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RIDE QUALITY EVALUATION 1: QUESTIONNAIRE STUDIES OF AIRLINE PASSENGER COMFORT

Memorandum Report 403214

Short-Haul Air Transportation Program

by

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ABSTRACT

As part of a larger effort to assess passenger comfort in aircraft, two questionnaires were administered: one to ground-based respondents; the other to passengers in flight. Respondents indicated the importance of various factors influencing their satisfaction with a trip, the perceived importance of various physical factors in determining their level of comfort, and the ease of time spent performing activities in flight. The in-flight sample also provided a rating of their level of comfort and of their willingness to fly again. Comfort ratings were examined in relation to (1) type of respondent, (2) type of aircraft, (3) characteristics of the passengers, (4) ease of performing activities, and (5) willingness to fly again.

1. Introduction

What factors determine how comfortable a person riding in an aircraft feels? Such a question is of both practical and theoretical importance. Clearly, it is of concern not only to the commercial airlines, their marketing divisions, and aircraft design engineers, but also to psychologists and human factors specialists. There is obvious relevance of passenger comfort to the problems of aircraft design and to the problem of competitive advantage in the marketplace. In addition, the general problem of how people react to motion must be recognized in the specific context of the aircraft environment. In large measure, how comfortable a person feels in flight should depend on the physical variables (motion, temperature, pressure, etc.) to which he is exposed. However, other aspects of the situation (being in a plane, having certain attitudes about flying, social interactions on the plane, experiences in terminals, etc.) may also influence level of comfort, and thus alter the relationship between physical parameters and comfort. Unfortunately, little systematic data exist concerning the comfort of the airline passenger, although considerable information is available relating to the pilot and crew. However, most of this information is specifically concerned with the handling quality of the aircraft and not its ride quality.

The work reported here is part of an effort to assess passenger reactions to aircraft ride quality. The effort arose in the context of short-haul aircraft design. In order to develop short-haul systems having acceptable ride quality, it was necessary to explore the limits of comfort

for potential passengers with respect to various motion parameters. If such limits could be established for all possible motion variables, then a set of standards would exist for the development of new transportation systems. Initially, regular users of air travel were surveyed concerning their perceptions of aspects of flying. This initial probe was ground based, out of the environment of concern. In the second step of this program, the same kind of information was obtained from persons on board regularly-scheduled commercial flights. Both of these surveys were questionnaire studies.

These questionnaires were designed to help answer the following questions: (1) Who flys, how often, and for what reasons? (2) What factors are important in determining a passenger's satisfaction with a flight or a trip? (3) What physical characteristics of a flight do people perceive as important in determining their level of comfort? (4) How do passengers feel about flying? (5) How comfortable are they, and how does their comfort vary with who they are and what they experience? (6) How does level of comfort relate to one's ability to engage in various activities? and (7) How does comfort relate to one's willingness to fly again? Data concerning questions 1 through 4 were obtained from both questionnaires, while the last three questions were addressed only in the in-flight questionnaire.

The UVA/NASA ride-quality assessment program is basically a psychophysical enterprise. It involves both physically-measured characteristics of flight and subjective judgments. Also, both field studies and controlled experimentation have been undertaken. Phases of the project which have been completed include (1) a summary of general travel surveys to determine the

characteristics of air travelers (Lee and Jacobson 1972), (2) a literature review on the environmental variables related to human comfort (Jacobson 1974), (3) the design and construction of an instrument package for continuous measuring of the physical characteristics of the flight environment, (4) the design and administration of a ground-based questionnaire relating to the perceived aspects of flight, and (5) the design and administration of an in-flight questionnaire to assess people's experiences in aircraft.

This paper reports the results obtained from the questionnaires (4 and 5). The in-flight questionnaire was administered to passengers on-board regularly-scheduled commercial flights. Test subjects from the UVA/NASA subject pool were also present on each flight. The instrument package (3) was also on board so that the physical aspects of the flight were recorded. The second paper in this series will concern the physically-measured aspects of commercial flights and how they relate to the subjective judgments of both passengers and test subjects.

In addition, extensive research is being undertaken on the flight simulators at the NASA Langley Research Center and studies are underway involving in-flight simulators. A second in-flight questionnaire study is in progress with a revised questionnaire; a future paper will concern those results.

In this paper, the two questionnaires are described, then the samples actually obtained are characterized and compared to the results of previous travel surveys. The specific results of these questionnaires are then reported; first for those items common to both questionnaires, then for those specific to the ground-based sample, and finally those specific to

the in-flight sample. Subjective ratings of comfort from in-flight passengers receive special attention. They are related to type of aircraft, type of respondent, and individual differences of the passengers. Comfort judgments from the test subjects are compared to those of the passengers. Finally, the relation of comfort to the ease of performing activities and to a person's willingness to fly again is assessed.

2. Method

Questionnaires. Two questionnaires were administered; one to the ground-based subjects, the other to the passengers on board regularly-scheduled commercial flights. In order to maximize the response rate, these questionnaires were designed to be (1) as short as possible, (2) easy to administer, (3) clear, and (4) self-explanatory.

The in-flight questionnaires were completely anonymous. On the ground-based questionnaire, the respondent could supply his (or her) name and telephone number if he (or she) was willing to participate in a follow-up interview, but this identification was not required. Both questionnaires were in four-page booklet form, and were identified as projects of the University of Virginia, the National Aeronautics and Space Administration, and the participating airlines.

