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(See page 579)

THE AMERICAN
JOURNAL OF PSYCHOLOGY

Founded in 1887 by G. STANLEY HALL

Vol. LI JULY, 1938 No. 3

A THEORETICAL FIELD-ANALYSIS OF AUTOMOBILE-DRIVING

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Of all the skills demanded by contemporary civilization, the one of driving an automobile is certainly the most important to the individual, in the sense at least that a defect in it is the greatest threat to his life.[1] But despite the consequent importance of knowledge about the nature and acquisition of this skill, no more than a beginning in this direction has been made by psychologists, and that chiefly in the field of devising tests to measure some of its inferred components.[2] A systematic set of concepts is needed in terms of which we can describe precisely what goes on when a man drives an automobile, and such a theory, if it is to be useful, must have practical as well as psychological validity. The following paper has been written in the effort to make a systematic description of this sort.

When this undertaking was first proposed, the effort was made to base the analysis upon the more familiar concepts of present-day psychology—habits, attitudes, and response-sequences. In this effort, however, the writers had but small success. Very little in the way of a useful theory emerged. They finally concluded that the task of the automobile driver is so predominantly a perceptual task, and that the *overt* reactions are so relatively simple and easily learned, that the analysis has to be carried out on a perceptual level and with concepts more appropriate to this requirement.

* Accepted for publication August 1, 1937. The authors state: "This article is the outcome of discussions between a psychologist and a practical student of driving."

[1] Accident statistics are now widely publicized. Cf., *e.g.*, R. B. Stoeckel, M. A. May, and R. S. Kirby, *Sense and Safety on the Road*, 1936, 211, 242. Over a period of a year, one driver in every twenty is involved in an accident resulting in death or injury.

[2] See, for example, H. R. De Silva, *Research in Driving Skill*, Mass. State College, 1935.

Their alternative was, therefore, to utilize concepts like the 'field' of the driver, 'valences,' and the general cross-sectional method employed by Lewin.[8]

From this starting point it was possible to formulate a theory better suited to the facts at hand. We may assume that driving is a type of locomotion through a 'terrain' or field of space. It is psychologically analogous to walking or running, except that driving is locomotion by means of a tool; that is to say, the automobile can be thought of as a tool for more effective locomotion in the same way that a club is a tool for more effective striking. The primitive function of locomotion is to move the individual from one point of space to another, the 'destination.' In the course of simple locomotion 'obstacles' are met with, *i.e.* are seen, and the locomotion itself must be appropriately modified in order to avoid them. 'Collision' with an obstacle stops locomotion and may produce bodily injury. Locomotion is therefore guided chiefly by vision, and this guidance is given in terms of a 'path' within the visual field of the individual such that obstacles are avoided and the destination ultimately reached. These concepts of *terrain, destination, obstacle, collision* and *path* should be applicable to any type of locomotion, whether that of the infant learning to walk, the open field runner in football, or the operator of an automobile. It might seem more logical to apply them first to the simpler types, but nevertheless we shall attempt to work them into a theory of automobile driving, with the idea that a general hypothesis which would cover the more difficult problem would assuredly include valid principles for the solution of the simpler ones.

The Field of Safe Travel and the Nature of Steering

The visual field of the driver is a rather special sort of field in several respects. It is selective in that the elements of the field which are pertinent to locomotion stand out, are attended to, while non-pertinent elements, such as 'scenery,' normally recede into the background. The most important part of the terrain included in this pertinent field is the road. Within the boundaries of the road lies, according to our hypothesis, an indefinitely bounded field which we will name the *field of safe travel*. It consists, at any given moment, of the *field of possible paths which the car may take unimpeded*. Phenomenally it is a sort of tongue protruding forward along the road. Its boundaries are chiefly determined by objects or features of the terrain with a negative 'valence' in perception—in other

[8] Kurt Lewin, *Topological Psychology*, 1936, 1-

words obstacles. The field of safe travel itself has a positive 'valence,' more especially along its mid-line. By *valences*, positive or negative, we refer to the meanings of objects by virtue of which we move toward some of them and away from others. The valences of objects with respect to locomotion may be quite different ones from their valences with respect to eating or esthetic enjoyment when the individual is not simply propelling himself between them. For instance, a hot-dog wagon has a negative valence with respect to locomotion, but a positive one with respect to appetite.

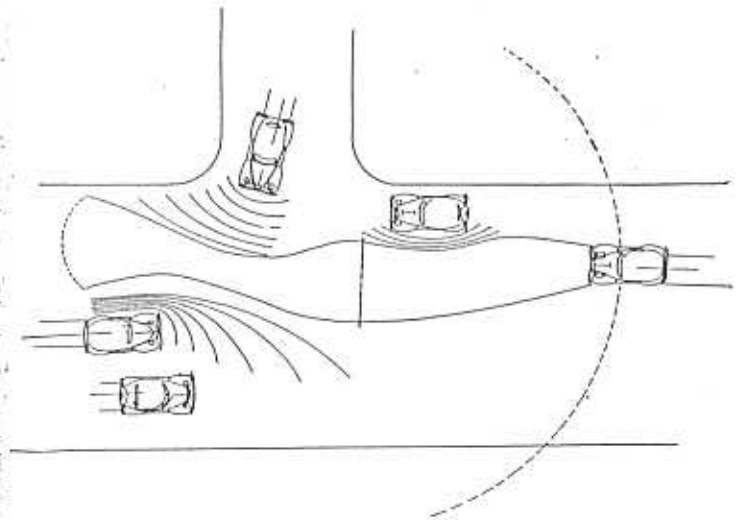

Fig. 1. The Field of Safe Travel and the Minimum Stopping Zone of a Driver in Traffic

(If, in this and the following figures, the page is turned around and the figure is viewed from what is now the right, the reader may the better be able to empathize the situation, since he will then have the point of view of the driver of the car whose field of safe travel is under discussion.)

