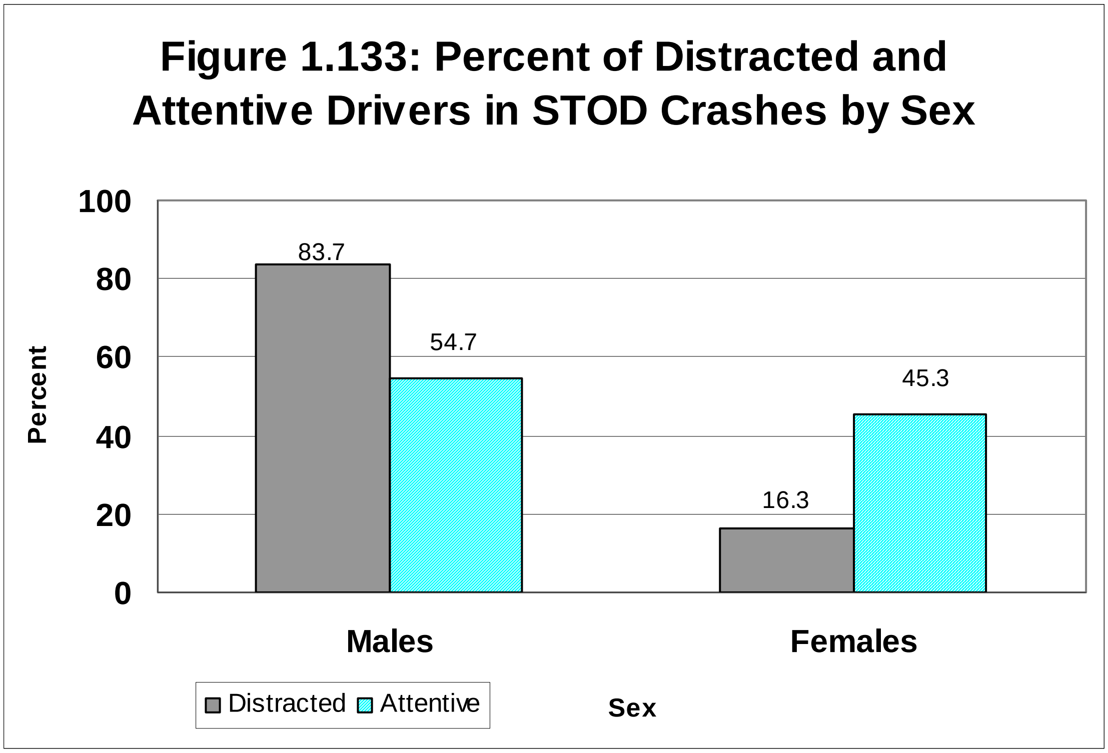


Figure 1.133: Percent of Distracted and Attentive Drivers in STOD Crashes by Sex
100
80
60
40
20
0
Percent
83.7
54.7
16.3
45.3
Males
Females
Distracted
Attentive
Sex

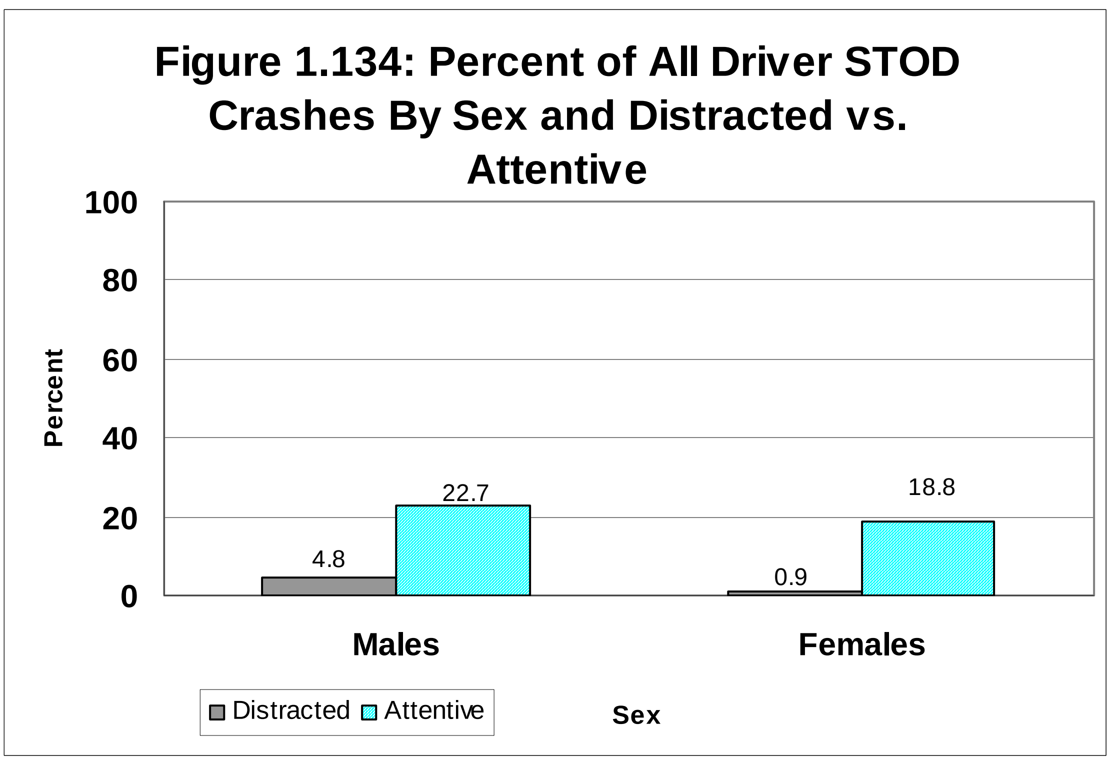


Figure 1.134: Percent of All Driver STOD Crashes By Sex and Distracted vs. Attentive
100
80
60
40
20
0
Percent
4.8
22.7
0.9
18.8
Males
Females
Distracted
Attentive
Sex

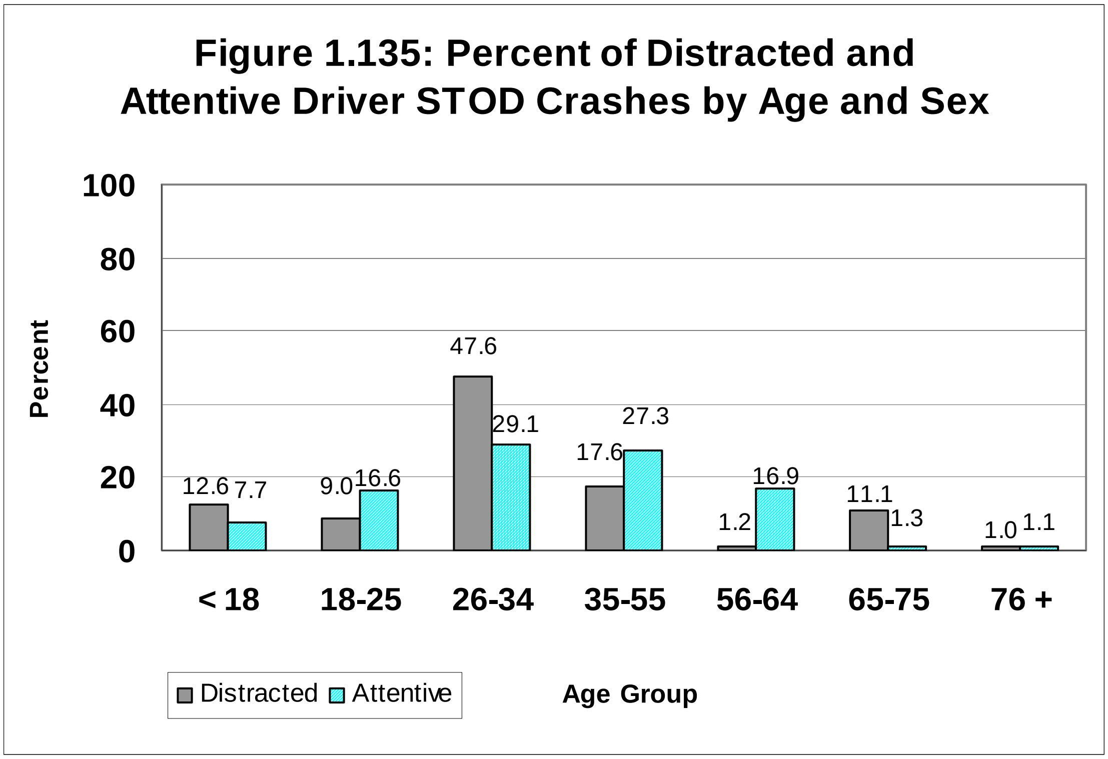


Figure 1.135: Percent of Distracted and Attentive Driver STOD Crashes by Age and Sex
Percent
100
80
60
40
20
0
12.6
7.7
9.0
16.6
47.6
29.1
17.6
27.3
1.2
16.9
11.1
1.3
1.0
1.1
< 18
18-25
26-34
35-55
56-64
65-75
76 +
Distracted
Attentive
Age Group

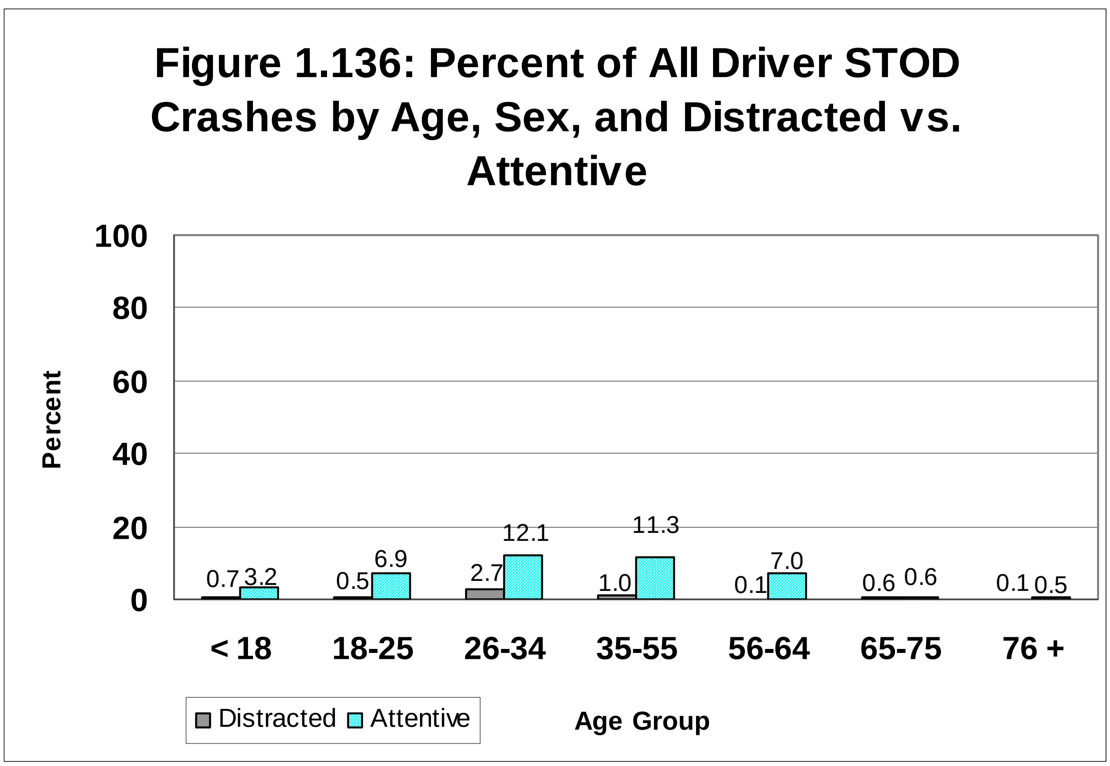


Figure 1.136: Percent of All Driver STOD Crashes by Age, Sex, and Distracted vs. Attentive
Percent
100
80
60
40
20
0
0.7
3.2
0.5
6.9
2.7
12.1
1.0
11.3
0.1
7.0
0.6
0.6
0.1
0.5
< 18
18-25
26-34
35-55
56-64
65-75
76 +
Distracted
Attentive
Age Group