Both questionnaires asked for information in three categories: (1) general information regarding the respondents; (2) the perceived importance of various factors relating to satisfaction with an airplane trip; and (3) the perceived importance of various flight characteristics relating to comfort. The ground-based questionnaire also contained items relating to (a) activities which occupy one's time in flight, (b) general statements about air travel, (c) factors influencing choice of mode of transportation, and (d) characteristics of recent trips by the respondent. The in-flight questionnaire asked for (a) a comfort rating, (b) the difficulty of performing certain tasks, and (c) an evaluation in terms of willingness to take another flight; all three items were specific to the flight these passengers had just experienced. Two final items on the

in-flight questionnaire asked for the respondent's potential use for a high-frequency shuttle service, and a short-haul, intercity prop jet service. These questionnaires are reproduced as Figures 1 and 2.

Samples. The ground-based sample consisted of 528 employees of businesses and industries in the Commonwealth of Virginia. The questionnaires were sent to businesses in Richmond, Charlottesville, Waynesboro, Fredericksburg, Front Royal, Martinsville, Narrows, and the Tidewater area of Virginia. They were distributed by the companies or their travel offices to regular travelers. The ground-based data was collected in 1972.

The in-flight sample was obtained on the aircraft of Allegheny Airlines Commuter Service. Questionnaires were distributed to passengers on 130 flight segments of regularly-scheduled, commercial flights. Three types of aircraft were involved—the Nord 262, the Volpar Beech 18, and the deHavilland Twin Otter. All three are used for low-density, short-haul travel, and flight times were all less than one hour. The questionnaires were distributed to passengers either by the stewardess or one of the test subjects near the end of the flight. The 758 respondents represent a return rate in excess of 95%. The in-flight data were obtained in 1972-73.

Table 1 compares various characteristics of our ground-based and in-flight samples with the characteristics of the general flying public, as summarized in Lee and Jacobson's (1972) review of several thousand responses to general travel surveys. The in-flight sample closely approximates the general flying public in most respects. The ground-based sample overrepresents males; 41-60 year olds; executives; and people who travel

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> This questionnaire is part of an effort by the National Aeronautics and Space Administration and the University of Virginia to obtain information from the flying public to be used in the design of future transportation systems. The goal is to identify the needs and desires of airline passengers so that they can be satisfied by future systems. Your cooperation in completing this form will be appreciated and can only benefit you, the air traveler.
>
> We would like only your first impressions on each question, and you need not answer any questions that offend you.
>
> Thank you for your cooperation.

1. Age ______   2. Sex: ☐ Male ☐ Female

3. Occupation ____________________

4. In a sentence or two, how do you feel about flying? (Examples — I love to fly; I do it whenever possible; or I hate to fly and do so only when forced to by my job.)

____

____

5. Primary purpose of most of your flights?

☐ Business ☐ Personal ☐ Other

6. Who provides the funds for most of your flights?

☐ Business ☐ Personal ☐ Other

7. How often do you fly? (Examples — Once a week, once a month, etc.)

____

8. Place a check in the box which describes the importance of each of the following in determining your satisfaction with an airplane ride.

	Unimportant	Very Little Importance	Somewhat Important	Very Important	Of Greatest Importance
Comfort	☐	☐	☐	☐	☐
Convenience	☐	☐	☐	☐	☐
Cost	☐	☐	☐	☐	☐
Reliability	☐	☐	☐	☐	☐
Safety	☐	☐	☐	☐	☐
Time Savings	☐	☐	☐	☐	☐
Ability to Work	☐	☐	☐	☐	☐
Services on Board	☐	☐	☐	☐	☐
Surroundings	☐	☐	☐	☐	☐
Services in Terminal	☐	☐	☐	☐	☐

9. Place a check in the box which describes the importance of each of the following in determining your feeling of comfort on an airplane ride.

	Unimportant	Very Little Importance	Somewhat Important	Very Important	Of Greatest Importance
Pressure Changes	☐	☐	☐	☐	☐
Noise	☐	☐	☐	☐	☐
Temperature	☐	☐	☐	☐	☐
Lighting	☐	☐	☐	☐	☐
Seat Comfort	☐	☐	☐	☐	☐
Up & Down Motion (bouncing)	☐	☐	☐	☐	☐
Side to Side Motion (rolling)	☐	☐	☐	☐	☐
Work Space and Facilities	☐	☐	☐	☐	☐
Presence of Smoke	☐	☐	☐	☐	☐

10. Which **five** of the following activities occupy most of your time in flight? Rank them using the numbers from 1 to 5 to show the position of each, with 1 representing the **most time** and 5 the least time. Use each number only once.

___ Eating	___ Conversation	___ Looking out the window
___ Drinking	___ Writing	___ Thinking
___ Sleeping	___ Daydreaming	___ Walking in the aisle
___ Reading	___ Smoking	

11. Below are some statements about air travel in general. Considering your **overall flight experience**, place a check in the column which indicates the degree to which you agree with each statement.

	Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree
The ride is very comfortable	☐	☐	☐	☐	☐
Writing is difficult during flight	☐	☐	☐	☐	☐
Service in the air is generally very good	☐	☐	☐	☐	☐
Flying is too expensive	☐	☐	☐	☐	☐
Service in the terminal is very good	☐	☐	☐	☐	☐
Reading is easy during flight	☐	☐	☐	☐	☐
It is easy to sleep during flight	☐	☐	☐	☐	☐
Conversation is easy during flight	☐	☐	☐	☐	☐
Eating is easy during flight	☐	☐	☐	☐	☐
Airplane seats are comfortable	☐	☐	☐	☐	☐
Concentration is difficult while flying	☐	☐	☐	☐	☐
It is easy to relax while flying	☐	☐	☐	☐	☐
I am more tired at the end of a flight than at the beginning	☐	☐	☐	☐	☐
Airplane interiors are in excellent condition	☐	☐	☐	☐	☐
I feel cramped due to lack of seating space on airplanes	☐	☐	☐	☐	☐

12. If you are going on a trip, what are some of the factors you would consider in choosing to go by air rather than by another mode of transportation (such as train, bus, car, etc.)?