Fig. 1 is a representation of this field at a specific instant. The field of safe travel, it should be noted, is a spatial field but it is not fixed in physical space. The car is moving and the field moves with the car *through* space. Its point of reference is not the stationary objects of the environment, but the driver himself. It is not, however, merely a subjective experience of the driver. It exists objectively as the actual field within which the car can safely operate, whether or not the driver is aware of it. It shifts and changes continually, bending and twisting with the road, and also elongating or contracting, widening or narrowing, according as ob-

stacles encroach upon it and limit its boundaries. As will later be evident, other factors may also serve to constrict these boundaries, but for the present we may point out that its depth is limited by frontal obstacles such as other vehicles, policemen and stop lights, and its width by 'marginal' obstacles like curbs, ditches, soft shoulders, walls, parked cars, pedestrians or 'white lines.'

It is now possible to define precisely the operation of steering an automobile. *Steering, according to this hypothesis, is a perceptually governed series of reactions by the driver of such a sort as to keep the car headed into the middle of the field of safe travel.*

The Determinants of Accelerating and Decelerating, and the Minimum Stopping Zone

Collisions are avoided during all kinds of locomotion by one of two methods—changing the direction of the motion or stopping it. For the driver of the car this means steering away, or decelerating. Having offered a hypothesis for the former, we have next to consider the problem of what factors determine the response of taking the foot off the throttle or stepping on the brake.

First, however, the question arises: What initiates and maintains locomotion itself? In the simplest case we may suppose that speed of locomotion is a function of the urge within the individual toward his destination. This directed motive—'vector' if one prefers the word—may be consciously represented by the experience of 'hurry.' It is, of course, perfectly true that people frequently drive an automobile without any specific destination. Driving 'for pleasure' may be considered, however, in common with most play, the using of a tool or a skill for its own sake. If driving is locomotion with a tool—a very ingenious, elaborate, and versatile tool—it is not surprising that like most tools its manipulation, once acquired, may be an end in itself. Speed of locomotion in this situation becomes a very complex matter; but, limiting ourselves to the simpler case, it appears that locomotion is maintained and augmented by a motive of the simplest kind to be found in all behavior—that of 'going somewhere.'

Accelerating is then a function of this motive. To what may we ascribe decelerating? Once more, to take the simplest case and disregarding such limits on speed as legal taboos, we may suppose that it occurs when the field of safe travel visibly contracts, and that stopping, like steering, is primarily an avoidance reaction to obstacles. In the diagram of Fig. 1, for example, if the car ahead, which is apparently passing the other, is instead

turning into the side street, then the field of safe travel will be cut off and our driver will, it is to be hoped, stop.

We do not, however, have as yet a sufficiently precise description. How much contraction of the field of safe travel can occur, and what is the relation between contraction and deceleration? The answer is given by another field concept. There is within the field of safe travel another zone, phenomenally less precise but behaviorally and objectively just as real, which is set by the minimum braking distance required to stop the car. It is the zone within which our driver could stop if he had to, and it can be supposed to be present implicitly in every driver's field. How accurately it accords with reality is another question. Unlike the field of safe travel, the size of this *minimum stopping zone* is dependent on the speed of the car—and also, it may be noted, on the condition of the road-surface and of the brakes.[4] The driver's awareness of how fast he is going does not consist of any estimate in miles per hour; instead, he is aware, among other things, of this distance within which he could stop.

Normally, the forward margin of the minimum stopping zone is well behind the forward boundary of the field of safe travel. Speed may be increased up to the point where the zone nears the size of the field, and when this happens driving begins to feel 'dangerous.' For the experienced driver, the car is in a sense projected to its potential location at the front of this zone. Hence, when the field of safe travel contracts by reason of an abstacle which encroaches upon it, deceleration occurs *in proportion as the forward margin of the field recedes toward the minimum stopping zone.*

A sudden frontal contraction or a shearing off of the field of safe travel, which cuts it down to or below the minimum stopping zone, produces in the driver a feeling of imminent collision, sometimes approaching panic, and an immediate and maximum braking reaction. There is an 'emergency.' Much more frequently, however, there occurs a gradual contraction of the field, and, as it approaches the front boundary of the zone, there follows a gradual slowing reaction of such strength as to keep the zone continually smaller than the field.

