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Standards of Rider Comfort: Noise, Vibration and Age of Rider as Factors[1,2]

Final Report, covering the period June 1973--June 1974

on

NASA Research Grant NGR 47-025-001

by

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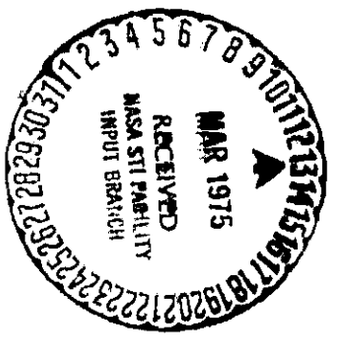

Footnote 1: The NASA Technical Officer for this grant is Mr. Ralph W. Stone, NASA Langley Research Center, Hampton, Virginia.

Footnote 2: This research will be continued on NASA Research Grant NSG 1074.

Transportation poses many problems for a complex society. As urban growth continues, more and more individuals must travel greater distances between home and work. Air pollution, traffic congestion, travel time and the drain on natural resources all increase with the increase in travel. Many of these problems can be traced to the automobile, an uneconomical but private and comfortable means of transportation.

Mass transit is an obvious alternative but one which brings problems of its own. Informal questioning of individuals who normally commute via private automobiles suggests that the ride quality of buses and subways suffers by comparison. Many of those who drive would use mass transit were the riding environment more comfortable.

Pressure is being brought to bear on mass transportation to improve and extend services. Factors which contribute to user satisfaction have recently been receiving the attention of investigators. A symposium on vehicle ride quality was held at Langley Research Center, Hampton, Virginia, in July, 1972 (1). The view expressed by many was that vibration was a major factor in bringing about passenger discomfort. The problem is serious for short haul commercial aircraft in that they are prone to high amplitude vibration as well as visual/vestibular interactions conducive to motion sickness. The problem of vibration is also shared by ground transportation vehicles. Kirby and Mikulka (2) reported high correlations between vibration parameters and the comfort judgments of bus passengers. Noise is also a source of potential discomfort. A passenger of a private automobile is able to carry on a conversation or listen to a radio while speeding along

an access route to the city. The typical bus passenger contends with engine noise, noise generated by the flexing of the bus chassis, and the conversation between other passengers. All of these may be viewed as sources of stress which contribute to discomfort.

Mass transit vehicles can be designed with a greater capacity to provide an acceptable ride. The inability to define the term "ride quality" prevents economically feasable efforts in this direction. A suitable definition would require a listing of those stimuli (noise, vibration odors, temperature, etc.) along with their magnitude which are associated with a comfortable ride. With this kind of information i. hand, it would then be possible to write design standards for the construction of mass transit vehicles which would assure passenger acceptence.

N.A.S.A. grant NGR 47-025-001 to Norfolk State College was awarded for the purpose of providing basic information concerning the relationship between the comfort responses of passengers and the noise and vibration produced by a commercial bus travelling over urban and suburban streets and highways. A primary objective was to provide information concerning the age of the passenger as a determinant of the comfort response.

The rationale for studying passenger age is based on the proposition that any design standards which may ultimately result from this research should not exclude any group of potential passengers. The existing practice of checking out the ride and handling qualities of vehicles with test subjects, who are usually young, healthy, well educated males, would not accomplish that end. Jacobson (3) has reported data indicating that commercial airline pilots and crew members con-

sistently rate the ride quality of a flight much higher than the passengers. A survey of passenger attitudes (4) indicated that present ground transportation systems fall short of the needs of older persons.

The decision to use a bus in a field research setting, rather than ride simulators available at Langley Research Center, was based on several considerations. Many older individuals whose health is sufficient to maintain an independent existence, nonetheless, have health problems. These problems would often preclude their acceptance as subjects on ride simulators. Another concern determining the research setting was the desireability of collecting data under natural conditions. Even though noise and vibration are likely sources of passenger discomfort, we must bear in mind that other factors may have an appreciable effect. The field research approach also allows us to measure passenger attitudes towards aspects of the bus riding environment while their memory of the experience is still fresh.

This report covers activities for the period from 1 June 1973, when research activities began, to 30 June 1974.

1. The months of June to July were occupied with activities in preparation for data collection.

   (A) A 48 mile route through Norfolk and Virginia Beach, Virginia was selected. The route contained 18 road sections which represented urban and rural streets and highways. The same road sections were judged by each group of passengers.

   (B) A training task for the passengers was prepared by photographing horizontal lines of five different lengths. The numbers one though five were assigned to the lines. The passengers were expected to retain the simple number code and to assign the correct number as a sequence of forty photographic slides of individual lines were presented.

(C) A questionnaire was constructed to assess demographic variables as well as attitudes toward traveling. The questionnaire was primarily adapted from the University of Virginia's Allegheny Airline survey (O.M.B. No. 104-S-72003). The questionnaire was designed to provide other researchers with a description of our subject population as well as to provide data for our purposes.

(D) Passengers were recruited for the investigation. Recruiting is done by contacting senior citizens service groups, social and fraternal organizations, and undergraduate students at Old Dominion and Norfolk State College. All passengers are paid volunteers.

(E) The student research assistants were given training on research with human subjects and techniques of data analysis. The faculty members visited other groups involved in research on the passenger comfort problem.

II. The period from September 1973 until June 1974 has been concerned with data collection and analysis. Data was collected on six bus rides. Two groups totalling 40 persons were of college age (18 to 25 years), two groups totalling 51 persons were of retirement age (60 to 75 years), and two groups totalling 33 persons were middle aged (40 to 50 years).

