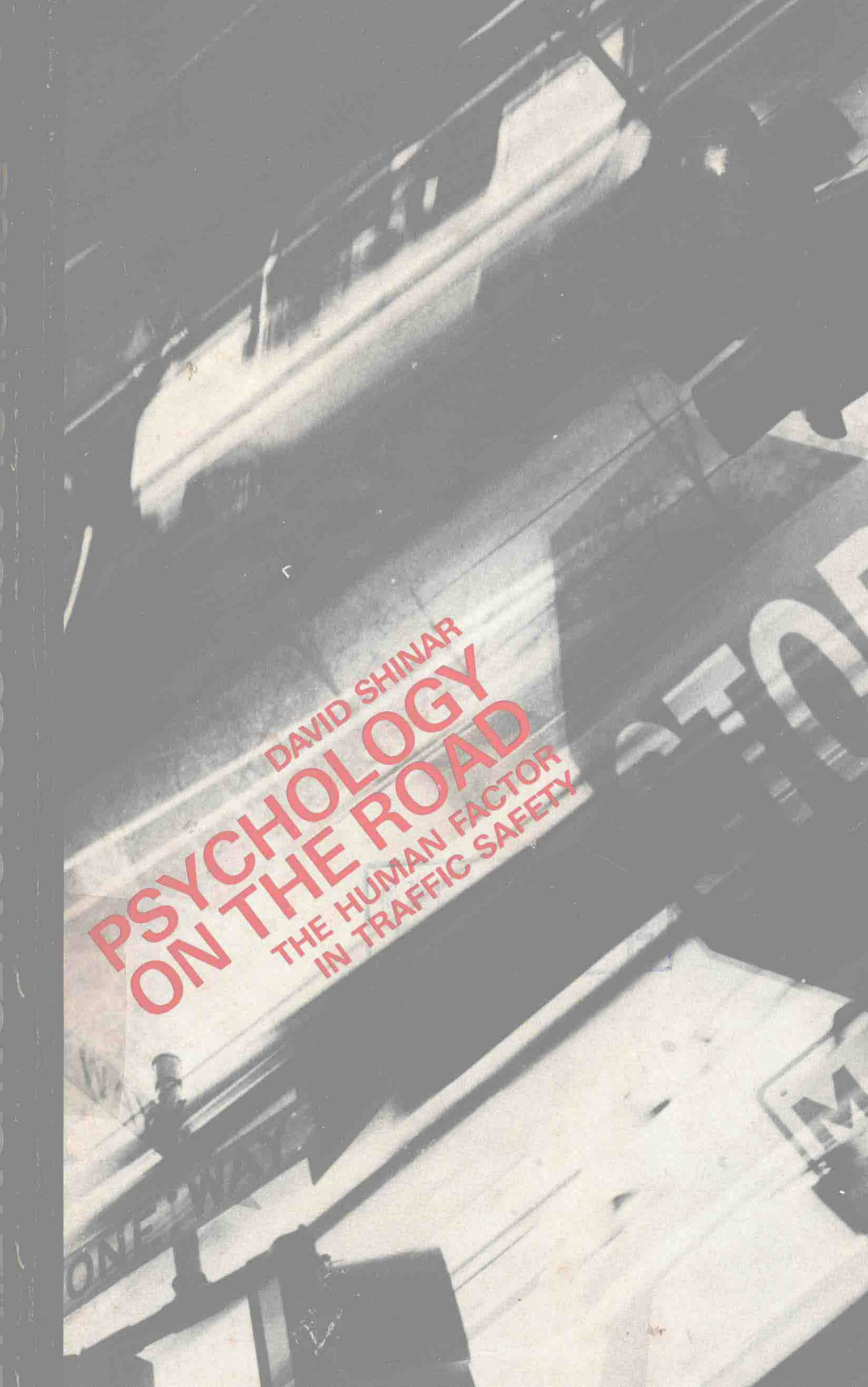
DAVID SHINAR
PSYCHOLOGY ON THE ROAD
THE HUMAN FACTOR IN TRAFFIC SAFETY
ONE WAY

PSYCHOLOGY ON THE ROAD

THE HUMAN FACTOR IN TRAFFIC SAFETY

DAVID SHINAR
Institute for Research in Public Safety
School of Public and Environmental Affairs
Indiana University

Department of Industrial Engineering and Management
Faculty of Engineering Sciences
Ben Gurion University of the Negev

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To
Eva, Busia, and Pessah

FOREWORD

This book symbolizes the growing interaction of psychologists and engineers. While many scholars attempt to bridge the two professions, few have the advantage of David Shinar who, by nature of his training and research in both psychology and engineering, has been able to utilize the role of both disciplines in highway safety.