____

____

13. Please fill in the table below for your past few intercity trips, as best as you can remember.

Trip	Route	Mode		Purpose of Trip	Length of Stay
1	From	☐ Automobile	☐ Train	☐ Business	
	To	☐ Airplane	☐ Bus	☐ Other	
2	From	☐ Automobile	☐ Train	☐ Business	
	To	☐ Airplane	☐ Bus	☐ Other	
3	From	☐ Automobile	☐ Train	☐ Business	
	To	☐ Airplane	☐ Bus	☐ Other	
4	From	☐ Automobile	☐ Train	☐ Business	
	To	☐ Airplane	☐ Bus	☐ Other	
5	From	☐ Automobile	☐ Train	☐ Business	
	To	☐ Airplane	☐ Bus	☐ Other	

> The success of this program depends on your understanding of the questions asked and our knowledge of your feelings. To accomplish this, we would like to discuss this questionnaire in greater depth with you. If you are willing, please put your name and telephone number at which we can contact you in the space below and we will make an appointment to talk to you at your convenience.
>
> Name ____________________ Telephone Number ____________

FIGURE 1. GROUND-BASED QUESTIONNAIRE

Approval Expires 12-31-72

ALLEGHENY COMMUTER
Operated by Atlantic City Airlines, Inc.

UNIVERSITY OF VIRGINIA

This questionnaire is part of an effort by Atlantic City Airlines, the National Aeronautics and Space Administration, and the University of Virginia to obtain from you, the flying public, information to be used in the improvement of transportation systems. The goal of the program is to identify the needs and desires of airline passengers, so that future systems may increase passenger satisfaction.

Your cooperation in completing this form will be most appreciated and can only be of benefit to you, the air traveler. Thank you, and enjoy your flight.

Maurice C. Young
President, Atlantic City Airlines, Inc.

Please indicate only your first impression on each question. You need not answer any question that offends you.

1. Age _____ 2. Sex: ☐ M ☐ F

3. Education:
   - ☐ High School not completed
   - ☐ High School completed
   - ☐ College

4. Occupation:
   - ☐ Housewife
   - ☐ Craftsman, Mechanic
   - ☐ Professional, technical
   - ☐ Professional, nontechnical
   - ☐ Student
   - ☐ Armed Forces
   - ☐ Secretary, Clerk
   - ☐ Salesman
   - ☐ Manager, Official, Executive
   - ☐ Other_____

5. Industry of Employment_____

6. Approximate Household Income (before taxes):
   - ☐ Under $5,000
   - ☐ $ 5,000-$ 9,999
   - ☐ $10,000-$14,999
   - ☐ $15,000-$19,999
   - ☐ $20,000-$24,999
   - ☐ $25,000-$29,999
   - ☐ $30,000-$34,999
   - ☐ $35,000 or more

7. What is the primary purpose of this trip?
   ☐ Business ☐ Personal ☐ Other

8. How do you feel about flying?
   - ☐ I love flying
   - ☐ I have no strong feelings about flying
   - ☐ I dislike flying
   - ☐ I fly because I have to

9. Approximately how many times have you flown in the past **two** years?
   - ☐ None, this is my first flight
   - ☐ 1-3
   - ☐ 4-6
   - ☐ 7-9
   - ☐ 10 or more

10. How important is each of the following items in determining your feelings of comfort? Rank them using the numbers from 1 to 9, with 1 representing the **most important**, and 9 the least important. Please use each number only once.
    - _____Pressure changes (ears pop)
    - _____Noise
    - _____Temperature
    - _____Lighting
    - _____Seat comfort
    - _____Up and down motion (bouncing)
    - _____Side to side motion (rolling)
    - _____Work space and facilities
    - _____Presence of smoke

    Other_____

11. Place a check in the box which describes the importance of each of the following in determining your satisfaction with an airplane ride.

	Unimportant	Very Little Importance	Somewhat Important	Very Important	Greatest Importance
Comfort	☐	☐	☐	☐	☐
Convenience	☐	☐	☐	☐	☐
Cost	☐	☐	☐	☐	☐
Reliability	☐	☐	☐	☐	☐
Safety	☐	☐	☐	☐	☐
Time Savings	☐	☐	☐	☐	☐
Ability to Read	☐	☐	☐	☐	☐
Ability to Write	☐	☐	☐	☐	☐
Services on Board	☐	☐	☐	☐	☐
Surroundings	☐	☐	☐	☐	☐

12. Consider the motion you are experiencing. Indicate your reaction to this motion by checking the appropriate box:
    - ☐ Very Comfortable
    - ☐ Comfortable
    - ☐ Neutral
    - ☐ Uncomfortable
    - ☐ Very Uncomfortable

13. How difficult does the motion of this flight make the following activities?

	Not at all Difficult	Slightly Difficult	Difficult	Extremely Difficult	Impossible
Concentration	☐	☐	☐	☐	☐
Reading	☐	☐	☐	☐	☐
Writing	☐	☐	☐	☐	☐
Sleeping	☐	☐	☐	☐	☐

14. After experiencing the motion of this flight, I would: (Check only one)
    - ☐ be eager to take another flight
    - ☐ take another flight (without any doubts)
    - ☐ take another flight (but with some doubts)
    - ☐ prefer not to take another flight
    - ☐ not take another flight

15. Suppose a high-frequency shuttle service (8 or more round trips per day) were available at your local airport, scheduled to connect with flights of over 300 miles from a larger airport some distance away. Would you use the shuttle instead of ground transportation to the larger airport, if the cost were competitive?
    ☐ Yes ☐ No

16. Suppose a 25-passenger prop jet flew from an airport 15 minutes from your home or office to cities within 300 miles. Would you use this service rather than travel to a major airport an hour away?
    ☐ Yes ☐ No