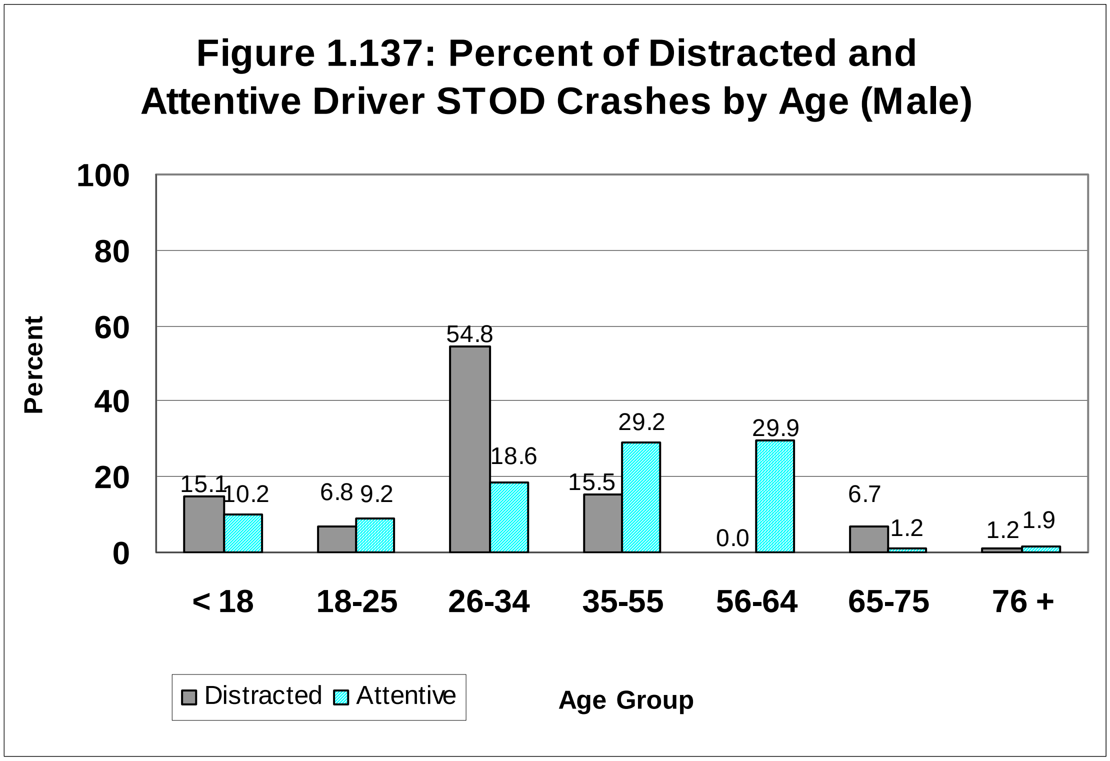


Figure 1.137: Percent of Distracted and Attentive Driver STOD Crashes by Age (Male)
Percent
100
80
60
40
20
0
15.1
10.2
6.8
9.2
54.8
18.6
15.5
29.2
0.0
29.9
6.7
1.2
1.2
1.9
< 18
18-25
26-34
35-55
56-64
65-75
76 +
Distracted
Attentive
Age Group

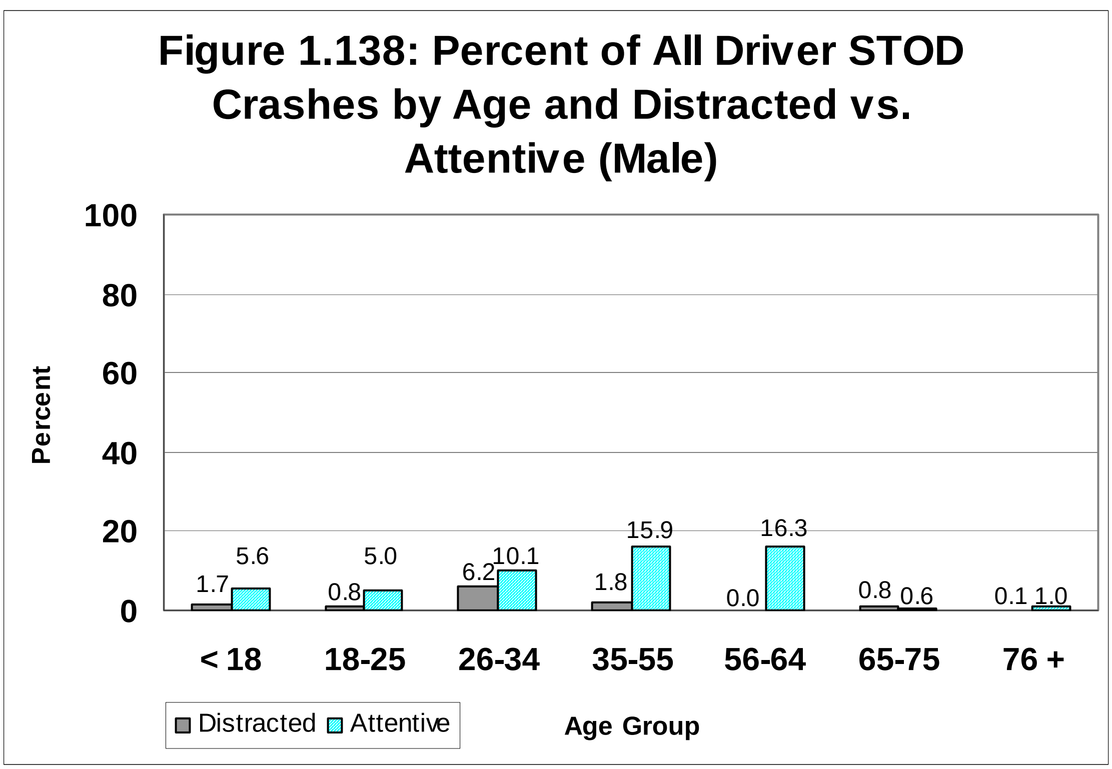


Figure 1.138: Percent of All Driver STOD Crashes by Age and Distracted vs. Attentive (Male)
Percent
100
80
60
40
20
0
1.7
5.6
0.8
5.0
6.2
10.1
1.8
15.9
0.0
16.3
0.8
0.6
0.1
1.0
< 18
18-25
26-34
35-55
56-64
65-75
76 +
Distracted
Attentive
Age Group

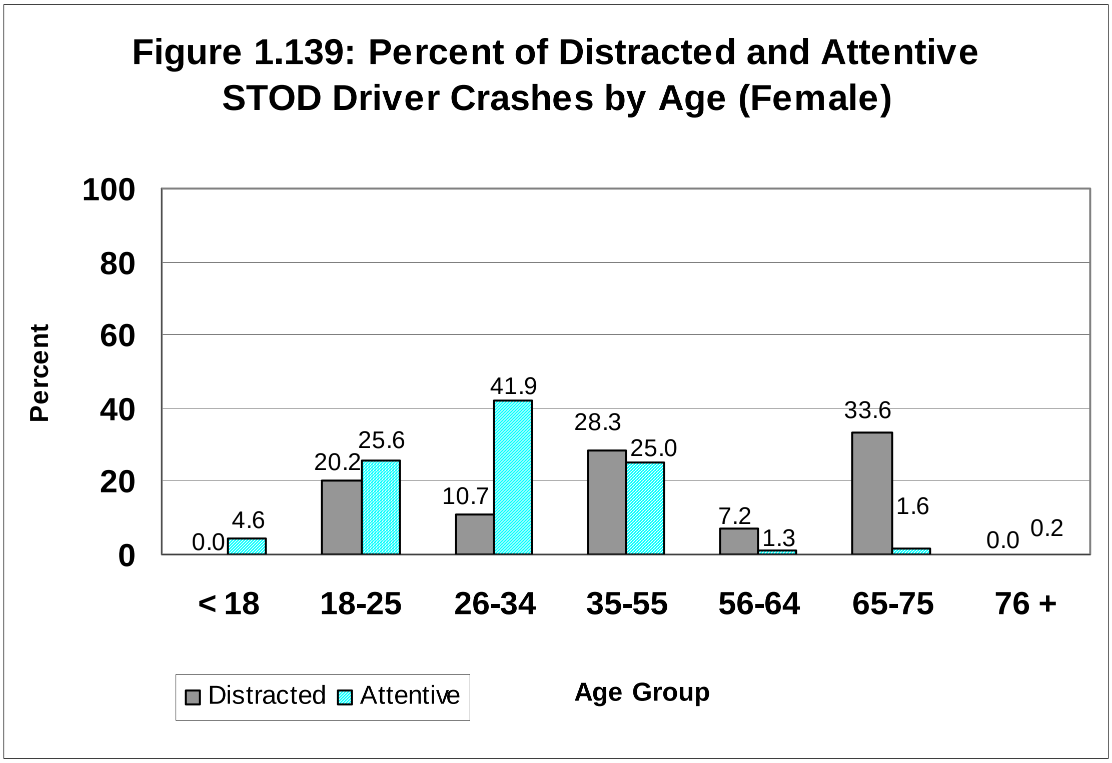


Figure 1.139: Percent of Distracted and Attentive STOD Driver Crashes by Age (Female)
100
80
60
40
20
0
Percent
0.0
4.6
20.2
25.6
10.7
41.9
28.3
25.0
7.2
1.3
33.6
1.6
0.0
0.2
< 18
18-25
26-34
35-55
56-64
65-75
76 +
Distracted
Attentive
Age Group

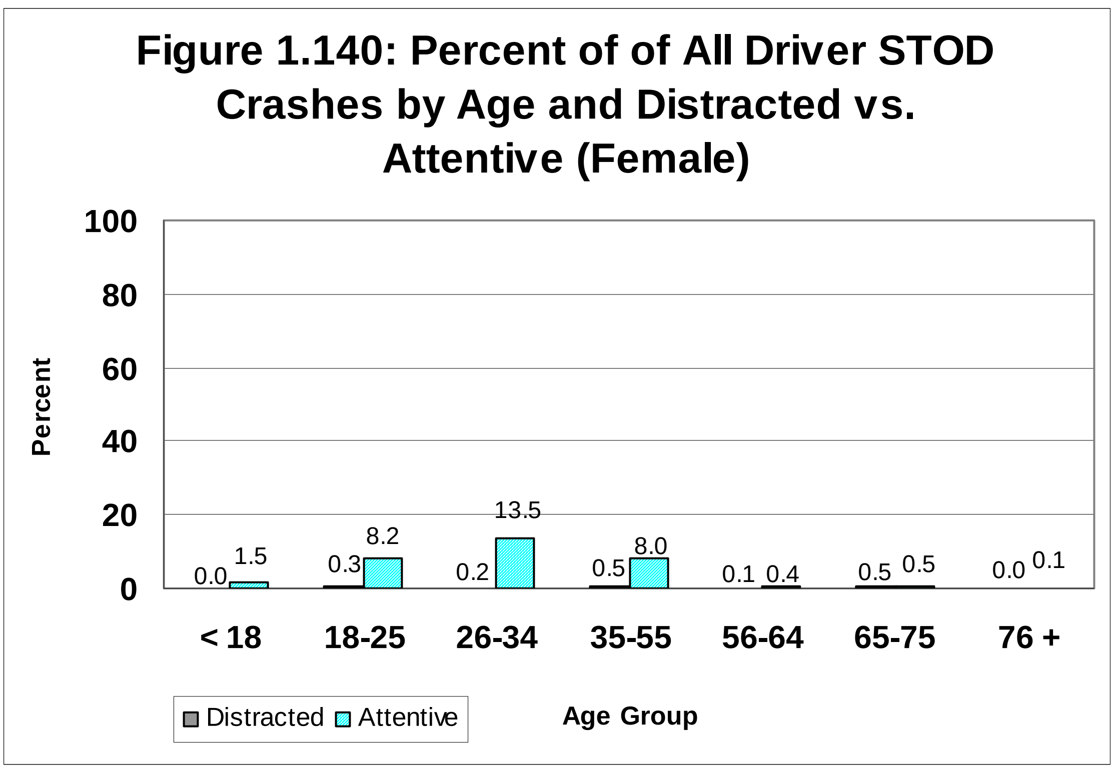


Figure 1.140: Percent of of All Driver STOD Crashes by Age and Distracted vs. Attentive (Female)
100
80
60
40
20
0
Percent
0.0
1.5
0.3
8.2
0.2
13.5
0.5
8.0
0.1
0.4
0.5
0.5
0.0
0.1
< 18
18-25
26-34
35-55
56-64
65-75
76 +
Distracted
Attentive
Age Group

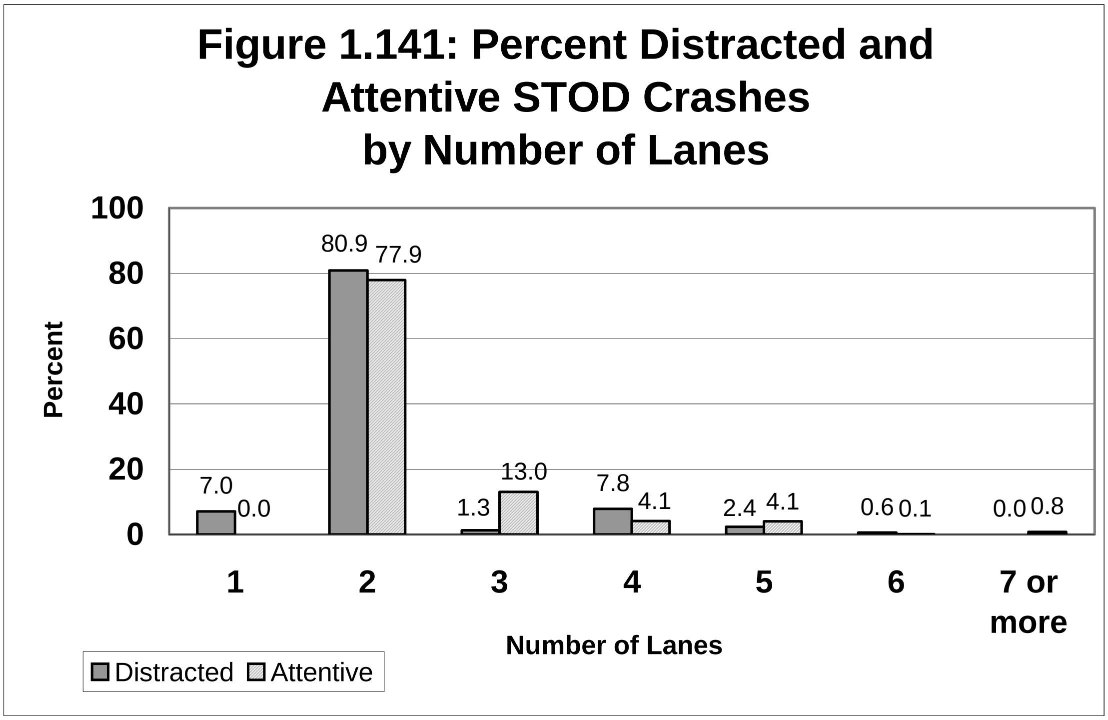


Figure 1.141: Percent Distracted and
Attentive STOD Crashes
by Number of Lanes
100
80
60
40
20
0
Percent
7.0
0.0
80.9
77.9
1.3
13.0
7.8
4.1
2.4
4.1
0.6
0.1
0.0
0.8
1
2
3
4
5
6
7 or more
Number of Lanes
Distracted
Attentive