The ratio of depth-of-field to depth-of-zone which tends to be maintained in given traffic conditions by a given driver is probably to a large extent habitual. It might be designated as the *field-zone ratio* and thought

[4] Tables giving the minimum stopping distance for different speeds under standard conditions have been widely publicized. See, for example, Stoeckel, May, and Kirby, *op. cit.*, 1936, 176.

of as an index of cautiousness. The ratio may be expected to decrease when the driver is in a hurry.[5]

Expressions of the foregoing principle may be found in such common-sense rules as never driving so fast that one cannot stop within the 'assured clear course,' and never 'overdriving' one's brakes or one's headlights. Inattentiveness in the driver usually means that objects in the terrain or inside the car which are not pertinent to locomotion stand out in his visual field and that consequently his field of safe travel, if it exists at all, may become incorrectly bounded. The *objective* field of safe travel contracts until it threatens to get below the stopping-zone, or does so, without a corresponding contraction of the *behavioral* field. Frequently, it may be suggested, the remedy is not merely increased vigilance or tension in the driver, but the development by learning of semi-automatic perceptual habits and motor habits such that a safe margin is maintained between stopping zone and field of safe travel.[6]

When an obstacle suddenly cuts off the field of safe travel well inside of the stopping zone—an 'emergency'—an entirely new field may open up which did not exist an instant before. Obstacles such as the shoulder of the road, or the curb, or even a shallow ditch which just previously had a minus valence may take on a positive valence and become no longer obstacles but a field of travel. The possibilities for the opening up of a new field depend on the driver's sensitivity to the pertinent field as a whole, and upon the degree to which this field is imbued with meaning for locomotion. The negative valences of obstacles vary in strength, some being more-to-be-avoided than others. The experienced and skillful driver is able to shift his field of travel with considerable flexibility in case of an 'emergency' and thereby avoid a collision. In such a case the field of safe travel is highly relative. It might be called the field of safest travel.

[5] Except for emergencies, more efficient brakes on an automobile will not in themselves make driving the automobile any safer. Better brakes will reduce the absolute size of the minimum stopping zone, it is true, but the driver soon learns this new zone and, since it is his field-zone ratio which remains constant, he allows only the same relative margin between field and zone as before.

[6] The relative importance of effortful attention and of habit in safe driving needs to be worked out. It seems to be assumed, on the basis of what motorists say to police officers after accidents, that most accidents are 'caused' by inattention. Hence, it is concluded, drivers need to be warned sternly of their responsibility to be attentive. Such an inference is characteristic of the theological psychology of legal thinking. It is more likely that drivers need to be taught safe habits, among which is the habit of attending to the field-zone ratio. Contemporary safety campaigns tend to emphasize the factor of vigilance and to play upon the fear-motive to such an extent that the development of correct habits may be hampered in some drivers. These campaigns (*e.g.* '*And Sudden Death*') may be more successful in producing attitudes of timidity than in improving the average driver's performance. If drivers *knew how* to drive safely most of them would do so.

The bearing of our hypothesis on the problem of high speed driving is not hard to make out. A good road which is free from traffic offers a very much expanded field of safe travel. The driver's urge toward his destination, especially if he is one who tends to maintain a fairly constant field-zone ratio, will result in high speed. He tends to feel that a higher ratio between field and zone than is demanded by safety is wasteful of time. With increasing speed, however, the minimum stopping zone extends farther and farther down the road. Accordingly the field of safe travel must at all times extend even farther down the road in proportion. Even with a perfectly clear highway a limit to this extension is eventually reached, since obstacles become harder to see as their distance increases, the acuteness of human vision being what it is. Since, at very high speeds, the driver's attention must be fixed at greater

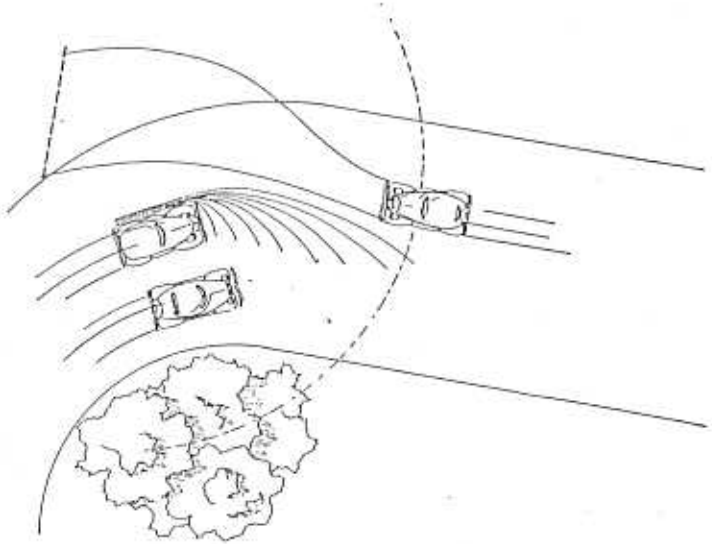

FIG. 2. SUDDEN REORGANIZATION OF THE FIELD OF SAFE TRAVEL TO MEET AN EMERGENCY

An unforeseen contraction of the old field below the minimum stopping zone.

and greater distances—for he has to operate farther and farther ahead in his visual field and scan the road for increasingly minimal cues—the purely sensory task of seeing the zone and the field correctly is more difficult, the strain is greater, and chances for error multiply.

These two fields which have been proposed cannot of course be conceived of as visible, strictly speaking, in the sense than an object with a contour is visible. Nor are their boundaries sharply defined as are lines and contours, although for convenience we may diagram them as if they were. They are *fields within which certain behavior is possible*. When they are

perceived as such by the driver, the seeing and the doing are merged in the same experience. Since their boundaries are set by behavioral possibilities, these boundaries are more or less correct and appear as transitions more or less sharp depending on the skill and experience of the driver. Driving skill largely consists, we suggest, in the organization, within the pertinent visual field of the driver, of a correctly bounded stopping zone for the entire repertory of speeds, roads, and surface conditions, and a field of safe travel which is precisely moulded to the actual and potential obstacles in the total field at any given instant. In other words, the field must be shaped in accordance with the objective possibilities for locomotion. If we add that there are concurrent motor reactions which maintain a safe and constant ratio between these two, and which keep the car running in the middle of the field of travel, we shall have described the basic operations of driving an automobile.