(Please see last page)

THANK YOU FOR YOUR ASSISTANCE

FIGURE 2. IN-FLIGHT QUESTIONNAIRE

Table 1. Characteristics of the samples

	General Travel Surveys	Ground-based Sample	In-flight Sample
N	3000+	528	758
Sex			
Male	75%	98%	88%
Female	25	2	12
Age			
20 & under	12	9	6
21-40	40	37	47
41-60	35	60	42
over 60	13	3	5
Education			
College	80	N.A.	81
Noncollege	20	N.A.	19
Occupation			
Executive Managerial Professional Technical	60	84	68
Other	40	16	32
Purpose of Trip			
Business	75	93	79
Other	25	7	21
Income			
Median	$22,000	N.A.	$22,293

Note: N.A. = not asked on this questionnaire.

for business reasons. Given the distribution procedures for the ground-based questionnaires, these differences are quite reasonable.

Both samples were asked about their attitudes toward flying and the frequency with which they fly. In the ground-based sample, 60% of the respondents enjoy flying, 35% are indifferent or have no strong feelings, and 4% dislike flying. The in-flight sample answered a slightly different question. Here 45% of the people like flying, 34% have no strong feelings, 1% dislike flying, and 20% said they fly because they have to. It is possible for a person to check two response alternatives on this item, but they usually only checked one. People who checked "I fly because I have to" might enjoy flying or hate it. Some data, discussed later, suggest that checking this category is associated with a negative evaluation of flying.

As may be seen in Table 2, both samples contain a high percentage of frequent travelers: for the in-flight sample, 75% of the respondents had flown 10 or more times in the last two years and only 2% of these people had never flown before. The ground-based responses were coded as number of flights per two-month period. Clearly, the ground-based sample is biased toward very seasoned air travelers.

For each flight, there were three types of respondents. The passengers, of course, completed the entire questionnaire reproduced above. The crew completed a shortened questionnaire. Each flight also contained one or two test subjects from the UVA/NASA subject pool. These individuals are used for ride-quality studies on both commercial and experimental vehicles, as well as simulators. They include engineers, graduate students, secretaries, and others. The test subjects circulated the questionnaires, set up and

Table 2. Frequency of flying

In-flight Sample

Times flown (in past 2 years)	None	1-3	4-6	7-9	10+
Percent of respondents	2.3	6.0	9.4	7.3	75.0

Ground-based Sample

Times flown (per 2-month period)	1	2	3-5	6-8	9+
Percent of respondents	45.2	23.0	17.6	3.8	10.3

monitored the equipment which measured the physical variables, and rated their own comfort levels.

3. Results

Standard statistical techniques were used to explore the responses to individual items of the questionnaires as well as to study relationships between responses to sets of items. Responses of the ground-based and in-flight samples were compared, and then relations based on the data internal to each questionnaire were explored. Differences in responses based on various subject characteristics were also examined. The data analyses were performed on UVA's CDC-6400 computer and were predominantly run in the SPSS program package (Nie, Bent, and Hull 1970).

Factors in air travel satisfaction. The relative importance of nine factors relating to air travel satisfaction are shown in Figure 3 for both the ground-based and in-flight samples. The mean ratings are shown for each of the nine factors. All nine factors are judged at least somewhat important (no mean rating fell below 2.50); all are desirable, but some are clearly more essential than others. The rank ordering of the nine factors is the same for both groups, and the mean ratings from the two samples are quite close; the greatest discrepancy occurs for comfort, which seems slightly more important for the in-flight sample. Safety and reliability are of greatest importance to both samples. In both samples, comfort is rated less important than safety, reliability, time savings, and convenience, and more important than cost. There is a break in the mean ratings separating the first five factors from the last four. The first five all have mean ratings above 3.50 in both samples; the last four all fall below 3.50. The ground-based sample also rated terminal services. The mean rating of 3.30 places it between comfort and cost in importance.