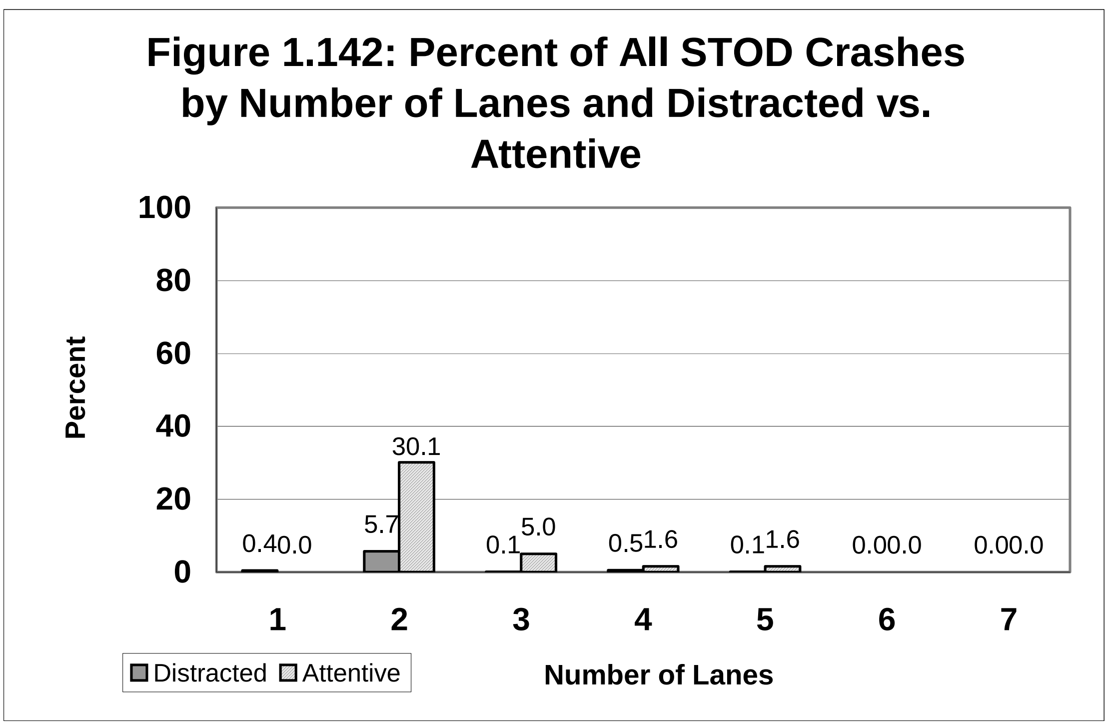


Figure 1.142: Percent of All STOD Crashes
by Number of Lanes and Distracted vs.
Attentive
100
80
60
40
20
0
Percent
0.4
0.0
5.7
30.1
0.1
5.0
0.5
1.6
0.1
1.6
0.0
0.0
0.0
0.0
1
2
3
4
5
6
7
Distracted
Attentive
Number of Lanes

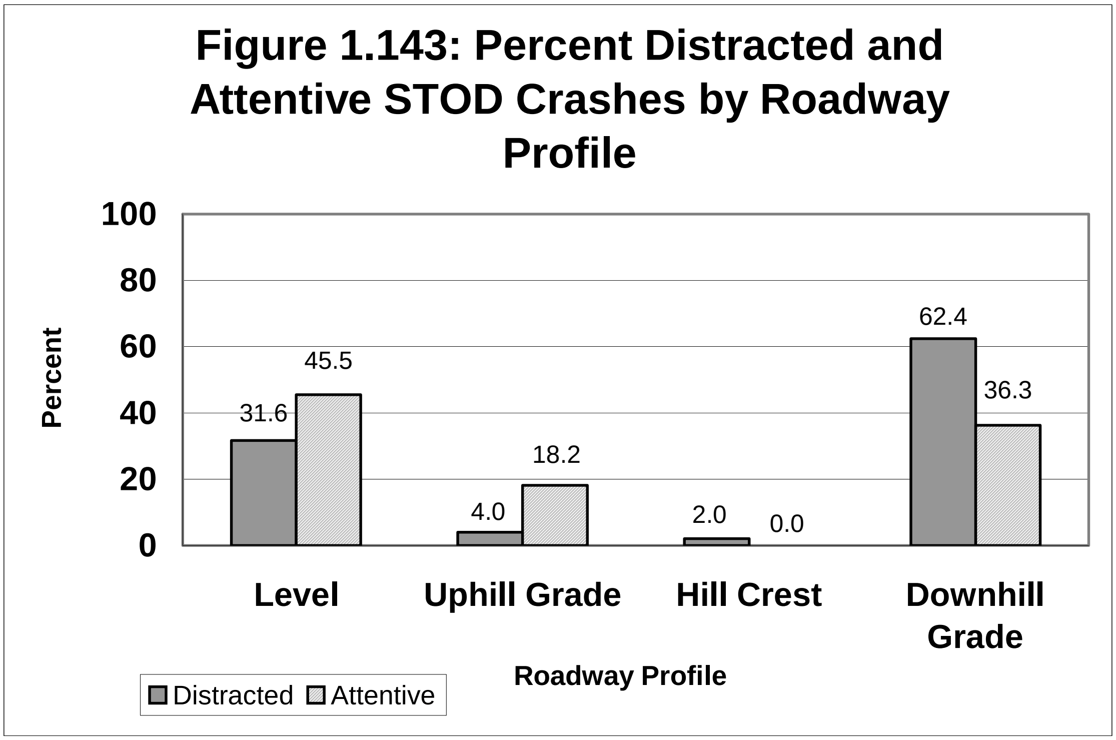


Figure 1.143: Percent Distracted and Attentive STOD Crashes by Roadway Profile
100
80
60
40
20
0
Percent
31.6
45.5
4.0
18.2
2.0
0.0
62.4
36.3
Level
Uphill Grade
Hill Crest
Downhill Grade
Roadway Profile
Distracted
Attentive

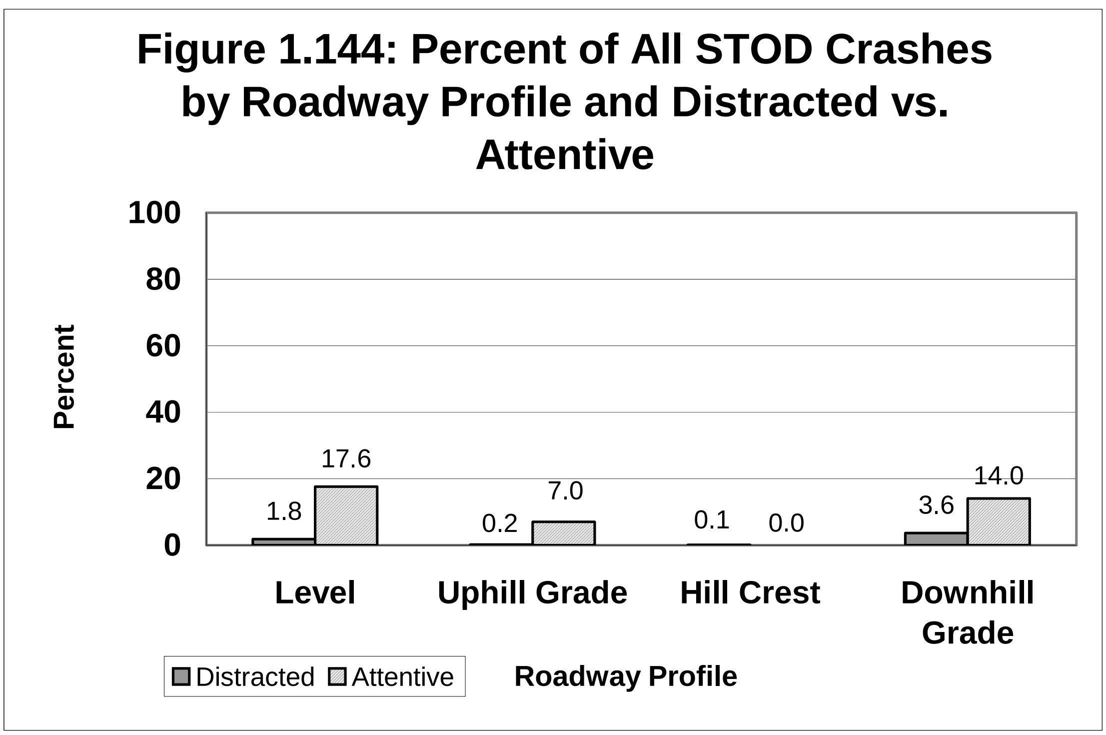


Figure 1.144: Percent of All STOD Crashes by Roadway Profile and Distracted vs. Attentive
100
80
60
40
20
0
Percent
1.8
17.6
0.2
7.0
0.1
0.0
3.6
14.0
Level
Uphill Grade
Hill Crest
Downhill Grade
Distracted
Attentive
Roadway Profile

Figure 1.145: Percent Distracted and Attentive STOD Crashes by Relation to Junction

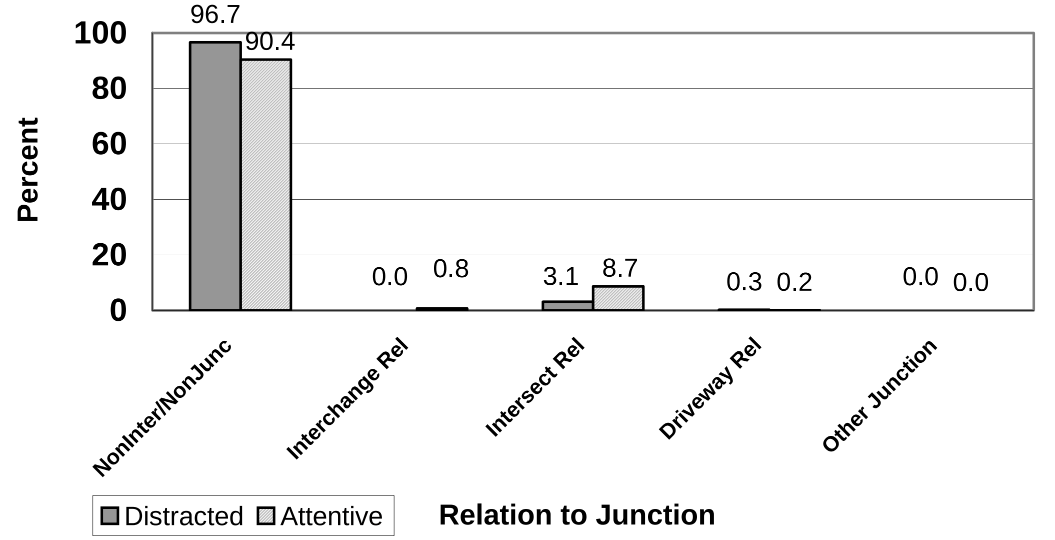
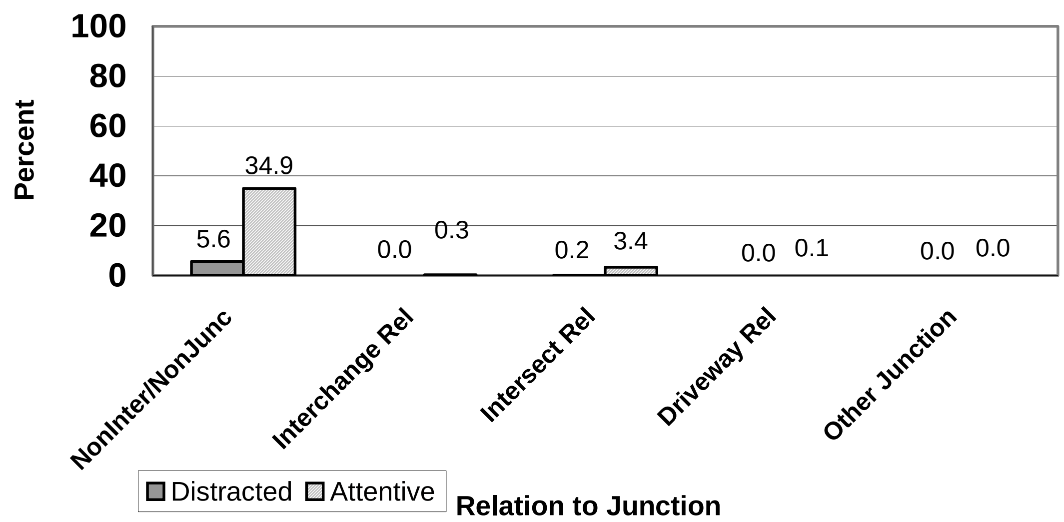


Figure 1.146: Percent of All STOD Crashes by Relation to Junction and Distracted vs. Attentive