Factors Limiting the Field of Safe Travel

(1) Natural boundaries. So far we have said that the driver's field of safe travel is limited and shaped by obstacles which encroach upon it, but this statement is by no means complete. Limits to this field of the possible seen paths which the car may take may be set, not only by obstacles, but also by physical and physiological factors. Such limitations are, first, the distance at which daylight vision becomes inadequate, because of purely optical factors; secondly, the margins of the field lighted by headlights; thirdly, constriction of the field by fog, snow, *etc.*; fourthly, the diminishing or even the destruction of the field by glare from oncoming headlights; and, finally, such physical limits as the horizon at the top of a hill which the driver is approaching. All these factors, when they cause a diminishing of the field-zone ratio, should bring about a reaction of deceleration. Outside of these natural boundaries of the field there lurk what we shall call *potential* obstacles.

(2) Inflexibility at higher speeds. Another fact which limits the field of potential paths of the car is that it may not include sharp turns at high speed. The field, of course, conforms to the turns of the road and to obstacles on its edges, but it cannot conform by curving more than a certain amount for a certain speed without the occurrence of skidding. One may conceive that the centrifugal force which produces a skid operates as a kind of potential obstacle which encroaches on the concave side of a field of safe travel (Fig. 3). The field becomes less flexible, more rigid or straighter, with higher speed, for the reason that, if one turns too sharply,

one is literally likely to 'run into' a skid. This description of skidding may at first sound implausible because we tend to identify skidding with the obstacle *into which* we may skid; but an examination of Fig. 3 will show that, while the field of possible paths is bounded on the right by actual obstacles, it is bounded on the left by the potential skid which would occur if the car were swung into it. At a given speed, the feeling of losing traction with the road is projected into the terrain ahead in such a way as to make certain paths impossible.

(3) Obstacles and their 'clearance lines.' It has already been stated that obstacles limit the field of safe travel by virtue of their minus valence for

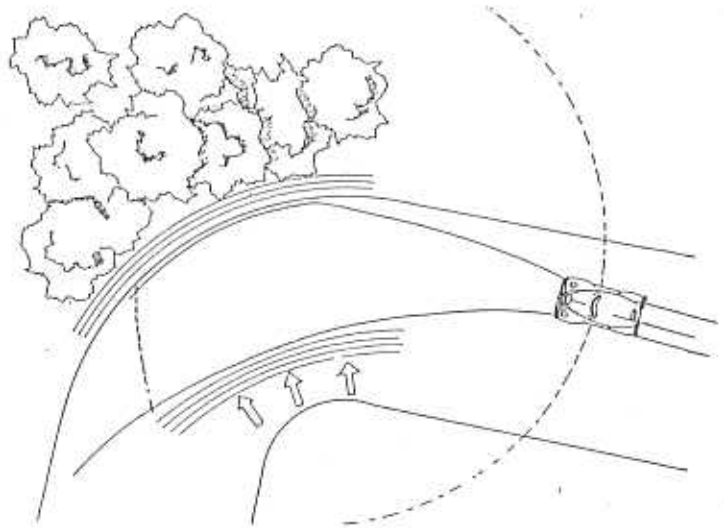

Fig. 3. Inflexibility of the Field of Safe Travel at High Speed
The field is bounded on the right by fixed obstacles and on the left, at this speed, by a projected feeling of the potential skid.

locomotion. The open terrain between the obstacles, if it leads off toward the destination, has a plus valence. This negative valence of an obstacle, we could suppose, is an indicator of the consequences of collision with the object in question. The child learning to walk about probably learns these valences rather readily. An object or place which is attractive to the child induces locomotion toward it. In the course of such locomotions, the child bumps against fixed objects in his field, such as furniture, and, as a result of these collisions, acquires a repertory of avoidance responses to them. These avoidances are superimposed on the general activity of locomotion,

and, taking place as they do only in the immediate neighborhood of the obstacle, they can be represented in the child's field by a negative valence of the obstacle and of the space immediately surrounding it. We can thus suppose that every obstacle comes to have a sort of halo of avoidance, and that this halo can be represented by 'lines of clearance' surrounding it. In analogy with contour lines on a map, we could draw lines of equal negative valence around an obstacle, each line as it gets closer to the obstacle representing a greater intensity. Locomotion in a field containing obstacles would then be a matter of moving *toward* the destination and at the same

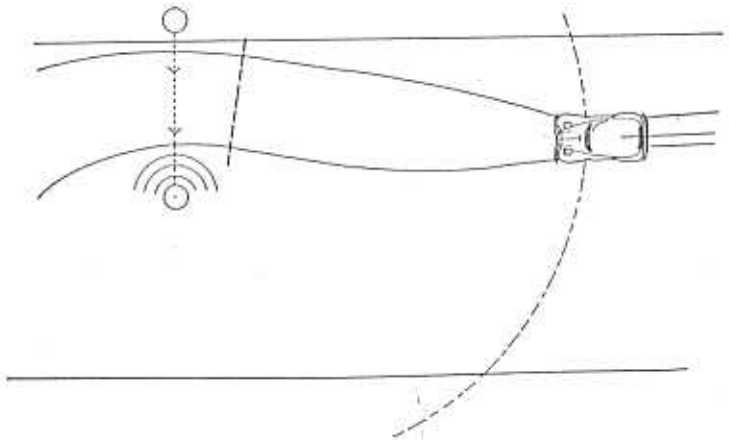

FIG. 4. THE FIELD OF SAFE TRAVEL AS DETERMINED BY THE *future* CLEARANCE-LINES OF A MOVING PEDESTRIAN

time *away* from obstacles. The resultant of these two tendencies, summating the motives (vectors) at each point, yields the *path* of locomotion.[7]