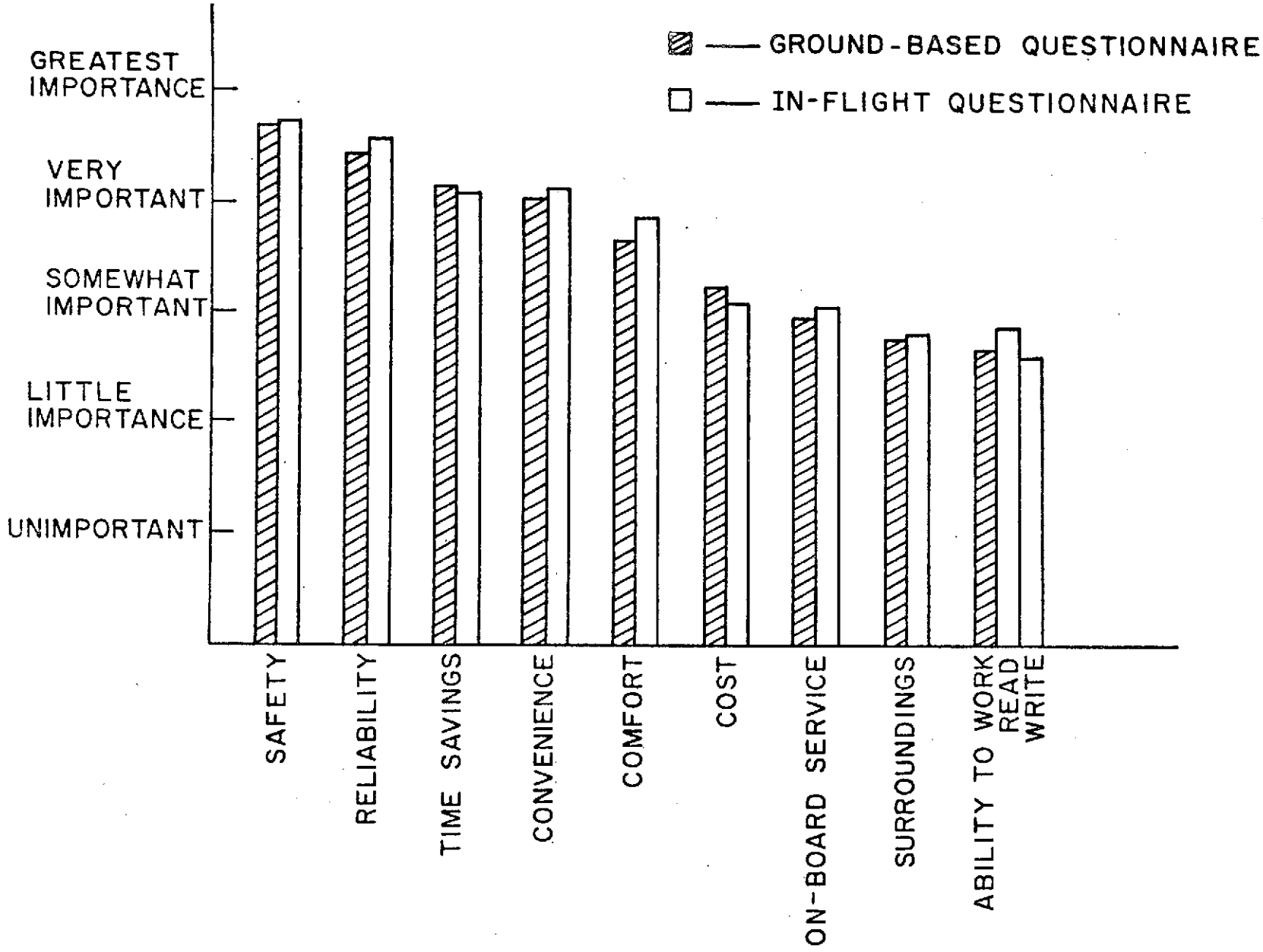

FIGURE 3. FACTORS IN AIR TRAVEL SATISFACTION

Table 3 shows the rank order of factors for various subgroups of the total flight sample. Partitioning the sample by sex; women rank time savings less important than convenience, and surroundings more important than ability to read. When purpose of trip is used as the partition, people traveling for business rate cost as of little importance. After all, the company's paying for it! People traveling for personal reasons rank time savings less important than convenience, and surroundings more important than ability to read. Thus, while the ground-based and in-flight samples agree on the rank ordering to these nine factors of satisfaction, some differences are apparent if the in-flight sample is divided on the basis of sex and of purpose of trip.

Physical factors in comfort. The perceived importance of various physical factors which relate to comfort were assessed differently for the two samples. On the ground-based questionnaire, a rating scale procedure was used. The in-flight questionnaire asked subjects to rank the nine factors with respect to their importance in determining feelings of comfort. Both questions were phrased to assess the perceived influence of these factors on general feelings of comfort. Table 4 contains the rank orderings derived for both total samples and for various subgroups of the in-flight sample.

The ground-based sample differs from the in-flight sample in several ways: the most pronounced difference is the ranking for pressure changes; this factor was ranked fifth in importance by the in-flight group but seventh by the ground-based group. Two possible reasons may account for this discrepancy; first, the in-flight group being in situ may for that reason perceive pressure changes, while the ground-based group may not

Table 3. Rank ordering of factors in satisfaction for various subsamples

	Total Sample	Sex		Purpose of Trip	
	All	Male	Female	Bus	Pers
Safety	1	1	1	1	1
Reliability	2	2	2	2	2
Time savings	3	3	[4]	3	[4]
Convenience	4	4	3	4	3
Comfort	5	5	5	5	5
Cost	6	6	6	[8]	6
Services on board	7	7	7	6	7
Ability to read	8	8	[9]	7	[9]
Surroundings	9	9	8	9	8
Ability to write	10	10	10	10	10

Table 4. Rank ordering of physical factors in comfort

	Total In-flight Sample	Sex		Purpose of Trip		Ground-based Sample
		Male	Female	Bus	Pers	
Seat comfort	1	1	[4]	1	1	1
Noise	2	2	2	2	3	3
Temperature	3	3	3	3	2	2
Up & down motion	4	5	[1]	5	4	4
Pressure changes	5	4	6	4	5	[7]
Side-to-side motion	6	6	5	6	6	5
Work space	7	7	9	7	[9]	9
Lighting	8	8	7	8	7	6
Smoke	9	9	8	9	8	8

remember their effects, being out of the situation. Alternatively, since the in-flight group is actually in the small planes, their frame of reference would be this type of aircraft, while the ground-based sample would include both these planes and larger cross-continent types of aircraft. Given the cities sampled in the ground-based survey, it is likely that most of the respondents have had experiences with the commuter airlines. But the memories of subjects in the ground-based sample may be dominated by the larger aircraft.

Clear sex differences are apparent in the ranking of these factors. Women rate up and down motion as of primary importance to their comfort while seat comfort is relatively unimportant. The mean rankings for the male and female in-flight subsamples are displayed in Figure 4. The spacing of these means is of particular interest. The women don't differentiate the first six factors as clearly as men do. Some reversals in rank are also apparent when partitions are based on purpose of trip and attitude toward flying. Work space is rated least important by those flying for personal reasons.