Standard city buses were chartered from the Tidewater Metropolitan Bus Company of Norfolk, Virginia. They were driven by drivers supplied by the bus company. Tire pressure was maintained at the same value for every ride. Buses of the same type and year were obtained for every ride. A research assistant briefed and monitered the driver as to speeds, manner of driving, and directed lane changes to enhance repeatability of environmental stimulation from ride to ride. All buses were air conditioned which served to maintain a relatively constant temperature on all rides.

The major phases of a bus ride were as follows:

(1) Passengers gathered at an assembly point and were escorted to a briefing room.

(2) They were served a light refreshment and were briefed as to the nature of the research and what was expected from them. Several possible sources of discomfort were mentioned, noise and vibration among them, however, the passengers were not led to believe that these sources were more important than any other.

(3) They were given the line length task. The purpose of this was to provide training for the comfort judgment task on the bus ride. The only difference between the two tasks was in the stimuli. They recorded their answers on mimeographed data sheets.

(4) The bus was boarded and the passengers were instructed as to how they were to respond. A six degree of freedom vibration transducer and magnetic tape recording instrument package (Biotron) had been placed in a standard location and warmed up before the bus was boarded.

Another tape recorder equipped with an omni-directional microphone to record the noise levels was in operation on the fourth bus ride. Problems with the supplier of the tape recorder resulted in late delivery such that we were unable to record noise on the first three bus rides.

Passengers were told to approach the ride as they would any other; sit where they liked, engage in conversation, enjoy the scenery, etc. As a road section was approached, a research assistant called out a ready signal. The passengers prepared to observe their comfort for the fifteen seconds required to traverse each road section. A research assistant announced the beginning and end of each road section. The first road section was designated as practice.

This was followed by eighteen other road sections. The passengers recorded their answers on mimeographed data sheets. All sections were spaced at least one minute apart. Proctors circulated to assure that the subjects complied with their instructions. Approximately one hour and twenty minutes were required to complete the route.

(5) Questionnaires were filled out at the end of the ride.

Proctors were on hand to assist. This terminated the bus ride.

There were three types of data to analyze: comfort ratings, questionnaire responses and vibration and noise data recorded in analogue form on magnetic tape. The data analysis is proceeding in three phases.

(1) The compilation of descriptive statistics for each type of data.

(2) The determination of any interesting differences between age groups within a data type.

(3) A determination of correlations between data types.

Comfort Ratings-- Descriptive statistics have been prepared. The standard deviations of comfort ratings for each road section were somewhat greater for the retired age group. This greater variability of comfort responses may reflect a more heterogeneous subject population, a more varied ride history, different rates of physiological ageing, or a lessened ability to make the complex judgment. An analysis of the other types of data is being conducted to restrict the alternative explanations.

It may be observed that the line judging task appeared to provide effective training for the bus ride in that only two cases of grossly inappropriate use of the comfort scale were found. In these cases, the subjects used the same comfort response for all road sections. Other researchers (5) who had not employed a training procedure, had reported a greater frequency of this type of inappropriate scale usage.

The mean comfort responses for seventeen of the eighteen road sections were greater for the retired age group. The college and middle-aged passengers showed equal discomfort. This effect was analyzed with t tests (6) and was found to be statistically significant for twelve of the seventeen road sections. This result was greeted with great surprise in that considerations of deteriorating health with advancing age would have led to the expectation of greater discomfort for the retired persons. The explanation of a general response bias can be ruled out in that both age groups used the full comfort scale. The six road sections on which both groups were in substantial agreement contained sections rated very comfortable and very uncomfortable. Two other explanations are being evaluated:

(1) Demographic factors other than age may be associated with the greater comfort for the retired group. These are being analyzed. Sex produces a weak effect in that males are less comfortable for six of the eighteen road sections, however, the age effect persists within a sex.

(2) It is also possible that we were not successful in producing the same motion environment for each age group. This will also be investigated.

Questionnaires-- These data have been partially summarized, and are too detailed for presentation here. The data have been coded for computer analysis in order to determine any correlations between demographic and attitudinal characteristics with the comfort ratings.

Vibration and Noise Recordings-- Technical problems with the data reduction system at Langley Research Center, Hampton, Virginia, are currently being resolved. When this has been accomplished, the recordings of the noise and motion environment during each road section will be reduced to measures of power spectral

density, range, and variance. Techniques for this analysis have been developed (7). Correlations between these measures and the comfort ratings will be determined to isolate stimuli which are associated with the comfort response. A standard multiple regression computer program is being adapted to our data.

The question of whether the age of the passenger determines his comfort can be erroneously answered in two ways. If we falsely conclude that a particular age group requires a softer, quieter ride, then our standards of rider comfort will be too stringent and result in needless expense in building mass transit vehicles. If we falsely conclude that the comfort requirements of the aged are the same for younger persons, we are falling short of the national policy embodied in the Urban Mass Transit Act of 1970 which states in part:

> It is hereby declared to be the national policy that elderly and handicapped persons have the same right as other persons to utilize mass transportation facilities and services; that special efforts shall be made in the planning and design of mass transportation facilities and services so that the availability to elderly and handicapped persons of mass transportation which they can effectively utilize will be assured; and that all Federal programs offering assistance in the field of mass transportation (including the programs under this Act) should contain provisions implementing this policy.

The research described above is being conducted in the field. Uncontrolled sources of variance exist in all types of research, however, the field researchers control of the environment is much less relative to that available to a laboratory researcher. These uncontrolled sources of variance can accumulate in some conditions more than others and result in spurious conclusions.

Replication, or the repetition of the same procedures with new passengers, will allow a determination of the reliability of the present results. This will assure that the tentative conclusions are not a function of the particular subjects used on the first series of rides. Replication will be one of the major purposes of the continuation under NASA Grant NSG-1074.

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