For the automobile driver these concepts can be taken over in their entirety. The driver has learned at least the essentials of locomotion when he learned to walk, and learning to drive is mostly learning the use of the tool. His field of safe travel is at every moment bounded and shaped by the halos of obstacles in the terrain. It is a reasonable hypothesis, moreover, that the more injurious a collision with an obstacle would be, the more it is avoided and the greater is the extent of its clearance-lines. Some

[7] The possibility that this analysis carried further is capable of explaining 'roundabout' behavior is worth considering. Lewin suggests that the detour performance requires a "restructuring" of the field and "insight"—an extra hypothesis which may not be necessary.

obstacles would then affect the field of safe travel more than others. For example, a heavy bus approaching at great speed would have more clearance-lines than a model-T Ford; and a precipice would have more clearance-lines than a shallow ditch.

(4) Moving obstacles. We are now in a position to deal with obstacles more fully. Two cases must be distinguished: that for stationary and that for moving obstacles. In the former case (curbs, trees, parked cars) the clearance lines radiate from the physical location of the obstacle and affect the field of safe travel as it impinges on this location. Figs. 1-3 have repre-

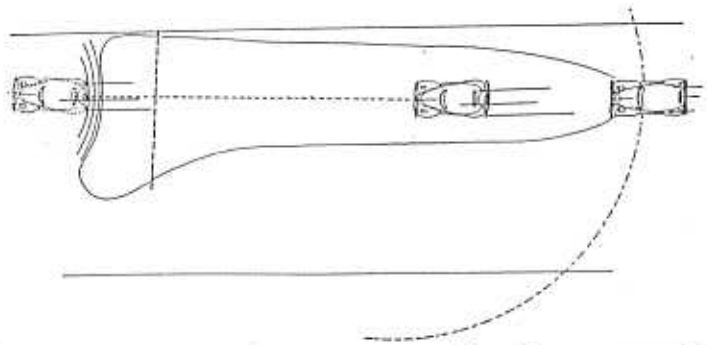

FIG. 5. THE FIELD OF SAFE TRAVEL AT RELATIVELY HIGH SPEED, WHERE A MOVING OBSTACLE IS PHYSICALLY WITHIN THE FIELD BUT WHERE ITS PROJECTED CLEARANCE-LINES DETERMINE THE FORWARD MARGIN OF THE FIELD

sented this state of affairs. For a moving obstacle (vehicle, person, animal) the clearance lines radiate from *the point where the obstacle will be when the driver's car comes closest to it,* or in other words from the point of potential collision. Consequently one may for example steer *toward* the present position of a moving pedestrian (Fig. 4), since, in effect, one is steering away from where he will be when the car reaches him. Likewise a car ahead going in the same direction may, at high speeds, actually be inside the field of safe travel without affecting it, since its clearance-lines are projected far ahead in the field where it would be if it stopped (Fig. 5). In general, the greater the speed of a moving obstacle, the farther ahead of it are its clearance-lines projected. Likewise, for all obstacles moving toward the driver, whether from the front or from one side, the greater their speed, the more do their clearance lines encroach upon the field of safe travel. Finally, the more unpredictable the movement of an obstacle, the more extensive are its clearance-lines. Examples would be

cars behaving 'strangely,' blind men, children (especially on bicycles), and old people. A street-car should have few and narrow clearance-lines to the side, since its lateral movement is usually predictable and negligible.

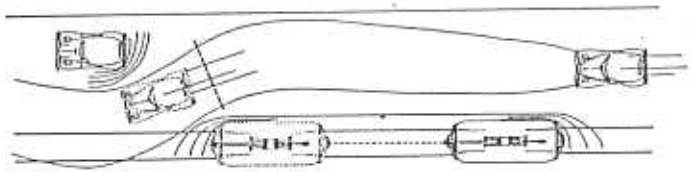

FIG. 6. A DRIVER ATTEMPTING TO PASS A STREET-CAR BEFORE REACHING A PARKED CAR

At this instant the field of safe travel looks open, since the clearance-lines of the trolley are projected as indicated for the moment when he will be passing it.

A parked car with a driver visibly sitting in it should have a wider halo than one without a driver, since the former may suddenly pull away from the curb.