Items specific to the ground-based questionnaire. In item 10 on the ground-based questionnaire, respondents indicated which of eleven activities they thought occupied most of their time during a flight. The five most important activities were ranked by each person. All the remaining activities were assigned a rank of 6 for the data analysis. The order of importance of these activities is shown in Table 5, along with the means and medians of the assigned ranks. Reading and thinking are clearly the most frequent activities; indeed these are the only activities whose modal rank was other than 6. Reading had a modal rank of 1, and thinking had a

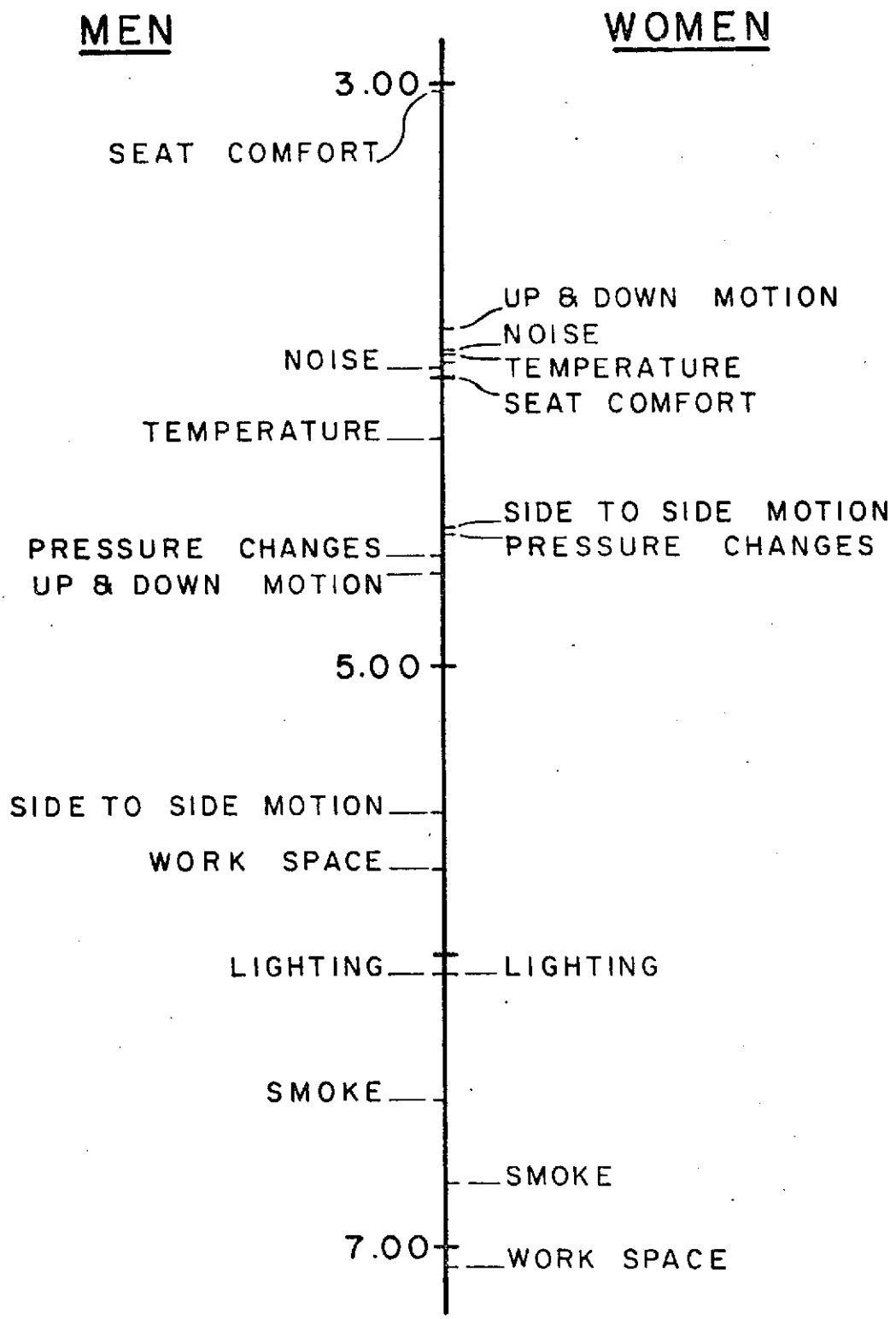

FIGURE 4. MEAN RANKINGS OF PHYSICAL FACTORS IN COMFORT ACCORDING TO SEX (Low Numbers Indicate Greater Importance)

Table 5. Item 10: Relative time spent on activities (ground-based sample)

	$\bar{X}$	Median	Rank (by $\bar{X}$'s)
Reading	2.13	1.39	1
Thinking	3.32	2.90	2
Conversation	3.86	3.78	3
Looking out window	4.33	4.92	4
Eating	4.54	4.69	5
Sleeping	4.89	5.57	6
Writing	5.00	5.72	7
Drinking	5.23	5.71	8
Daydreaming	5.49	5.86	9
Smoking	5.59	5.89	10
Walking in aisle	5.91	5.97	11

mode of two. Conversation is also frequently done. While most people read in flight, few write; lots of people think, but few daydream (or admit to it). Smoking, walking in the aisles, daydreaming, drinking, and writing are infrequently done. While some of these activities are limited by the characteristics of flight, writing and daydreaming would seem to be things people could do if they wished. The low ranking for daydreaming is probably due to the negative evaluation frequently associated with that term. Writing might be difficult to do although people might wish to be able to do it. However, in the previous question, ability to work was rated as less important than other factors in satisfaction with a flight.

Item 11 asked respondents to indicate their level of agreement with 15 general statements about air travel. Three general categories of statements were included: (1) items concerning factors in comfort; (2) items about the ease of performing certain activities; and (3) items relating to service and expense. A rating of 5 indicated strong agreement with the statement and 1 indicated strong disagreement; 3 was the neutral or uncertain point.