This text is one I would have liked to develop for my engineering students with an interest in human factors engineering. It should also be read by traffic safety and driver education students, as well as psychology students with an applied interest and hopefully attract more people to do research in this important area.

Were any scientist to be presented with several million observations he or she would doubtless claim to have little trouble in descriptive and predictive modeling of the process. Why in the case of highway safety do we experience so much casualty data each year and still make so little progress toward problem resolution? The answer is not a simple one as this text demonstrates. I contend that one explanation is the oversimplistic view of driver behavior by safety experts, government decision makers, and automobile and highway designers. Consequently, we are periodically whipsawed by simple solutions such as massive police enforcement, tough-fisted courts, enlightened driver education curricula, or alcohol safety action programs. At the other extreme is the frustration reaction that concedes that changing driver behavior is impossible. This leads to overemphasis on crash injury reduction (e.g., vehicle cockpit design and air bags), which assumes we can protect the driver against any and all erratic performance and subsequent accidents.

Dr. Shinar's view is a balanced one that avoids the above-mentioned extremes. With documentation from recent research, he fully impresses upon the reader the complexities of driver behavior and, at the same time, points out applications of basic human factors engineering principles. Designing the system around the capabilities and limitations of the driver will lead surely and inexorably to imporved highway safety.

This text provides an opportunity for traffic engineers to appreciate better the role of driver behavior in their design, and traffic safety experts to understand the effects of human behavior on the road. The text has the added benefit of Dr. Shinar's experience at

Indiana University in accident reconstruction and analysis. He links behavioral research to the causes of traffic accidents through a systematic analysis of recent accidents.

I have one final observation and a hope for the future of driver behavior research. As an important and well-documented collage of research findings in driver behavior, this text is presented not as a final answer but as a stimulus to continue to study the driver despite and because of his or her complexities and inconsistencies. We must recognize that basic research on the driving process is sorely needed now if applied research is to answer future problems. We must see the potential role of electronic technology to aid the driver in his or her information-seeking decision making and response behavior. In effect, we must design vehicular and highway systems based on the driver.

THOMAS H. ROCKWELL
Professor Ohio State University
Department of Industrial Engineering

PREFACE

While vehicle performance capabilities have been constantly improving over the past several decades, the capabilities of the human controller have remained fairly constant. Consequently, the interaction between the road user (drivers and pedestrians) and the vehicle has been receiving more and more attention from people concerned with highway traffic safety. While the increased awareness of the importance of human factors in highway safety has been reflected in an ever-growing volume of research, no attempt has been made in the recent past to integrate the material in a systematic manner around the human element in the vehicle-highway-road user system. This book hopefully fills this void. To reflect the increased interest and research in this area, I have tried to give this book a state-of-the-art flavor by biasing my selection of references toward more recent ones. Hence, approximately 70 percent of the research cited is from the last decade.

This book introduces the role of psychology in highway safety. It can be used as a textbook in courses on: traffic safety, driver education, and civil and industrial engineering. Parts of this book relate to all of the curricula represented by the experts working in these areas — physicians, industrial and systems engineers, civil engineers, optometrists, educators, and psychologists of various orientations.

I view the road user as a limited-capacity information processor whose efficiency (and safety) is enhanced or degraded by the highway and vehicle design features, as well as by his or her personality, skills, and impairments. This view reflects the influence of my former teacher and co-worker, Thomas H. Rockwell, who introduced me to, and in many ways shaped my thinking in, this area. The discussion of human factors in accident causation (Chapter Five) contains many concepts that I have developed as a result of a fruitful and very pleasant association with John R. Treat, working together on highway traffic accidents research.

The initial stimulus to writing this book came from my friend Peter Kincaid who originally asked me to contribute a chapter to an applied psychology book. That chapter was never written but instead was revised into what became this book. In the process, I was helped by my colleagues, Phil Cornwell, Allen Katz, John Treat, and Nick Tumbas who read, commented on, and — most instructive

for me — raised probing questions in various sections of the text. I also received valuable suggestions for improvement from James Noto (San Diego State University) and Eric Van Fleet (Western Illinois University). Most of all, I was helped by my wife, Eva, who critically read all of the drafts and served as a supporting consultant on all of the revisions of this manuscript.

I began this text while working at the Institute for Research in Public Safety, School of Public and Environmental Affairs, Indiana University, and finished it in the Department of Industrial Engineering and Management of Ben Gurion University of the Negev, Israel. It is a pleasure to acknowledge the formal support that both institutions provided me, and, in particular, I thank Rita Fortner, Lili Lang, Claire Penso, and Jody Vaught for readily responding to all my secretarial needs.