It should be remarked here that the correct location of the clearance-lines of a moving vehicle ahead demands, not only a sort of projection of

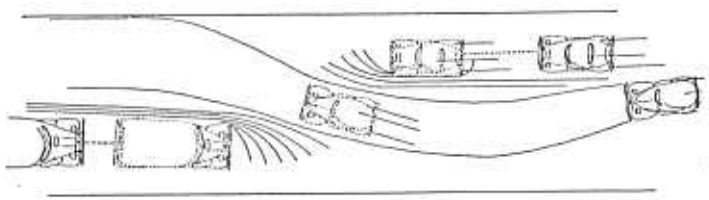

FIG. 7. A DRIVER PASSING WITH INTENT TO CUT IN

An integration of three perceived speeds of movement is involved in the seeing of this open field of safe travel.

this vehicle to the proper point in its own path, but also the correct projection of one's own car to the point of intersection of the two paths. Both one's own and the other person's field of safe travel are jointly involved. An example is given in Fig. 6. In other words an 'estimate' of the speed of the obstacle plus an 'estimate' of the speed of one's own car are combined—although the term *estimate* is misleading since there seems to be no conscious process of calculation involved. Here is a case of a highly complex situation, involving relationships between two speeds of movement, which would not be an easy problem to solve with pencil, paper, and formulae; but for the skillful driver the perceptual field-situation may be immediate, clear, and (let us hope) accurate. Complex 'estimates' of speed and location are represented in the experience of the driver only by the simple seeing of an open or a closed field of safe travel. In Fig. 7, which represents a driver passing the car ahead in the face of an oncoming driver, there is involved a projection of *three* cars, with *three* speeds of movement, to their correct positions at a future instant. Here indeed is a very extraordinary type of perceptual 'constancy-phenomenon.'[8]

(5) Potential obstacles. In addition to the actual obstacles which at any moment are encroaching upon the field of travel to some degree, there may be in the pertinent field *barriers to sight* which also throw out lines of clearance. For the trained driver, any intervening object from behind which a moving obstacle might suddenly cut into the field of travel—a building, a blind corner, or even a parked car—radiates clearance lines (Fig. 8), because it has a secondary or indirect negative valence. The limits to the field of safe travel imposed by darkness beyond the headlight-zone, by fog, and by curves or by the brow of a hill ahead, likewise constitute such barriers. Behind them there are *potential* obstacles. There may or may not be *actual* obstacles behind them; the objective field of safe travel may or may not be clear; but, since the driver can react only to his subjective field, the latter is properly shaped and limited by these barriers.

It must be admitted that for the average driver potential obstacles do not have the potency of visible obstacles. Very frequently one of these barriers to sight is not recognized, its negative valence is not perceived, and the field of safe travel is incorrectly related to the objective possibilities for locomotion. Psychologically this fact is not surprising, for the existence of a potential obstacle behind the barrier must be learned by experience and its negative valence transferred to the barrier. Probably each new type of sight-barrier which is met necessitates a new process of learning. More frequently, a barrier representing potential obstacles of

[8] The movement-perceptions of the three objects in question are subject in a very striking way to the principle of 'constancy.' When one considers the actual stimulus-cues for the perceived speed of the approaching car, the to-be-passed car, and finally the driver's own car, and realizes that these speeds are perceived in relation to a phenomenally stationary road, the degree of 'phenomenal regression' away from the stimuli and toward 'reality' is astounding.

low valence is disregarded. Even the most cautious driver undoubtedly drives on faith under certain circumstances. For example, a blind stop-street which enters the highway ahead does not usually affect the field of safe travel, although occasionally it conceals an automobile which will not stop at the intersection. A green traffic-signal is interpreted as a *guarantee* that the field will remain open and that unseen cars on the crossroad will not enter it. It is invariably assumed that the road does not end abruptly

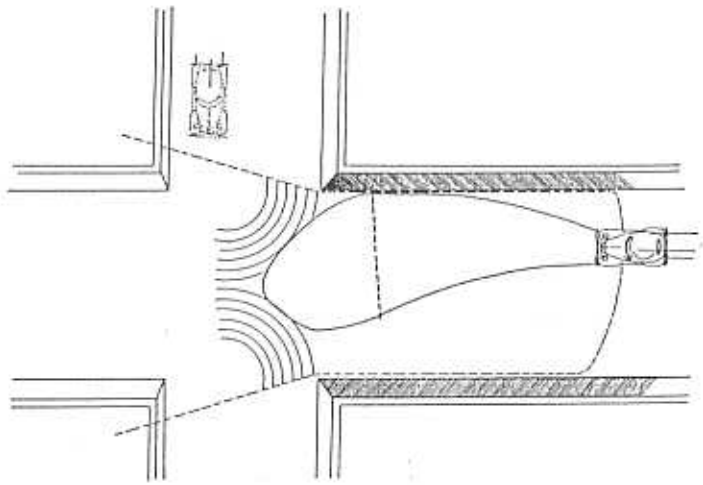

FIG. 8. A BLIND CORNER CONSTITUTING A BARRIER TO VISION AND ITS EFFECT ON THE FIELD OF SAFE TRAVEL

At this moment the clearance-lines of potential obstacles cut off the field.

in a stone wall just out of sight over the brow of the hill ahead—a very probable assumption, to be sure, but still an assumption. It is also generally assumed that the absence of warning signs by the highway means the absence of obstacles for which one should be warned.

The driver's field of safe travel, as he reacts to it, is delimited, we now see, by *probable* as well as by seen obstacles. Equally, it is not delimited by *improbable* obstacles. The more probable types of obstacles are usually indicated by highway signs, crossing signals, and the like, to which the driver supposedly learns to react as he would to the obstacles themselves. But the highway signs vary considerably in different parts of the country, and they are usually put up without any regard for the actual probabilities of the obstacles in question. The average driver becomes dimly aware that he must calculate the probabilities of the road for himself without much dependence on highway signs and consequently comes to perceive them as merely legal obstacles to which he must conform, when he does, for reasons distinct from the necessities of locomotion. Their negative valence is based on potential legal consequences rather than potential collision.