The item "the ride is very comfortable" was agreed to by 73.9% of the respondents and an additional 5.6% strongly agreed; the item mean was 3.72. However, only 55% of the respondents were in these two categories regarding seat comfort; 32% of the people disagreed with the statement "airplane seats are comfortable" ($\bar{X}$ = 3.18). Sixty-four percent of the respondents agreed that (they) "feel cramped due to lack of seating space on airplanes" ($\bar{X}$ = 3.61). The item "I am more tired at the end of a flight than at the beginning" showed a biomodal distribution of responses: seven percent strongly disagreed, 38% of respondents disagreed, 18% were uncertain, 32% agreed, and 6% strongly agreed; the item mean was 2.92. The interrelationships

between these four items were assessed using both the chi square test for association and Goodman and Kruskal's gamma coefficient for ordinal variables (1954). The items showed significant relationships for all pairs on both measures. The gamma value was .66 for the items ride is comfortable and seat is comfortable; indicating a relatively strong positive relation between these two judgments. A gamma of -.72 was found between feel cramped and seats are comfortable. Those people who found the seats comfortable tended not to feel cramped, and vice versa. People who said the seats are comfortable tended to disagree that they are generally tired at the end of a flight (gamma = -.34). Subjects who said the ride is comfortable tended to neither feel cramped (gamma = -.47) nor to feel tired at the end of the flight (gamma = -.46).

The items relating to activities in flight were examined in relation to the previous judgments from item 10. Ninety percent of the respondents agreed that "reading is easy during flight," and 75% disagreed that "concentration is difficult while flying." This agrees with the responses to item 10 where reading and thinking were the two most important in-flight activities. People do what it is easy for them to do. Seventy-four percent of the respondents agreed that "it is easy to relax while flying." However, only 57% agreed that it was "easy to sleep"; thirty percent disagreed. The statement "writing is difficult during flight" was disagreed with by 51% of the respondents, 21% were uncertain, and 28% agreed.

If these activities are arrayed by the rated ease of performing them, the resulting order is reading, relaxing, concentrating, conversing, eating, sleeping, and writing. Thus, for those activities which are common to both items 10 and 11, the correspondence of the rank orders is perfect.

Time spent performing an activity is directly related to the judged ease of doing it.

On the final set of statements, most people think that in-flight service is good; 84% of the respondents agreed with this item. Further there is general agreement that plane interiors are in excellent condition: nearly 56% of the respondents agreed, 26% were uncertain, and 18% disagreed. Terminal service is however rated poor: 49% of the respondents disagreed with the item terminal service is good and another 22% were uncertain. Forty-nine percent of our respondents think flying is too expensive. The median response was 3.47 which indicates more overall agreement than disagreement.

In-flight data: internal analyses. The basic measure of interest for the in-flight data was the rated comfort of the flight (item 12). This is the most direct assessment of the state of the passenger presumed to be the subjective correlate of ride quality. Comfort was rated on a five-point scale, labeled with adjectives ranging from very comfortable to very uncomfortable. These comfort ratings could then be related to (a) physical characteristics of the flight, (b) perceived characteristics of the flight, and (c) characteristics of the respondents as assessed by items 1 through 9 and various external information. Rated comfort could also be related to certain outcomes presumed to depend on the state of the subject, namely (a) the ease/difficulty of performing certain activities during the flight, and (b) the person's willingness to take another flight (evaluation).

It is assumed that many factors interact to determine how comfortable a passenger is: some of these involve physical inputs (the dynamics of the flight, physical environment, etc.); others, social inputs (stewardesses,

Table 6. Distributions of comfort ratings by type of respondent*

	Comfort Ratings					
	1	2	3	4	5	N
Passengers	5.9	32.0	38.0	20.1	4.1	748
Crew	35.1	38.8	13.4	12.7	0.0	134
Subjects	0.0	30.8	51.9	16.7	0.6	156

*Table entries are percent of row total.

Our test subjects are clearly more like the passengers than are the crews. Several explanations are possible for the crew's ratings: (a) the crew is generally so busy that they probably don't attend to their own comfort levels and therefore, having no negative evidence, rate the flight positively, and/or (b) as a matter of personal pride or airline policy, they are biased toward thinking their flights have to be comfortable for the passengers, and/or (c) the crew may have experienced such really bad prior flights that they seldom encounter a flight they would rate as uncomfortable ("You should have seen the flight back in '69 when the plane depressurized going over the mountain and an engine killed.") For whatever reason, the crew are bad judges of how comfortable their passengers are.

Types of aircraft. The relations of comfort ratings to rather detailed measures of the physical characteristics of flight will be reported in a subsequent paper. Global differences in comfort ratings as a function of type of aircraft are shown in Table 7. The raw chi square for the frequency table is 22.125 which has a p value of .005. The distribution of comfort ratings does vary with the type of aircraft. Both passengers and test subjects rated the Nord 262 better than either of the other planes, and the Twin Otter is rated most uncomfortable by both groups. The mean ratings by passengers for these planes were Nord 262 ($\bar{X}$ = 2.71), Volpar Beech ($\bar{X}$ = 2.97), and Twin Otter ($\bar{X}$ = 3.02). The test subjects yielded corresponding mean ratings of 2.47, 3.00, and 3.10. The comfort ratings are sensitive to differences in the types of aircraft on which they were obtained. The same pattern of means is apparent in both the passenger and subject data. The subjects show greater spread of the means and smaller standard errors than the passengers do.

Table 7. Distributions of passenger comfort ratings by type of aircraft*

	Comfort Ratings					
	1	2	3	4	5	N
Nord	7.6	35.3	38.0	16.4	2.7	408
Volpar Beech	1.0	34.0	37.0	23.0	5.0	100
Twin Otter	5.1	24.8	38.9	25.2	6.0	234

*Table entries are percent of row total.