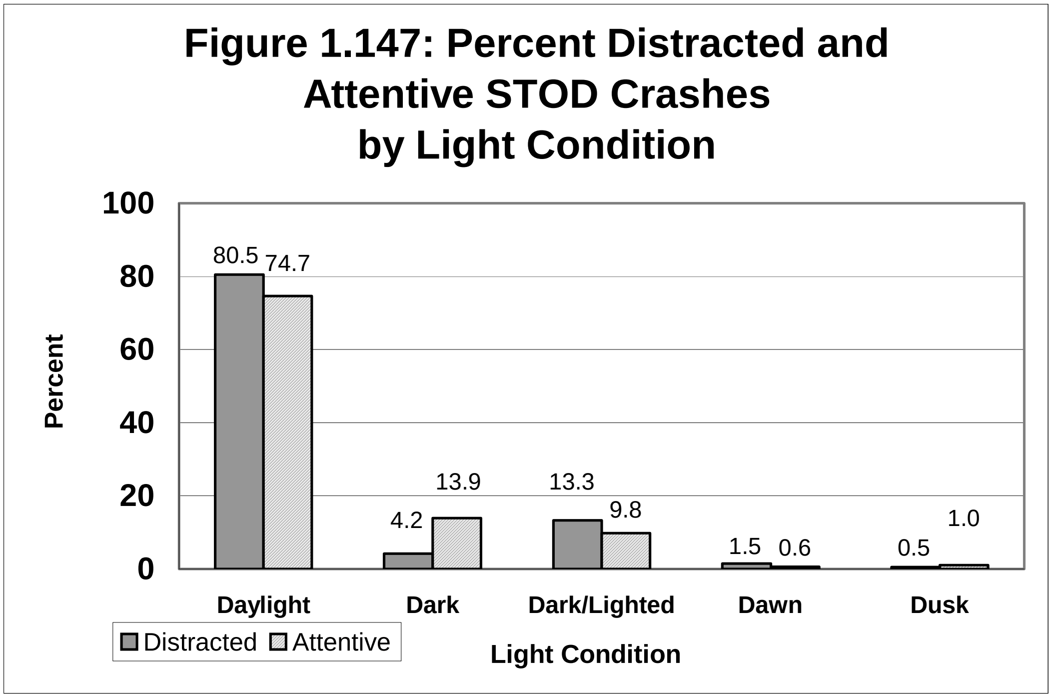


Figure 1.147: Percent Distracted and Attentive STOD Crashes by Light Condition
100
80
60
40
20
0
Percent
80.5
74.7
4.2
13.9
13.3
9.8
1.5
0.6
0.5
1.0
Daylight
Dark
Dark/Lighted
Dawn
Dusk
Distracted
Attentive
Light Condition

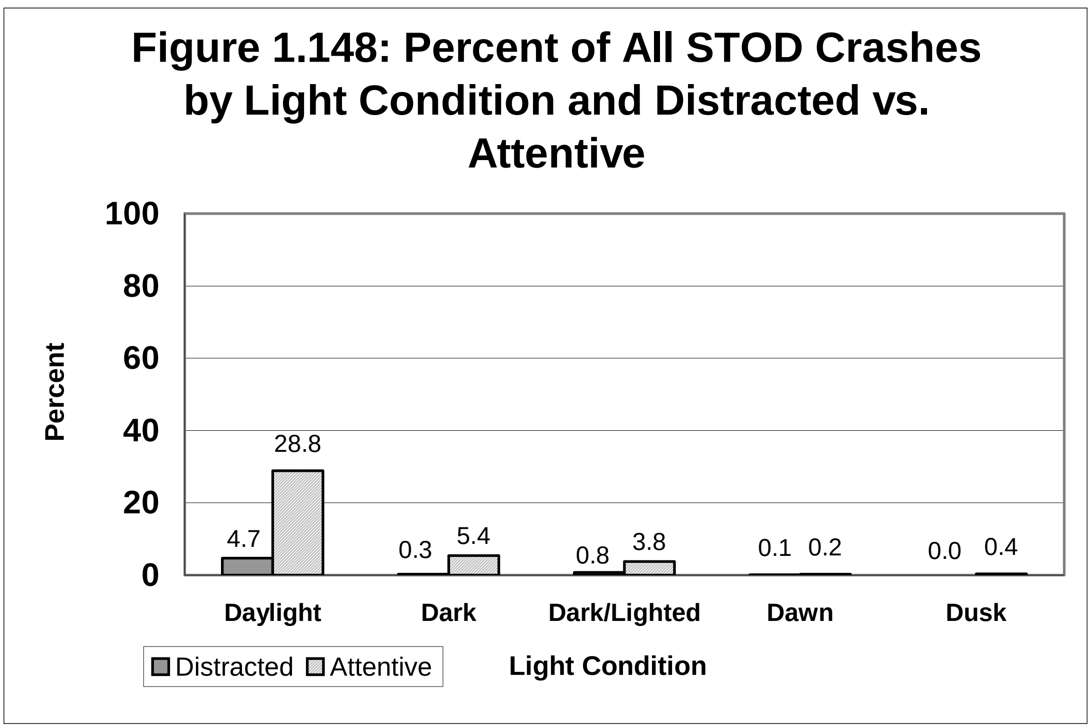


Figure 1.148: Percent of All STOD Crashes by Light Condition and Distracted vs. Attentive
100
80
60
40
20
0
Percent
4.7
28.8
0.3
5.4
0.8
3.8
0.1
0.2
0.0
0.4
Daylight
Dark
Dark/Lighted
Dawn
Dusk
Distracted
Attentive
Light Condition

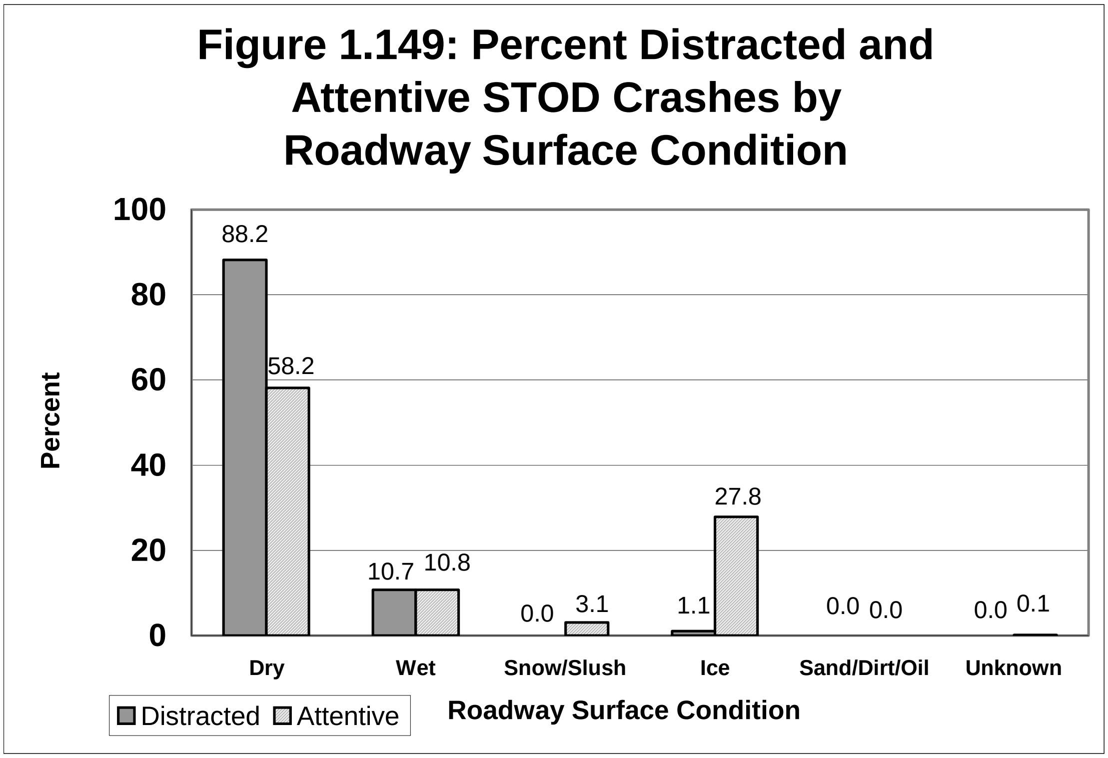


Figure 1.149: Percent Distracted and Attentive STOD Crashes by Roadway Surface Condition
100
80
60
40
20
0
Percent
88.2
58.2
10.7
10.8
0.0
3.1
1.1
27.8
0.0
0.0
0.0
0.1
Dry
Wet
Snow/Slush
Ice
Sand/Dirt/Oil
Unknown
Distracted
Attentive
Roadway Surface Condition

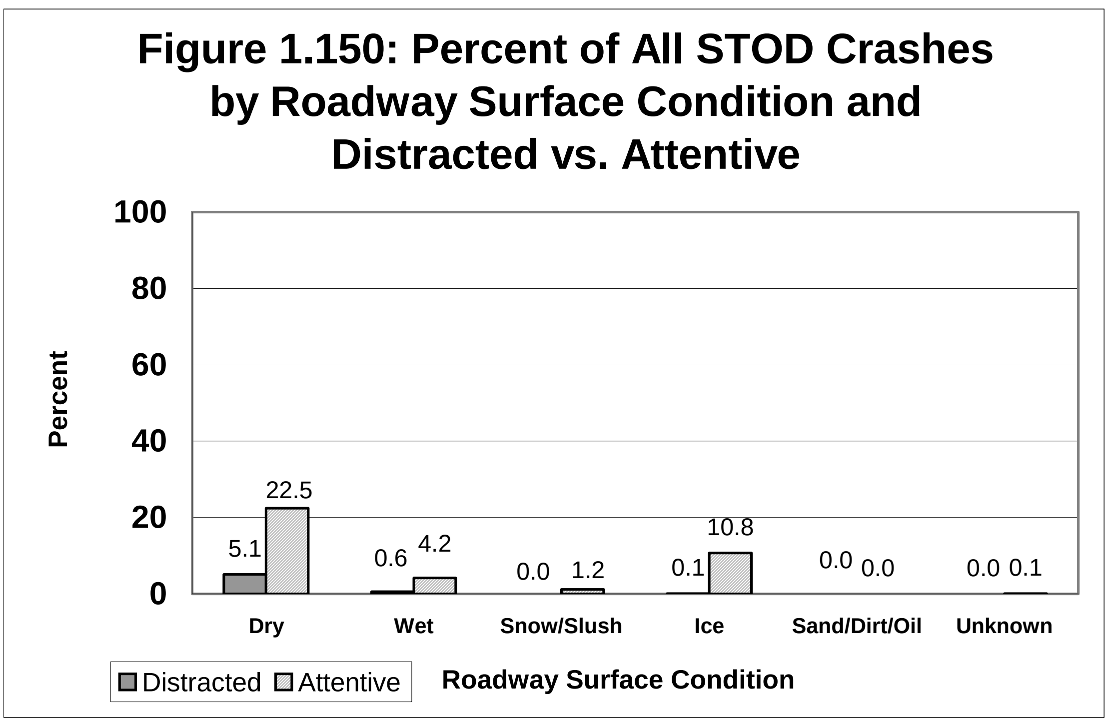


Figure 1.150: Percent of All STOD Crashes by Roadway Surface Condition and Distracted vs. Attentive
100
80
60
40
20
0
Percent
5.1
22.5
0.6
4.2
0.0
1.2
0.1
10.8
0.0
0.0
0.0
0.1
Dry
Wet
Snow/Slush
Ice
Sand/Dirt/Oil
Unknown
Distracted
Attentive
Roadway Surface Condition

Figure 1.151: Percent Distracted and Attentive STOD Crashes by Roadway Surface Type

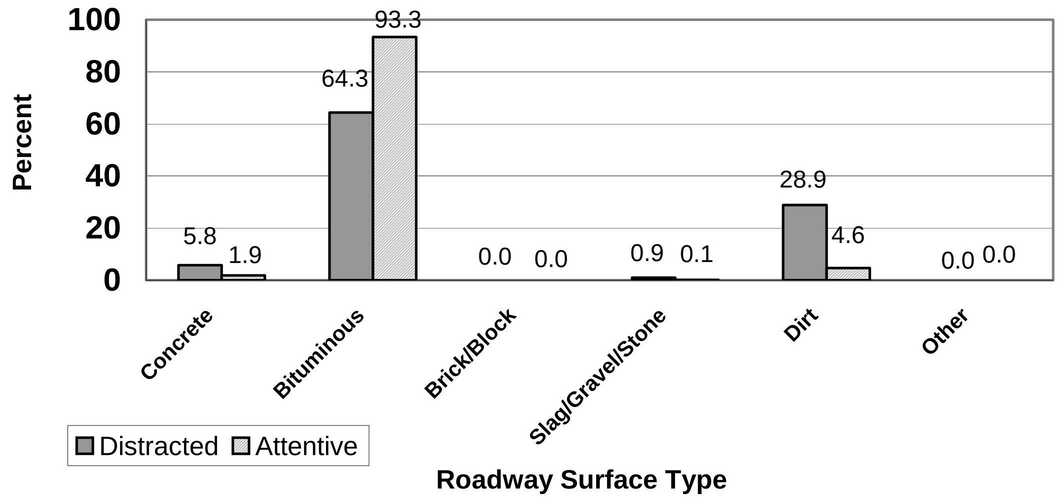
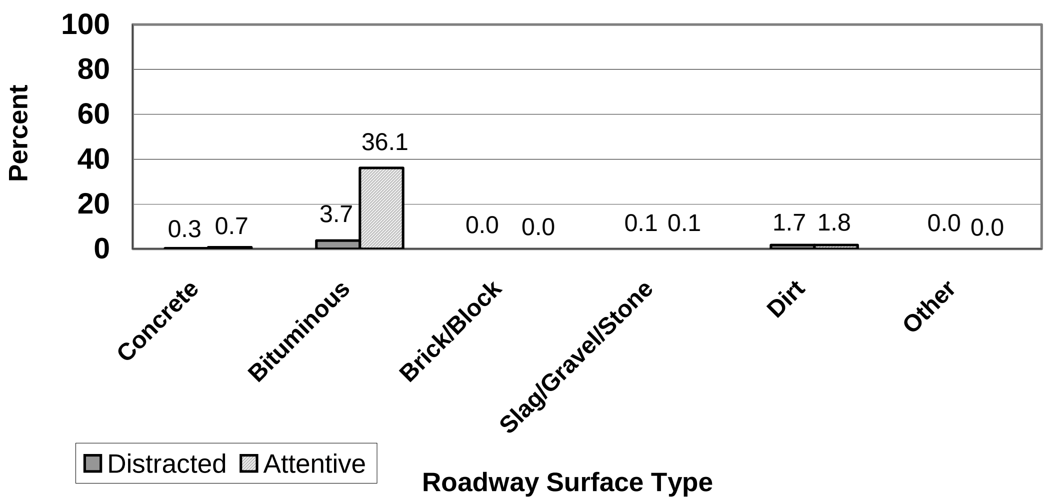