(6) Legal obstacles and legal taboos. The field of safe travel is modified, not only by the various types of obstacles already described, but also by perceived symbols—more specifically by signals, gestures, signs and markings. The traffic signal showing red and the traffic policeman with arms outstretched are the most obvious examples. Arm signals and the stop-lights of the car ahead are cues which enlarge its clearance lines or shift them to one side. Highway markings indicating lanes and the areas around fire-plugs are symbolic obstacles, as are "private" signs on driveways and roads. Finally, "stop" signs at intersections, blinkers, and a variety of highway signs, "slow," "curve," "school," "speed limit 20 m.p.h" and the like, affect the field of safe travel with varying degrees of effectiveness. Too frequently they are not reliable indicators of the objective possibilities for locomotion and, as we have suggested, become purely legal taboos. A sign which is not occasionally 'reënforced' will in the end no longer stand for anything, as students of the conditioned response are well aware.

There are, accordingly, in the pertinent field of the driver, obstacles whose negative valence is partially or wholly legal. This fact is illustrated by their greatly increased negative valence when a traffic policeman is present in the field as compared with the same field without the policeman. Likewise, manoeuvres, which are warranted by the visible field-conditions but are legally tabooed, are seldom made in the visible presence of the law, as for example passing on curves where the field of view is unrestricted, or at a clear intersection where another road enters only from the right. Traffic laws being absolute can agree only roughly with the actual facts of dangerous driving. From the point of view of the driver who undertakes to drive safely but also skillfully and efficiently, the unrealistic legal restrictions present a problem of compromise.

THE FIELD OF THE OTHER DRIVER

It has been said that driving an automobile is a highly individualistic activity. There is no way of communicating with another driver except by way of the horn, or by arm signals—neither of which is a particularly sociable mode of interaction. As a consequence perhaps of this anonymity on the road, the situation is one conducive to competitive rather than coöperative attitudes. Each driver tends to think of his own task and to regard the other drivers merely as obstacles.

On the other hand, the driver does take into account the field of the other person. It is always assumed, for example, that *the other driver sees you*. The clearance lines of an approaching car are projected, not as if it were simply an inanimate moving obstacle or an incalculable agent, but

on the assumption that it is avoiding you as much as you are avoiding it. More specifically, it is assumed that the other driver's field of safe travel does not overlap yours. To speak of an 'assumption' is, of course, inadequate, but the behavioral fact remains. For example, when a driver sees two cars approaching on a two-lane road and the rear car swings out to pass with the intention of cutting in before the various paths meet, the driver is usually very much aware of his own menacing aspect in the field of the passing driver. Frequently he uses his advantage to the utmost,

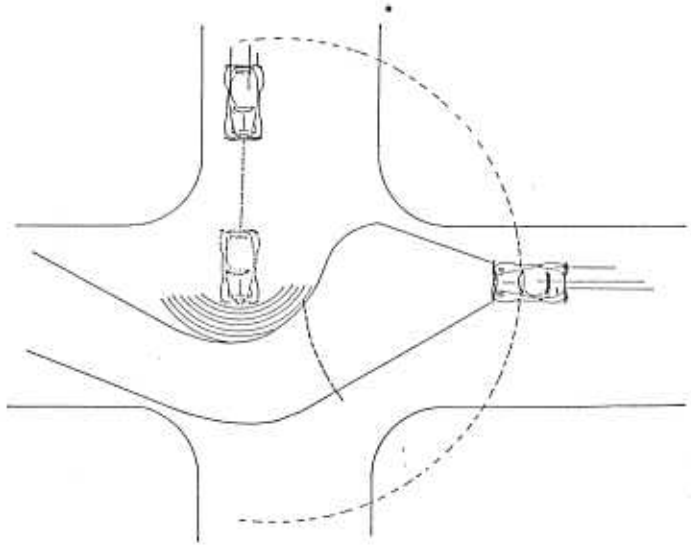

FIG. 9. BLUFFING AT AN INTERSECTION

A driver projecting his field of safe travel on the assumption that he is a formidable obstacle in the other driver's field.

maintaining speed despite his dubiously open field of safe travel, in the bold manner of a dog facing a canine trespasser on home ground.

Another example is the use of the horn, by which one announces one's presence as an obstacle encroaching on the other person's field. If the other person behaves as if he did *not* see you—if his field of safe travel is apparently incorrect—then his clearance lines encroach unduly on one's own field. In this situation blowing the horn simply expands one's *own* clearance lines in the other person's field, advertising that "I am a dangerous obstacle," and one goes on the faith that this expansion of clearance lines in the other's field will indirectly clear up one's own at present constricted field. The obstacle, one trusts, will stop.

Occasionally, however, the obstacle itself may decide to advertise its dangerousness and behave in a powerful and unyielding fashion. We then have the situation of mutual bluffing. Each driver expands his own clearance lines to the utmost, maintaining speed or using the horn, and they may persist even up to the point where their respective minimum stopping zones touch. At this point we may leave them to their fate.