Finally, I would like to thank Wiley editors Wayne Anderson and Susan Giniger, and production supervisor Joe Cannizzaro, for bringing this work to its present form.

DAVID SHINAR

CONTENTS

ONE
INTRODUCTION

Consider an alien hovering over some great urban center in the United States and watching with curiosity what is happening below. What does he (she, it) see? Well, aside from the smoke rising out from the numerous chimneys, most of the movement appears to be limited to rectangular objects (vehicles) moving in an orderly manner along dark stripes (roads), which are intermittently crossed by bipods (pedestrians). Unknown to our

alien, what he is observing is an operations system transporting (mostly unseen) people and goods. This system consists of three elements: the environment (road and signals), vehicles, and people (drivers and pedestrians). In our road-car-driver-pedestrian system the driver/pedestrian is the only decision-making component and therefore it is his or her actions or inactions that make this system go. Thus, our alien, assuming that he has visual capabilities similar to ours, must wonder what makes this system work. What capabilities are required to control the relatively harmonious car movements? How is the movement of vehicles and pedestrians coordinated? And — whenever an accident does occur — what are the causes of the breakdown in that system? These questions concern behavioral scientists engaged in improving our transportation system. Note that the human factors in transportation are not limited to the study of car drivers and pedestrians. It includes pilots, boat captains, train engineers, and the like. However, since the predominant mode in which most of us interact with the various transportation systems, in an active (rather than in a passenger-passive) manner, is in the capacity of drivers and pedestrians, this book deals with these two only.

For initial simplification, we can limit our discussion to the road-car-driver system, that is, assume that there are no pedestrians. As behavioral scientists we have a definite advantage over our observant alien: we know much more about the controlling element — the driver — and about the requirements placed on the driver by the road, traffic, and his or her own car. As the information processor in the system, the driver's role is to process mostly visual inputs from the road, traffic, and his or her own car's behavior, make decisions about appropriate control actions, execute these actions, and observe and respond to the new situation that results. A block diagram of these functions along with some others that will be discussed later is presented in Figure 1.1. While the mere description of these functions seems long and laborious, note that for the most part, as drivers, we are totally unaware of all such internal activities. This is demonstrated by the often-encountered phenomenon, when, after driving uneventfully for some time, we realize that we have no recall at all of the past events and scenery — even though the relevant time period may have been filled with various actions — involving complex decisions — such as passing, stopping, and turning.

The process depicted in Figure 1.1 can best be illustrated with an example. Let us assume that you, as a driver, are following another car and are in the process of deciding whether to pass it or not. To simplify the situation, let us further assume that there is no oncoming traffic and that the field of view is clear. The information you then need concerns the speed of the car ahead, your own speed, and

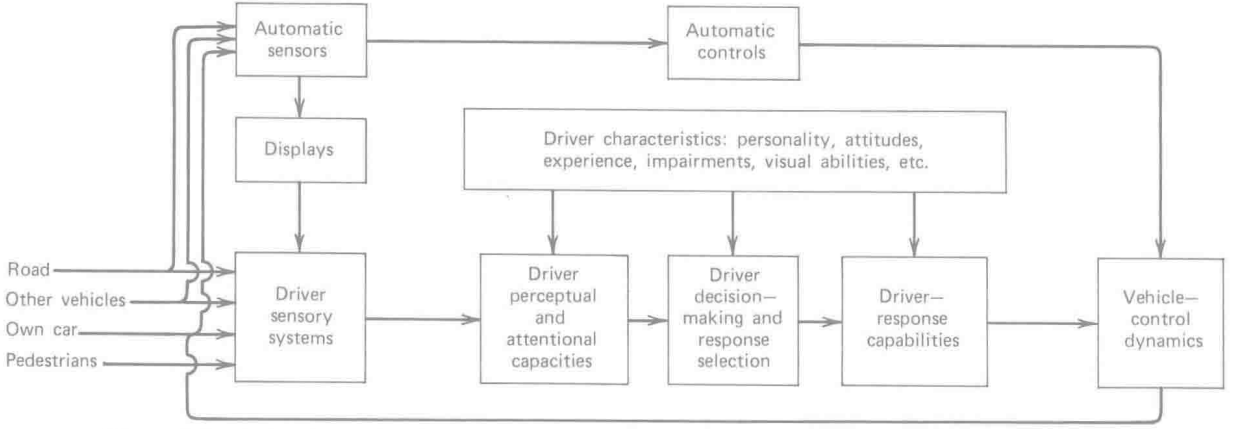

Figure 1.1. A simplified block diagram of the driver functions in the driver-vehicle-road system.

