Human Thresholds Related to Simulation of Inertia Forces

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• FOR THE PURPOSE of this report it was appropriate to review the simulator laboratory development at U. C. L. A. and then describe a series of tests conducted on the moving-base simulator.

The Institute of Transportation and Traffic Engineering at U. C. L. A. has been greatly interested for about 12 years in the research potential of a driving simulation laboratory. The Institute's first motion picture for playback to a driver seated in a vehicle mock-up was produced nearly five years ago. Shortly after that, with help from an Automotive Safety Foundation grant, the driver could sit in a real running vehicle operating on the rollers of a chassis dynamometer while he responded to the motion picture films.

Results of this work were reported in HRB Bull. 261. Briefly, it was possible to say that drivers responded differently to straight-road scenes than to winding-road scenes. Both speed and steering wheel movements reflected this difference in the expected direction, namely, slower speed and more wheel movements during the curving-road trip. Evidence and arguments were presented relating to the need for simulating inertial forces and the feasibility of one method of producing these forces of acceleration and centrifugation.

During the past three years with the help of a grant from the U. S. Public Health Service, four types of activity have been under way at the Institute:

1. Improvement of the visual display and feedback fidelity. A 160° wide-angle motion picture system was demonstrated at the first National Symposium on Driving Simulation in February 1960.
2. Development of data recording and processing techniques which now directly provide computer analysis capability without need of human chart reading and key-punching.
3. Conduct of research on driver behavior. Reactions to "wrong-way" driving, driving after staying awake all night, and left-hand off ramps behavior are currently under study. The initial phase of a study of blood sugar and driving fatigue is nearly complete and a pilot run of drunken drivers has been made.
4. Construction and testing of inertia forces apparatus.

Each of these four activities could be the subject of a presentation. However, this report shall deal with progress in the inertia forces simulation activity.

The method substitutes gravity for inertia force. A model (Fig. 1) of a proposed device serves to demonstrate the principle involved. It is a movable platform that can pitch, roll, and yaw. If the simulator vehicle and visual display are placed on the platform, the inertia force that a driver feels when slowing his vehicle is simulated by pitching the platform forward. Five, ten, possibly twenty degrees from the horizontal may be needed to produce the appropriate amount of force to match his deceleration rate. As was documented in HRB Bull. 261, pitching in this manner can produce a reasonably close approximation of vehicle deceleration rates as measured by recording accelerometers in the field.

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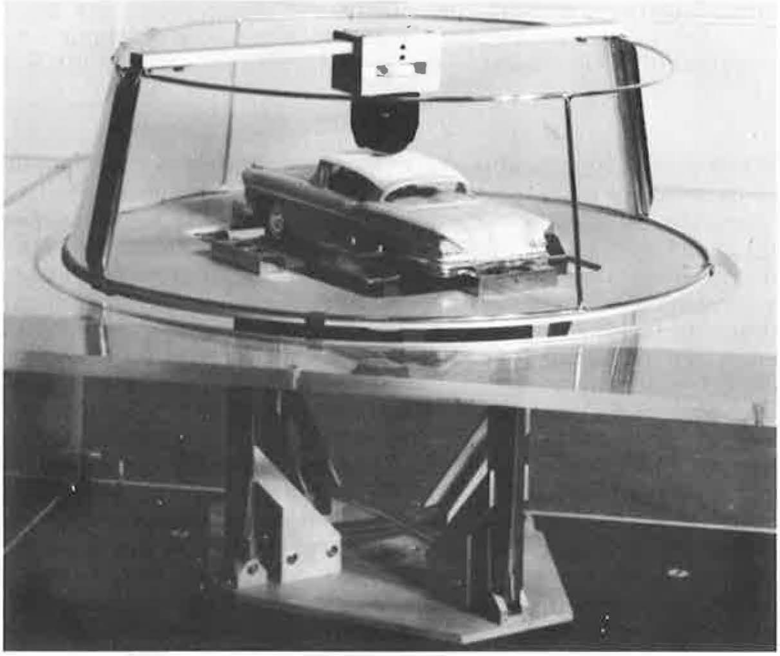

Figure 1. Proposed model which can substitute gravity for inertia force.