THE CAR ITSELF AS A FIELD

The perceptions of the driver are organized into a number of spatial fields, each being a sort of projection of the behavioral opportunities, each being a space within which certain behavior is possible and outside of which it is impossible. Within the field pertinent to locomotion are the field of safe travel, the minimum stopping zone, and on some occasions the field of the approaching driver or pedestrian. When the driver prepares to stop, overtake, or make a turn, his pertinent field *includes the road behind* for the reason that he must not encroach too suddenly on the field of safe travel of a potential driver who is coming up fast from the rear. The rear-vision mirror is the usual mediator of this rearward field. Finally, there is still another field which needs to be taken into account—that of the car in which the driver is sitting. We suggested that the car was a tool whose use was locomotion. It is also a sort of field which yields a variety of perceptual cues and which invites and supports specific actions. The impressions constituting it are kinesthetic, tactual, and auditory, as well as visual, and they interact with the impressions from the terrain to produce the totality of cues on which the driving-process is based. The 'feel' of the car or the 'behavior' of the car are terms which indicate what is meant by this particular field of experience.

In the first place, locomotion involves a feeling of contact with the terrain together with a feeling of exerting force against it. In the case of the driver these feelings are referred to the car; the actual impressions are secondary and indirect. The feeling of driving on an icy surface is similar to the feeling of walking on ice despite the different cues and different muscular movement involved. The perception of *traction* is therefore an important feature of the driving process. Under extreme conditions, as when rain freezes on the road, locomotion takes place predominantly by means of kinesthetic and tactual cues from the car-field. The driver 'feels his way' along the road. It is evident that he projects his actual impressions into the car-field and may be said to feel the road with the car in the same sense that one feels the ground with a walking-stick.

In the second place locomotion involves a constant orientation with respect to the path. The car, as we have already suggested, is kept pointed into the middle of the field of safe travel; the two are kept in alignment. The car is, therefore, something which can be oriented, pointed or aligned, and this characteristic depends on those sensory cues which go to make up the car-field. During a skid the car becomes disoriented with respect to its path. If the driver, however, maintains *his own* orientation to it and if the skid is only a moderate one, he can correct the car's orientation by simply steering into the middle of the field of safe travel.[9] But if the skid turns the car completely around or if the driver is unskilled, his own personal orientation to the path may be lost. The car is then 'out of control,' primarily because the *driver* is disoriented.

In the third place, locomotion involves the maintenance of an upright position. The tilt of the car on a high-crowned road and the corresponding pull of the wheel, the centrifugal force and the sway on a sharp curve, all contribute to the driver's sense of his car and the feeling of its stability or lack of it.

Enough has been said to indicate the nature of the car field. This field which the driver inhabits is one in which the impression and the action are especially intimately merged. The impression and the action imply one another. In common with other tools, it has a set of potentialities—a certain repertory of performances which the skillful driver knows and utilizes fully and of which even the tyro is forced to take some account. A high degree of driving skill demands a complete sensitivity to and control over this field. If this demand is fulfilled, the car tends to become, like any properly used tool, simply a sort of physical extension of the driver's body.

Application

The situation which faces highway-safety officials in dealing with a public who insist on killing themselves at an ever-increasing rate is similar to that of a bewildered parent dealing with a bad child. Despite past failure, the only thing the parent knows to do is to admonish him oftener and spank him harder. A wiser procedure would be first to try to understand what is going on in the child's head. Frequently the child does not *want* to misbehave, and most assuredly the driver does not *want* to kill himself.

Intelligent measures toward educating the public to drive safely can only

[9] Note that our definition of steering obviates the necessity of any 'rule' for getting out of a skid.

be taken when the performance of driving an automobile is thoroughly understood. Programs of testing and experimenting are necessary, but useful only if they have some theory to go on. Discussion of the problem should be disinterested rather than merely admonitory, should adopt the driver's point of view rather than the safety engineer's, should start from normal rather than abnormal driving, and should emphasize what the driver ought to do rather than what he ought not to do.

If driving is to be taught successfully—and there are already courses in a number of adult education and public school systems—it must be taught in terms which the driver will recognize. The concepts employed must refer to operations which the driver understands. If teaching is to be more than merely the memorizing of the local legal restrictions, the 'causes' of accidents as listed in statistical tables, a list of 'bad driving' practices, and a series of assorted 'don'ts,' then a systematic theory of driving is needed which can be verified by observation and experimentation. The theory which has been described is an effort in this direction.

Safe and efficient driving is a matter of living up to the psychological laws of locomotion in a spatial field. The driver's field of safe travel and his minimum stopping zone must accord with the objective possibilities, and a ratio greater than unity must be maintained between them. This is the basic principle. High speed, slippery roads, night driving, sharp curves, heavy traffic, and the like are 'dangerous,' when they are, because they lower the field-zone ratio. Hidden obstacles are dangerous, when they are, because they tend to put the driver's field of safe travel out of correspondence with reality. The various 'bad driving practices' are bad, when they are, for a *reason* and not simply because the traffic cop says so. The reason lies in the psychological principles; the 'rules of the road' follow from these principles and it is the principles, not the rules, which need to be taught.

The skillful driver recognizes the valences of obstacles quickly and automatically and projects their clearance-lines correctly. He knows the boundary line of a potential skid on the curve ahead in precise relation to his speed, the road surface, and the characteristics of his car. A sudden shift of the events in his field will lead to an immediate reorganization of the field-relations and not to a disintegration of them in panic. He calculates the other driver's field of travel with sagacity and never allows it to overlap his own. Finally, he does all these things because he has learned to do them, not because he is frightened into a continual state of strained attention.