Figure 1.152: Percent of All STOD Crashes by Roadway Surface Type and Distracted vs. Attentive



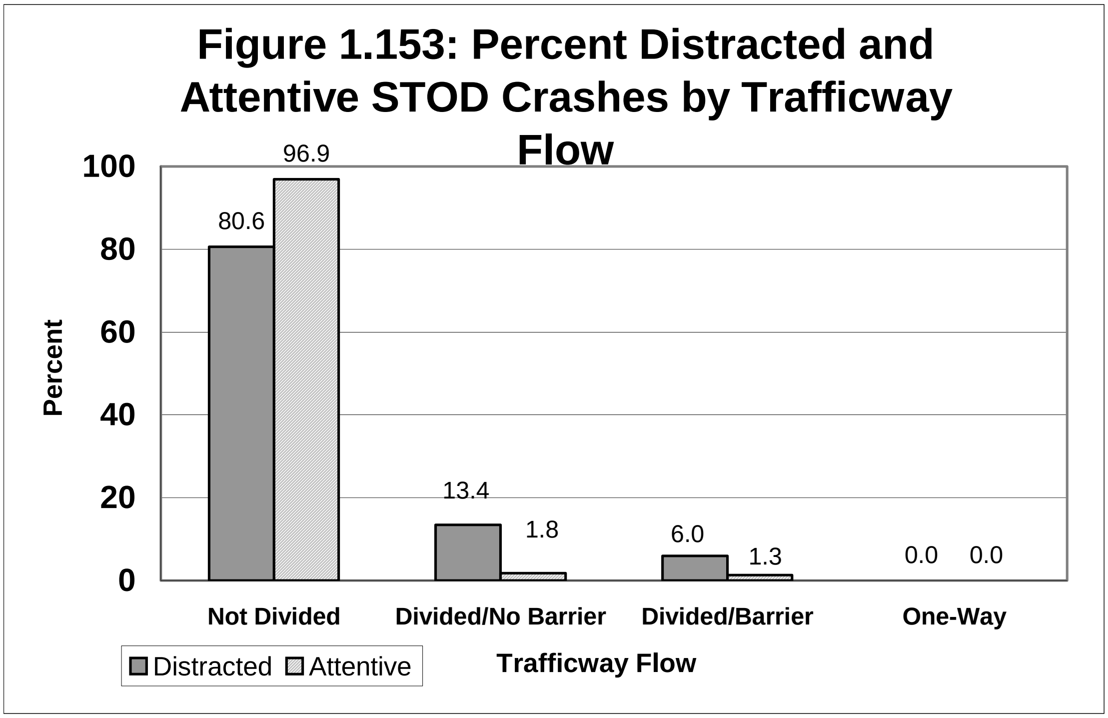


Figure 1.153: Percent Distracted and Attentive STOD Crashes by Trafficway Flow
Percent
100
80
60
40
20
0
80.6
96.9
13.4
1.8
6.0
1.3
0.0
0.0
Not Divided
Divided/No Barrier
Divided/Barrier
One-Way
Distracted
Attentive
Trafficway Flow

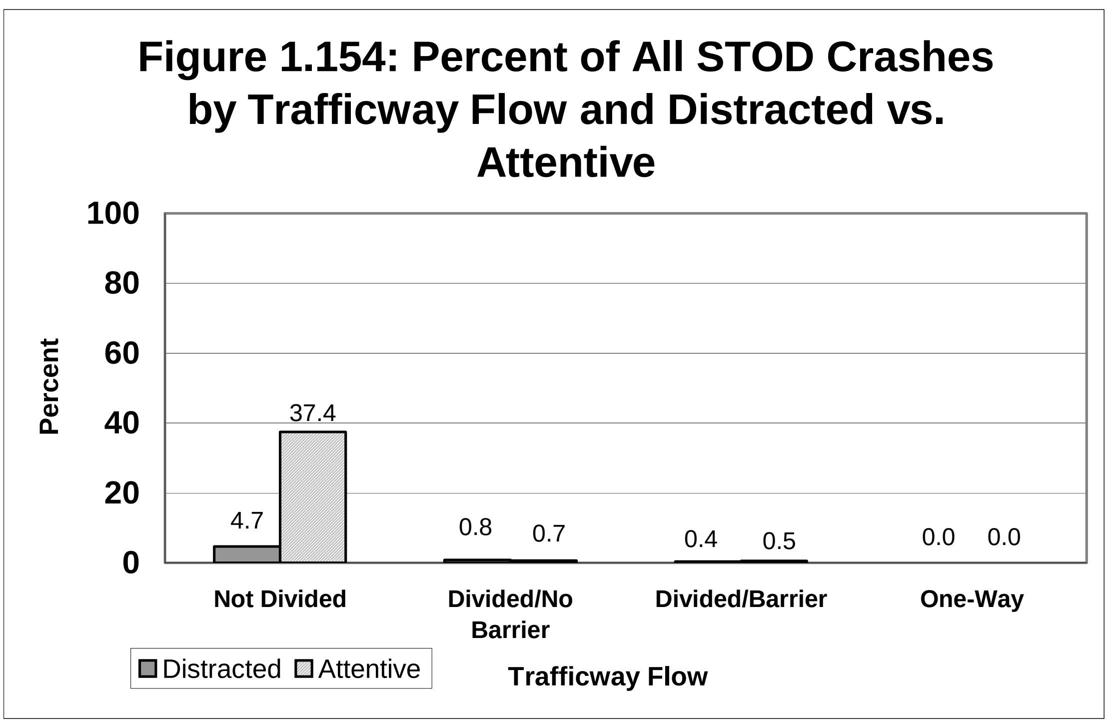


Figure 1.154: Percent of All STOD Crashes by Trafficway Flow and Distracted vs. Attentive
Percent
100
80
60
40
20
0
4.7
37.4
0.8
0.7
0.4
0.5
0.0
0.0
Not Divided
Divided/No Barrier
Divided/Barrier
One-Way
Distracted
Attentive
Trafficway Flow

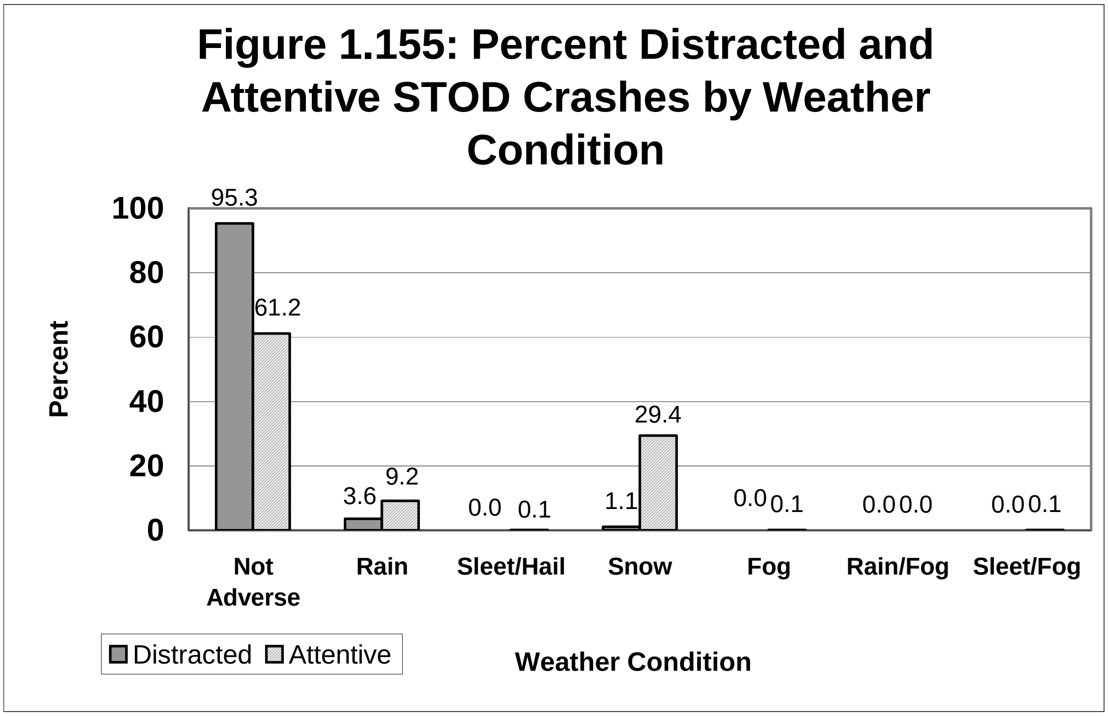


Figure 1.155: Percent Distracted and Attentive STOD Crashes by Weather Condition
Percent
100
80
60
40
20
0
95.3
61.2
3.6
9.2
0.0
0.1
1.1
29.4
0.0
0.1
0.0
0.0
0.0
0.1
Not Adverse
Rain
Sleet/Hail
Snow
Fog
Rain/Fog
Sleet/Fog
Distracted
Attentive
Weather Condition

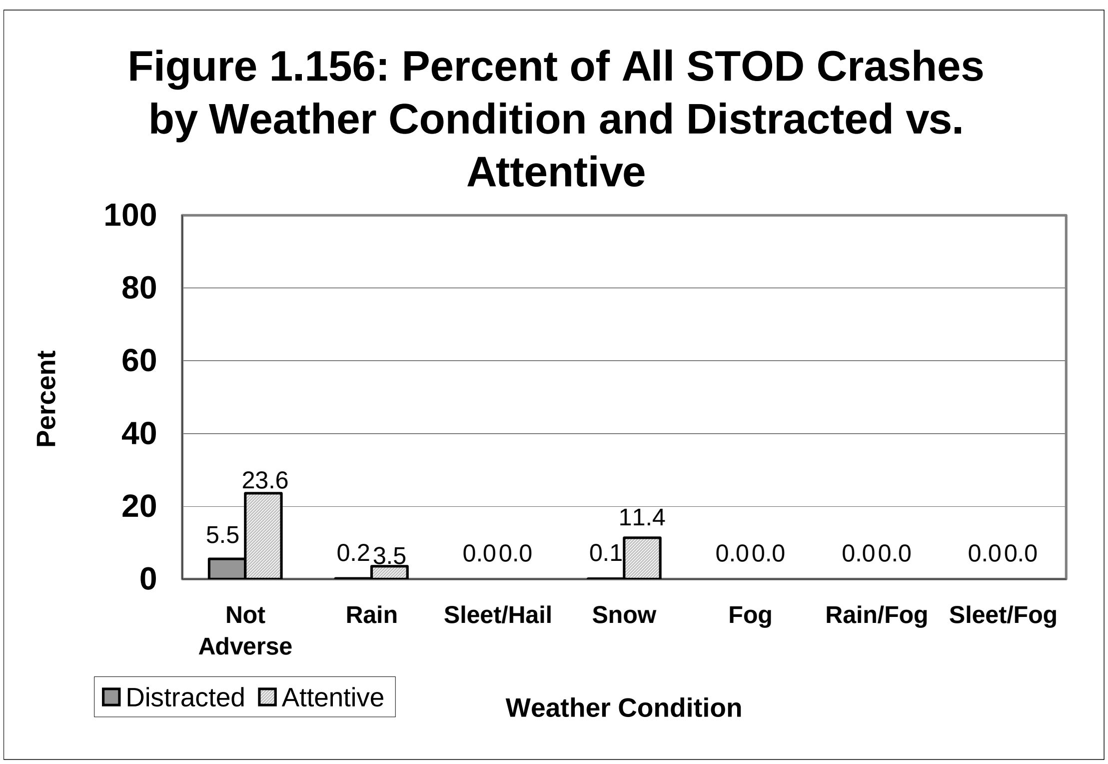


Figure 1.156: Percent of All STOD Crashes by Weather Condition and Distracted vs. Attentive
Percent
100
80
60
40
20
0
5.5
23.6
0.2
3.5
0.0
0.0
0.1
11.4
0.0
0.0
0.0
0.0
0.0
0.0
Not Adverse
Rain
Sleet/Hail
Snow
Fog
Rain/Fog
Sleet/Fog
Distracted
Attentive
Weather Condition