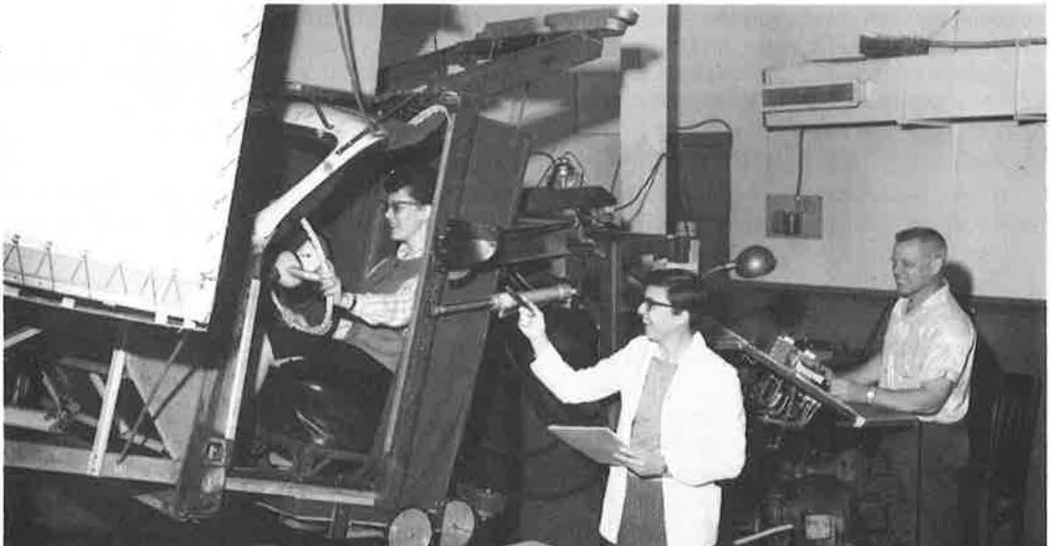

Figure 2. Driver demonstrating one position of the moving-base device.

The proposed device demonstrated one of several possible mechanical systems for producing pitch, roll and yaw. In order to investigate the possibilities of substituting gravity for inertia force, a moving-base device was constructed (Fig. 2). The driver can be pitched about an axis approximately shoulder high and rolled about an axis in the same horizontal plane located directly in line with the center of his body.

PROCEDURE

Using this device, a series of position judgments was obtained from drivers as they sat behind the wheel in the device and were moved to various positions. Two types of procedure were used as follows: (a) movement from an initial position to another position and a judgment requested while the driver remained in the "new" position; and (b) movement from an initial position to a new position and back to a level position and a judgment requested of the new position (the position immediately preceding the return to level).

These tests were performed to determine the accuracy with which drivers could determine the extent to which they had been pitched or rolled. The first procedure (a) relates to the perceived magnitude of the illusory inertial force during its presentation; and the second procedure (b) relates to perceived magnitude of the illusory inertial force after it had been experienced and the driver returned to a normal condition (in terms of inertial forces).

In order to maintain the attention of each driver, a subsidiary task was provided, namely, a vision acuity test. A series of slides projected an image on the projection screen 4 ft in front of the driver. He controlled (with a hand-held button switch) the rate of presentation of these 15 slides and gave an oral judgment as to the position of the checkerboard target in each. (These vision test slides were prepared from the Bausch and Lomb Orthorater test device.)

Whenever the driver heard a buzzer tone he interrupted the vision test and adjusted a pointer located in the cab to what he judged to be the horizontal or the new position angle. This pointer was mechanically linked to one outside the cab from which the experimentor recorded the judgment value to the nearest degree. A second pointer outside the cab displayed the actual angular position of the apparatus.

To eliminate any effects due to order of presentation, the series of angular positions was assigned using a random number table, and the various combinations of initial and new positions each appeared an equal number of times for each subject.

EXPERIMENT PLAN

It was postulated that the variance of measurements on a set of subjects in the experimental environment (moving-base device) for a given attitude of the device, is a relative measure of the disorientation associated with that attitude.

The experimental conditions were as follows:

Pitch 1: Subjects asked where horizontal is while they were in the "new" position.

Pitch 2: Subjects asked what the angle was after they have been brought to zero position.

Roll 1: Same as pitch 1.

Roll 2: Same as pitch 2.

There were 16 position sets for pitch, and 12 for roll; for example, from 0^0 to 25^0 was one pitch set and -15^0 to 25^0, another pitch set.

It was assumed that there was no difference in standard deviation of set of threshold responses for P_1 vs P_2 for a given pitch-attitude combination.

The number of subjects was 75. Representative results are given in Table 1.

DISCUSSION AND CONCLUSIONS

The results indicate that drivers (as tested) were not able to clearly distinguish among a variety of angular positions. The coarseness of their position thresholds may explain in part why it has been possible to create an illusion of inertial forces

TABLE 1

REPRESENTATIVE RESULTS[1]

Condition	Position (deg.)		Mean Position Estimate (deg.)	Std. Deviation (deg.)	Coef. of Variation	Judgment	
	Initial	Final				Range (deg.)	No.
Pitch 1	0	25	18.22	16.38	0.9	-25 to 78	178
Pitch 2	0	25	40.07	41.21	1.01	8 to 80	152
Roll 1	0	15	11.77	15.97	1.35	-40 to 45	190
Roll 2	0	15	28.14	27.03	0.95	-46 to 85	112

[1] All tests were performed in counterclockwise direction (minus sign indicates clockwise direction).

(in this device) when drivers have been subjected to a visual display that suggests motion that ordinarily would produce such forces.

It is possible that the moving-base device used in this research provides motion and changing exposure to gravity in such a way that kinesthetic, proprioceptive and pressure senses and the otolith are stimulated in similar manner and degree to that experienced when the driver is exposed to inertial forces in a moving automobile. The inappropriate sensations (in the moving-base device) due to stimulation of the semicircular canals are ignored or "overridden" by the strong suggestion of motion that he is receiving from the visual display (a motion picture of a driving scene).