knowledge about your car's performance capabilities: Does it have enough power to pass the other car in a sufficient amount of time? Looking first at the bottom row of boxes, note that you receive sensory information from the road in the form of roadside markers "going" by you, from the vehicle ahead in the form of its relative size, giving an indication of its distance, and from your own car concerning your own speed. This information, however, is useless until it is interpreted by the brain and results in meaningful perceptions of the relative speed of the two vehicles. Once this information is available to you, you make a decision concerning the appropriate responses necessary to perform the maneuver, if you have decided that the maneuver is appropriate. Next, you have to exercise your decision and actually perform the maneuver that you have decided on. Following this process, you finally perform an action that actually affects your car's behavior. Let us say that your decision was to start closing the gap between you and the car ahead. You then accelerate your car. The car, which has its own control dynamics, responds to your action, and you are now faced with a new situation of a new distance and relative speed between you and the car; and again, you go through the same process. This process will go on repeatedly until you have finished your maneuver.

Now let us look at the top part of this figure. To begin, much of the information that you receive is not provided to you directly from the environment, but is already interpreted for you through electronic systems. These are the automatic sensors in the car, such as your speedometer. The speedometer would be useless unless it had a meaningful display, which fortunately it does. This display, then, provides you with quantitative information concerning your speed. The speedometer and other automatic sensors are aids to the driver just as much as (moving further to the right) the automatic controls are. Automatic controls can be as common as automatic gears or as extravagant as "cruise-o-matic" systems, which are velocity regulator systems within the car. The automatic sensors and the automatic controls alleviate some of the load that is imposed on the driver, and provide him or her with more time to attend to other tasks that may be more important or more pleasurable.

Finally, inside the center of the diagram, notice that driver skills, level of arousal, experience, motivation, attitudes, and personality all influence the way we drive. Some of these are relatively stable for a given person, but differ widely among persons, such as driver skills, experience, and personality. Others, such as arousal, motivation, or attitudes, vary both among drivers and within drivers at different times and under different circumstances. All of these affect the way

we perceive the information, our decisions at every minute, and our ability to control the car.

This simplified conceptualization of the driver-vehicle-roadway system, is also useful to illustrate how a failure in any of its components can result in a system failure — easily recognized as an accident. The initial event, action, or situation that instigates the accident or makes it imminent may be a human, vehicular, or environmental deficiency — or a mismatch between any two or all three components. Thus, the danger source may be misperceived by the driver because of poor vision or inattention (human failure) low visibility due to glare, fog, or a view obstruction (environmental), or a poorly designed vehicle with many blind areas. In all of these cases the driver is likely to make wrong decisions and responses that — unless corrected in time — will lead to a collision. By knowing more about the way we process all the driving-related information and respond to it we can better understand the circumstances under which accidents occur and, hopefully, we can develop measures that will eliminate these circumstances — through driver selection and training, and improvements in vehicle and environmental design.

Let us return now to the pedestrian, who was temporarily taken out of the system. Contrary to some experiences we have all had from time to time, the relationship between the driver and the pedestrian should be one of coordination rather that competition. The joint objective of both should be to use the road while remaining separated from each other. This requires some agreement on norms and often involves subtle forms of communication between drivers and pedestrians.

In the following chapters we discuss most of the concepts listed within the boxes in Figure 1.1. We begin, however, with a brief review of the different methodologies involved in studying driver behavior (Chapter Two). This discussion provides a better understanding of how driving research results (to be discussed in the succeeding chapters) are obtained, and arms the reader with an ability to critically evaluate conclusions drawn from these results. In Chapter Three we evaluate how various driver characteristics — personality, attitudes, experience, and motivation — and temporary impairments — from drugs and fatigue — may influence driver behavior. The next two chapters discuss how human information processing limitations and capabilities influence the interaction between the driver and the environment (Chapter Four), and the role of information processing failures in accident involvement (Chapter Five). Chapter Six describes how knowledge of driver behavior can (and has been) directed toward improving the driver-vehicle-roadway system through driver

regulation, vehicle design, and highway design. Finally, in the last chapter, Chapter Seven, we focus our attention on the pedestrian — often the same person in the new role of the driver without a car. Our discussion of pedestrian behavior is more limited in scope than that of driver behavior and relates to situations in which the "horsepower" and the unassisted "human power" are likely to interact with each other.

TWO
DRIVING RESEARCH METHODOLOGY

This chapter serves as background for the more substantive discussions in the succeeding chapters. The variables investigated, the methods of investigation, and the various advantages and disadvantages associated with these methods are discussed here in detail so that research findings described in this book, and the conclusions derived from them, may be more critically evaluated.