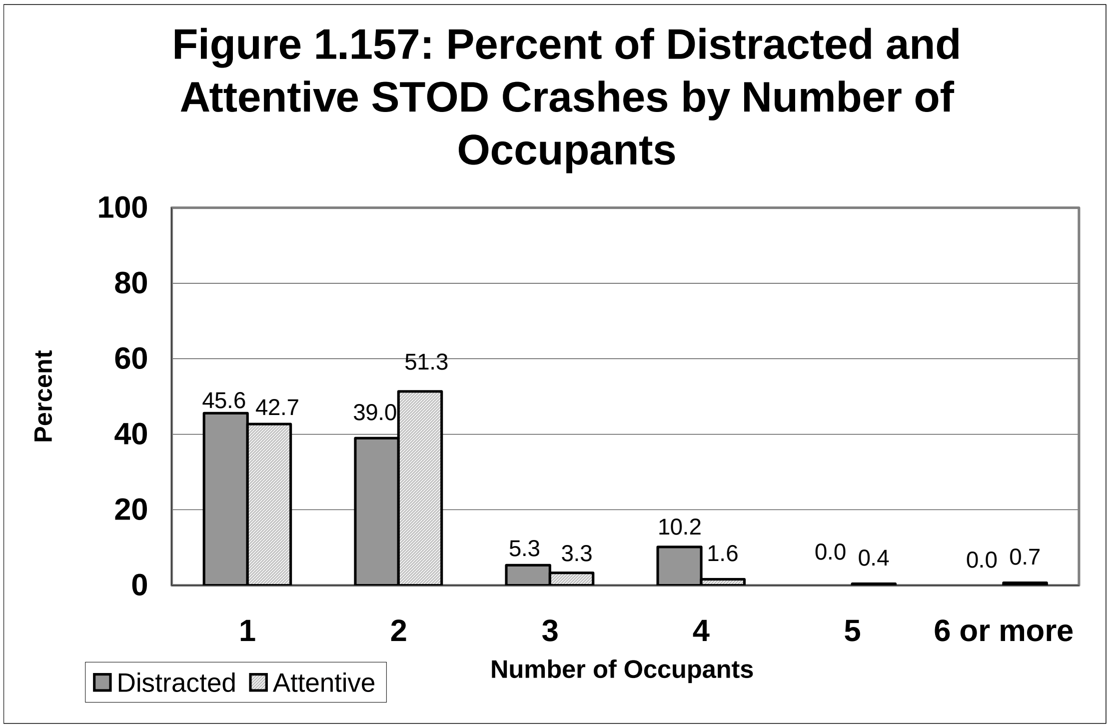


Figure 1.157: Percent of Distracted and Attentive STOD Crashes by Number of Occupants
100
80
60
40
20
0
Percent
45.6
42.7
39.0
51.3
5.3
3.3
10.2
1.6
0.0
0.4
0.0
0.7
1
2
3
4
5
6 or more
Number of Occupants
Distracted
Attentive

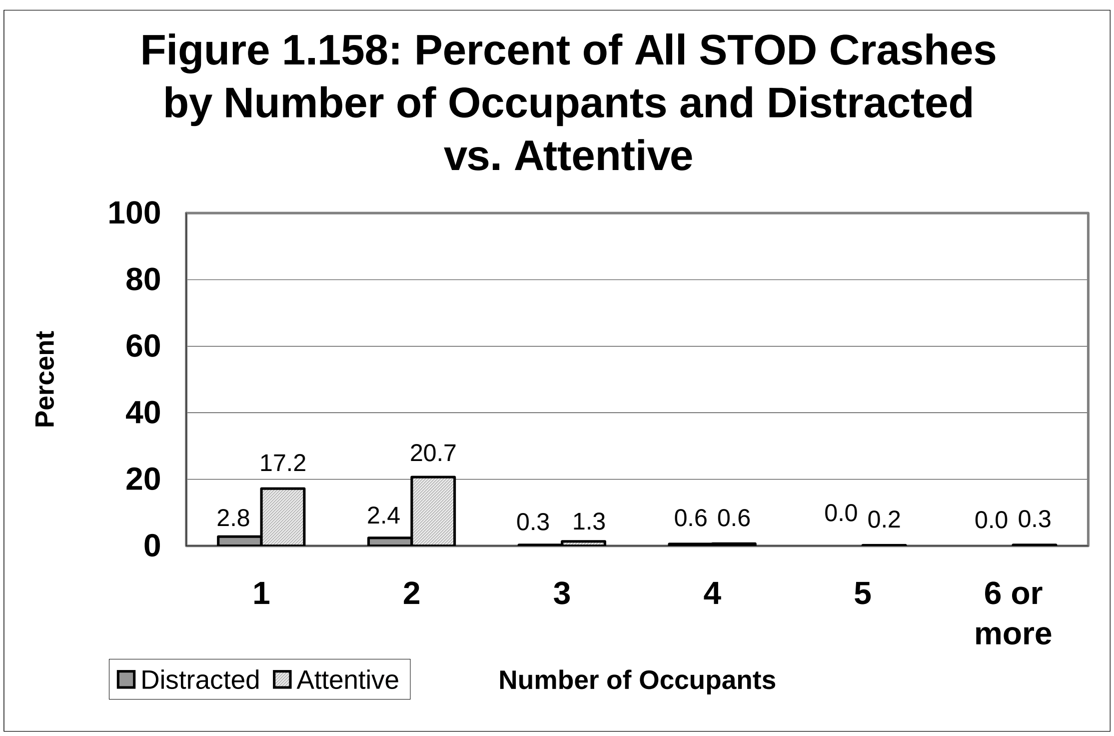


Figure 1.158: Percent of All STOD Crashes by Number of Occupants and Distracted vs. Attentive
100
80
60
40
20
0
Percent
2.8
17.2
2.4
20.7
0.3
1.3
0.6
0.6
0.0
0.2
0.0
0.3
1
2
3
4
5
6 or more
Number of Occupants
Distracted
Attentive

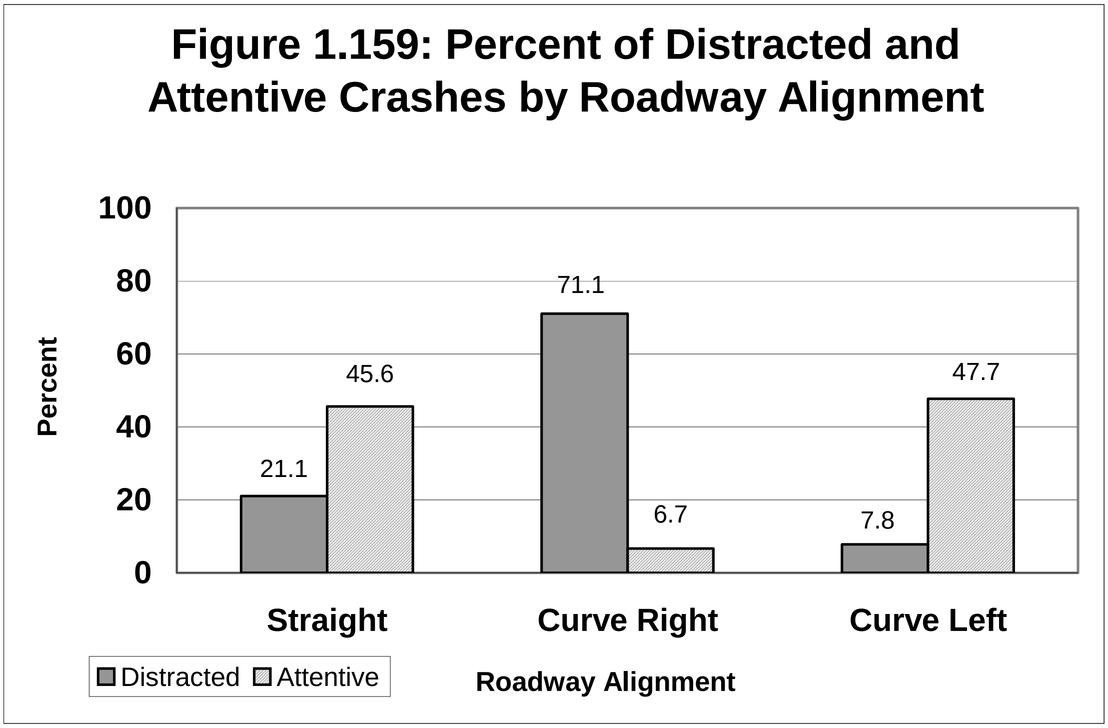


Figure 1.159: Percent of Distracted and Attentive Crashes by Roadway Alignment
100
80
60
40
20
0
Percent
71.1
45.6
47.7
21.1
6.7
7.8
Straight
Curve Right
Curve Left
Distracted
Attentive
Roadway Alignment

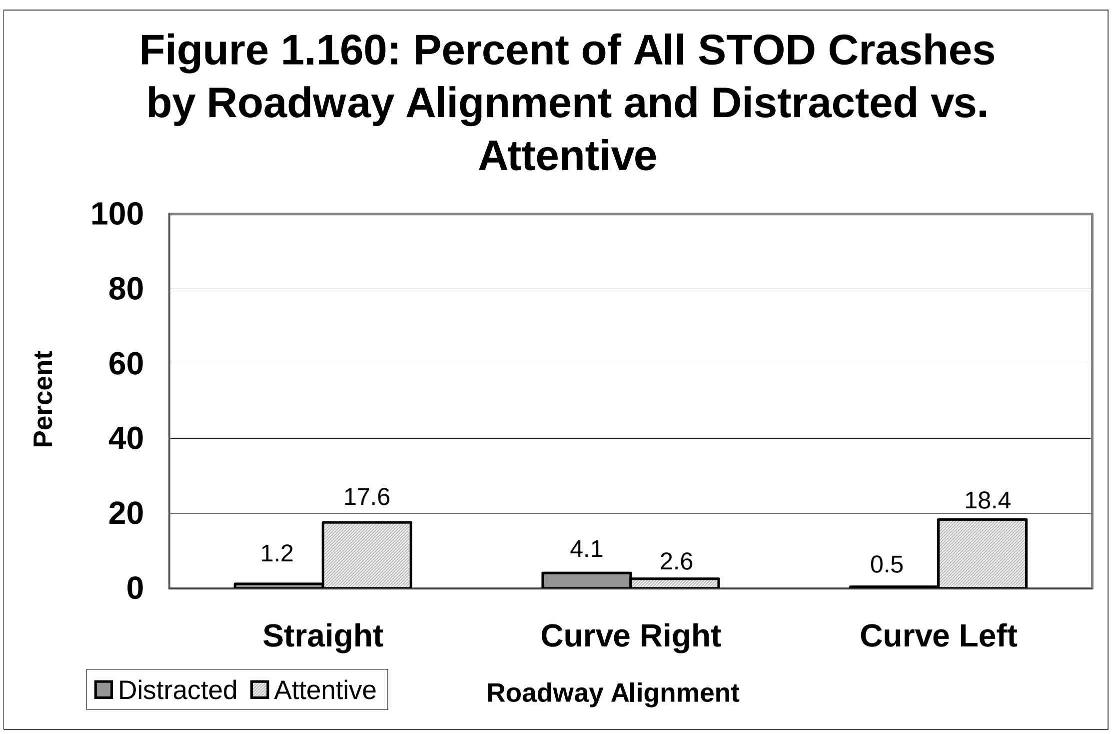
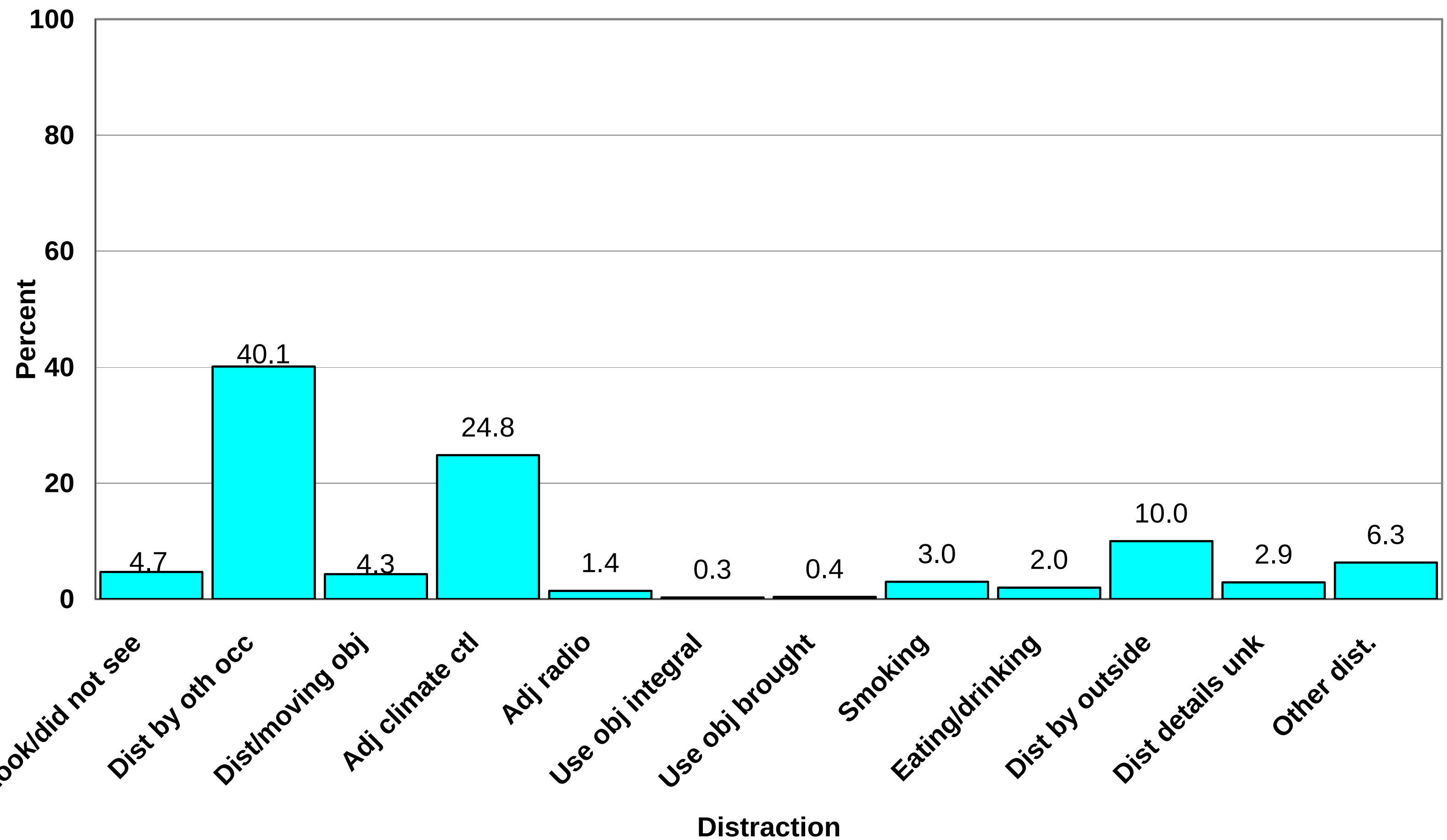


Figure 1.160: Percent of All STOD Crashes by Roadway Alignment and Distracted vs. Attentive
100
80
60
40
20
0
Percent
17.6
18.4
1.2
4.1
2.6
0.5
Straight
Curve Right
Curve Left
Distracted
Attentive
Roadway Alignment

Figure 1.161: Percent Recorded Distraction for Drivers in STOD Crashes



1.3.2 EXPERT PANEL ANALYSIS

1.3.2.1. Summary

Feedback from the panel of experts was received and synthesized. All reviewers gave thoughtful justification for their feedback and included expertise beyond the information they were sent. The verbatim feedback can be found in section 1.3.2.2.

The feedback from respondents was generally consistent: The two most important crash types to be considered by the SAVE-IT project are STSD and SD crashes. Specifically, respondents thought that rear-end crashes (part of the STSD and SD classifications) and road departure crashes (the majority of the SD classification) were the most pertinent types of crashes. In general, the reviewers placed lesser importance on IP (specifically intersection) and CTVT (specifically merge and intersection) crashes. One respondent advised against utilizing these crash scenarios in the SAVE-IT project because they are of lower frequency in the crash record and would be difficult to emulate adequately in a simulator for several reasons. Only one respondent mentioned STOD crashes as important. In this case the respondent argued that a 2-lane undivided road where the driver is adjusting climate controls is an important scenario, because it is a severe crash type and adjusting climate controls is cited in 25 percent of these crashes.

Some of the respondents did not feel that they could adequately prioritize the scenarios and provide feedback, in part because of the limitations of the database and analyses, and the inability to obtain exposure measures for the various types of distractions. One respondent provided feedback as to the types of distractors to utilize, along with the crash types, in testing the SAVE-IT system.

Respondents also gave a number of other valuable suggestions. Respondent A provided specific advice on the scenarios to be used to test the driver warning system in SAVE-IT. Respondents B and C commented that if the distraction variable “looked but did not see” were removed from the analyses as was the “drowsy driving” variable, quite different results would have been discovered. These respondents also commented on the difficulty of comparing the literature review results with the crash results because our crash categories differed from those in the literature review. Respondents C and D commented that because of the limitations of the crash databases, the selection of scenarios should be not strictly driven by crash database results. Finally, respondent D suggested that SAVE-IT should, in part, investigate driver distraction of “eating and/or drinking” because the literature suggests that this in-vehicle activity is quite frequent and would be challenging for any in-vehicle system to detect.

1.3.2.2. Verbatim Feedback from Experts

The following section provides the verbatim responses from our five experts. Only four responses are given because two of the experts provided a single joint response.

Response A:

You have requested the ten most important distracted-driving scenarios that could be mitigated by the SAVE-IT technology. I have chosen to focus on scenarios that I believe should be considered in subsequent testing of SAVE-IT with respect to crash avoidance systems (including driver warning systems). Since I am not familiar with the true technical capabilities of SAVE-IT, I will interpret "could" to mean "maybe will or maybe will not." Hopefully, the recommendations presented here will contribute to the development of a more effective system.

<u>Driving Scenarios</u>

The SAVE-IT literature review suggests that the following driving situations and hazard conditions should be examined:

- *Road departure (since it is prevalent and emphasizes lanekeeping)*
  - *Straightaway lane departure;*
  - *Curve departure, perhaps associated with excessive speed.*
- *Car following (since it is prevalent and emphasizes speed and headway maintenance)*
  - *Lead-vehicle stopped in travel lane;*
  - *Lead-vehicle decelerating with brake lights (braking);*
  - *Lead-vehicle decelerating without brake lights (coastdown, smaller deceleration than braking).*

At this time I would not attempt to examine intersection negotiation or lane change maneuvers because, as distraction-related scenarios, these are of lower frequency in the crash record. Furthermore, I believe the former will be complex to emulate adequately in a simulator due to concerns for appropriate perceptual cues and induced motion sickness. The latter is not recommended because it is extremely difficult to position the principal other vehicle (POV) into a 'blind spot' without test participant awareness.

<u>SAVE-IT Driver Warning Scenarios</u>

Consider evaluating SAVE-IT warning algorithms, displays, and other interventions in the context of the following scenarios:

- *Driver Aware (i.e., under no distraction) of Potential Hazard*
  - *True Positive (TP) Warning: This scenario would be useful to assess acceptability, i.e., is warning too early, too late, just right;*

- *False Positive (FP) Warning: This scenario, with the driver aware that nothing is wrong, will provide data on the tolerance for SAVE-IT false positive indications and interventions;*
    - *False Negative (FN) State: This scenario provides data on driver acceptance of system limitations and the effectiveness of any planned SAVE-IT status indicators on system operation.*
- *Driver Unaware (i.e., under distraction) of Potential Hazard*
    - *True Positive (TP) Warning: This scenario will provide data on the potential effectiveness of the SAVE-IT warnings or interventions;*
    - *False Positive (FP) Warning: This scenario will provide data on the potential 'startle' effects of SAVE-IT warnings presented due to false indications;*
    - *False Negative (FN) State: This scenario could provide 'baseline' data on driver response without any SAVE-IT support.*

Response B

Based on the two documents provided, the most important crash types related to distraction appear to be rear-end collisions (STSD) and road departure events (SD). The document reviewing the literature would support these two choices. Also, the document on the analysis of the CDS is supportive of these two crash types. Suggested scenarios include:

1. *Rear-end (STSD), Non-intersection, Lead vehicle decelerating, straight roadway.*
2. *Rear-end (STSD), Non-intersection, Lead vehicle stopped, straight roadway.*
3. *Road departure (SD), Non-intersection, Drive off road right, straight roadway.*
4. *Road departure (SD), Non-intersection, Drive off road left, straight roadway.*
5. *Road departure (SD), Non-intersection, Drive off road right, curved roadway.*
6. *Road departure (SD), Non-intersection, Drive off road left, curved roadway.*

These scenarios would be in daylight, dry weather, and dry surfaces.

These two crash types are suggested because they account for the highest percentage of crashes due to distraction. This was pointed out in the literature review document, and also is the case in Figure 14 of the crash analysis document, if you subtract the cases attributed to "looked but did not see". Effective technology applied to these crash types should have the best chance of achieving high safety benefits.

Other comments:

1. *It is not clear why "looked but did not see" is included in the crash analysis document. This does not appear to be an area that SAVE-IT would address.*
2. *The crash type groupings are different than those than have been commonly used within the Intelligent Vehicle Initiative (IVI) program. It might be useful to develop an equivalency table that compares the SAVE-IT categories to the IVI crash type categories.*
3. *It might be useful in the front of the crash analysis document to provide the reader with the magnitude of crashes (unweighted) that the analysis is based upon.*
4. *The literature review focused on crash databases. I would like to have seen a little*

more of the general literature reviewed on driver distraction like some of the Wierwille papers and the IVIS Demand study which provided a multi-variant approach to defining distraction and when distraction levels increased to the point where they were likely to interfere with driving.

Response C

After reading the literature review report and the draft report on crash data analysis, I recommend up to 4 crash scenarios that can be targeted (either in the Safety Warning Countermeasures or in Distraction Mitigation system). They are rank ordered from most important to least important.

1. Most important scenario: rear-end crashes
Rationale:
(1) It is one of most prevalent type of crash (nearly 25-30% of all crashes)
(2) Many rear-end crashes are attributed to distraction. The literature review report identifies between 23-37%, and the CDS data analysis (Figure 15) showed 50%, and Figure 14 showed 24% of all distract-related crashes.
(3) The type of distraction shown in Figure 74 seems to make sense (no disproportionately high % of "looked but did not see".
(4) Can piggyback with ACAS FOT study.

2. Second scenario: Single-vehicle run-off-the-road crashes
Rationale:
(1) Common crash type
(2) Some studies indicated that distraction contributed a great deal to this type of crash, although some other studies (inc. the present data analysis) showed moderate contribution.
(3) No "looked but did not see" problem.
(4) could be addressed in the Safety Warning Countermeasures if sensors (lane trackers) are available, and if not, could be addressed in the Distraction Mitigation.

3. Tied third place: Intersection crashes and lane change/merge
Rationale:
(1) common crash type
(2) results are mixed regarding the contribution of distraction.
(3) "looked but did not see" is the largest type of distraction in the current CDS data analysis, and it may be also true in the previous analyses (reviewed in the literature review report). Excluding this category may lead to much lower distraction effect. "looked but did not see" is especially problematic because it is hard to tell what it means and whether drivers lied.
(4) it is more difficult to deal with these types of crashes with vehicle-based sensors. Perhaps these can be dealt with the Distraction Mitigation system rather than the Safety Warning Countermeasures.

As you stated, determination of distraction impact on crash is very difficult. The policy reports may not be accurate. The drivers involved in crashes may be motivated to hide the real cause of crashes. The drivers and eyewitnesses may not remember the events by the *time they were interviewed. There is a large number of missing values. Crashes are by nature caused by multiple factors and therefore identification of single factors is never satisfactory. The real life (crash) is confounded and it is difficult to tease apart the different factors. The crash data is not collected using the most scientifically sound method typically employed in good science like in physics and experimental psychology. The classification of crash scenarios is not clear-cut. For example, the category names are somewhat different in the literature review report and the draft report on the crash data analysis (e.g., rear-end crash vs. STSD). Especially problematic is a category called "looked but did not see". In addition, the frequency of exposure is not known.*

Perhaps because of these reasons, and the use of different methods, different reports have produced different results (as reviewed in the literature review report). Because of the differences, it is often difficult to reach a definitive conclusion.

You asked us to identify 10 scenarios. I found that difficult to do because the literature review report described 5 scenarios and the draft report on data analysis also described 5 scenarios. These scenarios obviously overlap, but it is not very clear to me about the mapping/overlap. It would be nice to identify the mapping/overlap. Your draft report defined the detailed scenarios (the method section), but the analysis for second-level scenarios is not done or reported. Anyway, I believe 4 or 5 specific scenarios should be sufficient.

Response D

Per your request, I am enclosing my suggestions for SAVE-IT scenarios. I found the materials you sent interesting. Some of the findings looked surprising, but require some skepticism; for example there were some interesting age effects within crash types, but age distributions looked so different for males and females you have to wonder how real it is. Also, of course, there are the other limitations you cited in your reports, including the absence of exposure data. So my feeling was that we shouldn't be slavishly driven by the crash data alone in selecting scenarios.

My ten suggestions are in the attached table. I did not attempt to prioritize them. One reason was that I didn't really feel I could prioritize them very well. But the other reason is that I presume one thing you want in the work is a range of situations and distractors to look at, so that characteristics of the set are as important as the choice of any particular scenario. The set of suggestions in the table includes all five crash types from your report, of which three manipulate a single-vehicle scenario, and six involve multi-vehicle crash types. That adds up to nine. The tenth didn't specify the crash type because I thought you could use any of them.

I hope what I have provided is consistent with what you were looking for. Good luck with the research effort.

Crash Type	***Driving Scenario***	***Distractor***	***Rationale***
SD	*Isolated left curve on two-lane road*	*Occupant distraction*	*Left curve over-represented; Most frequently cited distractor for crash type*
SD	*Isolated left curve on two-lane road*	*External distraction*	*Second most commonly cited distractor for crash type*
SD	*Isolated left curve on two-lane road*	*Cell phone dialing or nav system input*	*Prototypical distracting technology*
STOD	*Two-lane undivided*	*Adjust climate control*	*Severe crash type, adjusting climate control cited 25%*
IP	*Failure-to-yield at signal in complex urban setting*	*Cell phone dialing or nav system input*	*Looked-but frequently cited; Prototypical distracting technology*
IP	*Minor intersection on a downgrade, right curve, entering vehicle*	*Cell phone dialing or nav system input or climate control*	*Right curves, downgrades appear over-represented*
CTVT	*Unprotected left turn at multilane signalized intersection*	*Cell phone dialing or nav system input*	*Looked-but frequently cited; Prototypical distracting technology*
STSD	*Urban commercial roadway, driveways, peds, animated commercial signing*	*External distraction*	*Visually and operationally complex setting with external distractions (commonly cited)*
Any	*any of the other scenarios*	*Eating something messy or drinking something hot*	*Commonly cited comparison distractor in literature, apparently engaged in more frequently, challenge for system to recognize*

1.4. DISCUSSION

As described earlier, in order to determine the potential benefits of systems such as SAVE-IT, it is necessary to understand the crash scenarios in which driver distraction is a likely contributor. The purpose of this report was to present the results of detailed analyses of distraction-related crashes and expert opinion of the crash and literature review results to help guide the SAVE-IT team in developing algorithms and technology best suited for the types of crashes and situations that the SAVE-IT system is most likely to be able to prevent. In our approach to the analysis of distraction-related crashes, we endeavored to consider these data in a way that was different from previous work so that new information on distraction-related crashes could be obtained. Toward this end, we defined crash types based upon the NASS definitions and compared the proportions of distraction-related to attentive crashes on the same variables. When combined with the findings from the literature review, this approach gave us a wide variety of ways in which to evaluate distraction-related crash scenarios.

Also as we discussed earlier, determining the effect of distraction on crash risk is challenging for several reasons. Crash reports, from which detailed crash databases are derived, often lack good information about distraction-related events leading up to the crash. The distraction information in crash reports is frequently self-reported or based upon best judgment and is, therefore, subject to inaccuracies. There can be more than one contributing factor to crashes such as speeding and distraction. Finally, even when crash data contain accurate distraction-related information, interpretation of these data is difficult because information about the frequency of exposure to the distraction scenario is not available. While Bayesian analyses could be conducted to determine the relative contribution of various distraction-related crashes to each other (analyses that we did not have resources to conduct in this task), the issue of exposure to various distraction-related events is still relevant. Thus, there are still significant gaps in our knowledge about the importance of various distraction-related crash scenarios. With these limitations in mind, however, we provide here conclusions that are based on what is known, what can be deduced, and expert opinion.

1.4.1. CRASH TYPES

Based upon the literature review, the present crash analyses, and the expert opinions, it is clear that the head-on crash (found in the STOD classification) is the least important distraction-related crash type. It is an infrequent type of crash, occurs in about the same proportion between distracted and attentive crashes, and accounts for the smallest proportion of distraction-related crashes.

The literature review and experts agreed that two of the most important distraction-related crash scenarios were single vehicle run-off-the-road and rear-end crashes. Interestingly, these two crash types, which are part of the SD and STSD crash classifications we used, were found to be two of the least important crash types in our comparison of distracted and attentive crashes. Instead we found that the two distracted crash types that showed the greatest positive difference from the attentive crashes were IP and CTVT crashes, which involve intersections and vehicles crossing paths. This difference in findings occurred primarily because of our inclusion of the “looked, but did not see” variable in the distracted crash category. Examination of Figures 1.103 and 1.132 show that the “looked, but did not see” variable accounts for 60 percent IP and 87 percent of CTVT distraction-related crashes respectively. If this variable were excluded from the analyses, as it often is, the proportions of these distraction-related crashes would decrease dramatically, while the proportions for the other crash types would increase. As discussed in the introduction, the usefulness of the distraction/inattention code, “looked, but did not see” is questionable. To the extent that actual distraction-related crashes are coded as “looked but did not see” the present analyses are accurate. While we estimate that at least the majority of these crashes are, in fact, distraction-related, we may be in error. With these limitations in mind, we conclude that both CTVT and IP crashes should also be considered important distraction-related crash types.

1.4.2. DRIVING SCENARIOS

The information from the literature review, crash analyses, and experts contains vast details for the specific driving scenarios associated with of these crash types that seem particularly relevant for distracted crashes.

1.4.2.1. SD (Single Vehicle Run Off the Road) Crashes

When compared to attentive SD crashes, distracted SD crashes were relatively more common for: women, particularly young women (18-34) and women over age 64; men over 55 years of age; during dark and dark/lighted conditions; during dusk; on dry roads; on non-divided and divided roads with no barrier; during both good weather and foggy conditions; when there were either two or four occupants in the vehicle; and on curves to the left. All of these findings suggest subject demographics and driving condition under which to study distracted SD crashes. The literature review and experts and suggested several other important SD driving scenarios. These included: straight lane departure; curve departure with excessive speed; and curve departure for both right and left curves.

1.4.2.2. STSD (Rear End) Crashes

When compared to attentive STSD crashes, distracted STSD crashes were slightly more common for: women, particularly women under 26 years of age; men 26-34 and 65-75 years of age; four lane roads; on grades (both uphill and downhill); during daylight conditions; on dry roads; on non-divided and divided-with-a-barrier roadways; during both good weather and sleet/fog conditions; when there is a single occupant in the vehicle; and on curves to the right. Again of these findings suggest subject demographics and driving condition under which to study distracted STSD crashes. The literature review and experts suggested several other important STSD driving scenarios. These included: lead-vehicle stopped in travel lane; lead-vehicle decelerating with brake lights on (braking); lead-vehicle decelerating without brake lights (coastdown, smaller deceleration than braking); straight roadways without an intersection; and urban commercial roadways, with driveways, pedestrians, and animated commercial signing.

1.4.2.2. IP (Intersection/Crossing Path) Crashes

When compared to attentive IP crashes, distracted IP crashes were relatively more common for: women, particularly women over age 55; men under age 18 and aged 35-55; on two- five-, and six-lane roads; on downhill grades; at interchanges; during daylight and dark conditions; on dry roads; on dirt roads; on divided roads with a barrier and one-way roads; during rainy weather conditions; when there are two occupants in the vehicle; and on curves to the left. The literature review and experts suggested only a few other IP driving scenarios. These were: Failure-to-yield at signal in complex urban setting; and minor intersection on a downgrade, with a left curve and an entering vehicle.

1.4.2.3. CTVT (Intersection/Crossing Path/Merge) Crashes

When compared to attentive CTVT crashes, distracted CTVT crashes were relatively more common for: drivers age 18-25 and driver over age 64 for both men and women; five lane roads; on level roads; at driveways and interchanges; during dark/lighted conditions; on dry roads; on non-divided and divided/barrier roads; during good weather conditions; and on curves to the right. The experts suggested only one other CTVT driving scenario: an unprotected left turn at a multilane, signalized intersection.

1.4.3. DRIVING DISTRACTORS

As discussed in a recent literature review (Eby & Kostyniuk, 2003), distracted driving is one form of inattention and is distinguished from inattention by a triggering event (a distractor) that can occur either outside or inside of the vehicle. Determining the effect of various distractors on driving performance and crash risk is proceeding slowly. It is important, however, to consider the various distractors when developing systems like SAVE-IT so that effective mitigation strategies can be developed and that appropriate sensing strategies can be developed that will detect those distractors that are most likely to lead to crashes.

1.4.3.1. Exterior Distractors (rubbernecking)

It is clear that events outside the vehicle have a high likelihood of diverting a driver’s attention from the task of driving. Several studies have found that exterior incidents are the most frequent contributor to distraction-related crashes (General Assembly of the Commonwealth of Pennsylvania, 2001; Glaze & Ellis, 2003; Stutts, Reinfurt, & Rodgman, 2001; Wang, Knipling, & Goodman, 1996). In addition, our analyses showed that 21 percent of distraction-related SD crashes, 21 percent of distraction-related STSD crashes, and 10 percent of distraction-related STOD crashes were coded with “outside event” as the distractor. Thus, there is good evidence that exterior incidents are common, may be of long duration, and frequently lead to distraction-related crashes. Sensing such incidents, however, may be difficult for a system like SAVE-IT.

1.4.3.2. Passengers

Travel with passengers occurs in about one-third of automobile trips. There is, therefore, potential frequent exposure to the distracting effects of passenger. Analyses of distraction-related crash data files have found passenger-related distractions to be a relatively common triggering event for the crash (General Assembly of the Commonwealth of Pennsylvania, 2001; Glaze & Ellis, 2003; Royal, 2003; Stevens & Minton, 2001; Stutts, Reinfurt, & Rodgman, 2001). The present crash analyses found that passenger distraction was the most common distractor in distraction-related SD crashes (26%) and STOD crashes (40%). Passenger distraction was also frequent in the other distraction-related crash types (STSD-8%; IP-21%; CTVT-5%). Given the frequency of exposure to this distractor, its potentially long duration, and its frequently reported contribution in distraction-related crashes, the presence of passengers should be an important input into the SAVE-IT system.

1.4.3.3. Eating/Drinking

The personal experiences of many of us would suggest that eating and/or drinking in the vehicle is a common activity. In fact, recent work by Stutts et al. (2003) has found that more than 70 percent of drivers in their study engaged in eating or drinking while their vehicle was moving. Eating and drinking in the vehicle has also been found to be a contributing factor in up to 5 percent of distraction-related crashes (General Assembly of the Commonwealth of Pennsylvania, 2001; Stevens & Minton, 2001; Stutts, Reinfurt, and Rodgman, 2001). Our crash analyses found that eating/drinking was the listed distractor in about 8 percent of distraction-related SD crashes, 2 percent of distraction related STOD crashes; 2 percent of distraction-related STOD crashes; and about 1 percent of distraction-related STSD and IP crashes. This distractor was singled out as important by one of the experts, who also pointed out that eating and/or drinking would be difficult for SAVE-IT to detect.

1.4.3.4. Using an Object Brought Into the Vehicle

According to NASS (2001) coding manual, objects brought into the vehicle include CB radios, razors, and portable CD players, but not cellular phones or cigarettes which are coded independently. Thus, many driver activities are subsumed in this category, including personal grooming. Recent studies have found that personal grooming is present in 45 to 60 percent of drivers (Royal, 2003; Stutts, et al., 2003). Reading or writing was present in about 40 percent of trips (Stutts, et al., 2003). The frequency of use for wireless technology and portable music devices is unknown. Collectively, these results show that the potentially distracting use of objects brought into the vehicle must be a common occurrence. Our analyses found that the use of objects brought into the vehicle was listed as the distractor in 9 percent of distraction-related SD crashes and 8 percent of distraction-related STSD crashes. Thus, this distractor is fairly important for the two most important crash types identified in this study. Objects brought into the vehicle will be difficult for the SAVE-IT system to detect.

1.4.3.5. Adjusting Vehicle Controls

The two main systems that drivers adjust in a vehicle are the climate control and the radio/entertainment control. Stutts et al. (2003) found that an astounding 100 percent of drivers in their study adjusted vehicle controls at some point when the vehicle was moving. The sheer frequency with which this potential distractor occurs, suggests that it is an important driver activity for the SAVE-IT system to sense. This activity also seems to be related to a relatively high frequency of distraction-related crashes. Our analyses found that adjusting vehicle controls was cited in 26 percent of distraction-related STOD crashes; 5 percent of distraction-related SD crashes; 4 percent of distraction-related STSD crashes; and 1 percent of distraction-related CTVT crashes.

1.4.3.6. Cellular Phones

Direct observation studies of cellular phone use have found that about 3-5 percent of the driving population are conversing on a hand-held cellular phone at any given moment during daylight hours (Eby, Kostyniuk, & Vivoda, 2003; Eby & Vivoda, 2003; NHTSA, 2001; Reinfurt, Huang, Feaganes, & Hunter, 2001). While this use rate is small, cellular phone ownership is increasing and use of these phones while driving is also expected to increase. In addition, cellular phone conversations can be long in duration, increasing the exposure to this distractor. This traffic-safety implications of this driver activity has received much attention in recent years (see Eby & Kostyniuk, 2003), however, phone use is not a frequently cited distractor in previous (Stutts, Reinfurt, & Rodgman, 2001) or current crash data analyses. Our results showed that cellular phone use was cited as the distractor in 4 percent of distraction-related SD crashes; 1.4 percent of distraction-related STSD crashes; and well less than 1 percent in the other crash types. When these low percentages are considered alongside the fact that use of cellular phones while driving is relatively infrequent (low exposure), we conclude that this distractor is important for the SAVE-IT system to consider.

1.4.3.7. Smoking

As discussed in a recent literature review (Eby & Kostyniuk, 2003), there is no information on the frequency with which drivers smoke while driving. However, we concluded that the activity is infrequent but may be increasing, since the vehicle is one of the few places left where a person can smoke besides their own home. Stutts et al. (2003) found that about 7 percent of drivers in their study smoked while the vehicle was in motion. Past work shows that smoking is a contributor in up to 5 percent of distraction-related crashes (General Assembly of the Commonwealth of Pennsylvania, 2001; Stevens & Minton, 2001; Stutts, Reinfurt, and Rodgman, 2001). The current analyses found that smoking was cited in about 2 percent of distraction-related STOD and IP crashes; about 1 percent of distraction-related SD and STSD crashes; and less than 1 percent in the other crashes types. Thus, as with cellular phone, the low exposure to this distractor combined with the frequency with

with smoking is listed as a contributing factor in distraction-related crashes, we conclude that this distractor should be considered by the SAVE-IT system.

1.4.3.8. Navigation Systems/Telematics

Few vehicles currently have navigation systems and other telematic devices installed, primarily because many of these systems are recent or are still under development. Depending on how these devices are designed, and if they are used jointly, they could have great potential to distract the driver from the task of driving. Even though use of these devices has not shown up in crash database analyses, including the current analyses, we include this distractor in our list of important distractors for the SAVE-IT system to consider for two reasons: (1) The distraction potential of current or future devices is unknown, especially when devices are used in combination; and (2) use of these devices should be easy to detect and mitigate.

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