Subject-passenger comparisons. A major concern of the in-flight test program is the degree of correspondence between the judgments of the experienced test subjects and those of the regular passengers. In particular, how well do the judgments of the test subjects approximate the mean of the passenger ratings for a flight? These questions arise in the context of simulator studies and testing experimental vehicles. Clearly, large samples of persons randomly selected from the general traveling public cannot be used for such studies. Sample size is limited by the economics of the situation, and who the particular subjects might be is limited by availability for testing, willingness to participate, state of health, etc. Test subjects need to be available for both ground-based and in-flight simulations, as well as regularly-scheduled commercial flights.

If a correspondence of judgments can be demonstrated in the commercial flight situation, then there is a greater likelihood that the results of simulation studies using the test subjects will generalize to the wider population of passengers. Of course, it is necessary to periodically re-examine the correspondence on additional commercial flights to insure that the test or simulation experience is not changing the subjects' responses.

In Tables 6 and 7, some correspondence is apparent in terms of the global distributions of comfort ratings. Responses of test subjects are more like those of the passengers than are the crew's, and the same conclusions are implied by the passenger and subject data.

A more direct indication of the correspondence is provided by Figure 5. This is a scatter plot of the mean of the passenger responses for each

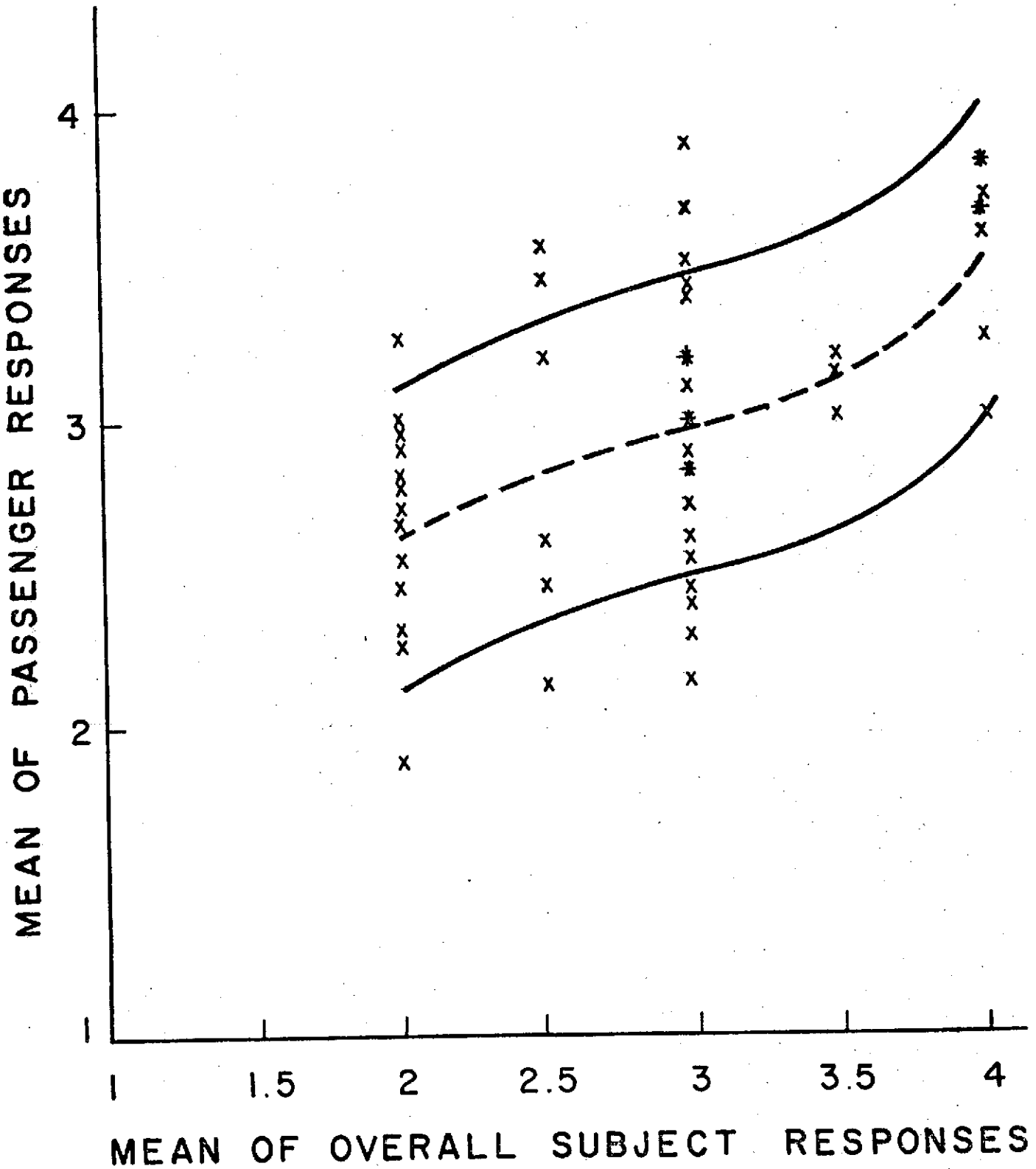

FIGURE 5. SCATTER PLOT OF PASSENGER MEAN RESPONSES AGAINST SUBJECT MEAN RESPONSES

flight against the response of the test subject or the mean of the responses of two test subjects, depending on the flight. Only flights for which the number of passengers was greater than or equal to five are included. This restriction limited the number of flights (N) to 63. The Pearson correlation coefficient for these data is .52. There are, of course, two reasons why this coefficient is not larger: (1) the data show a curvilinear trend; in a polynomial regression analysis both the linear and cubic trends are significant; and (2) the passenger means represent essentially a continuous variable, while the subject means represent a discrete variable with only 5 actual levels. A transformation of the data could remove the effect of (1), but r would still not appropriately indicate the degree of relation between those two variables because of (2).

An alternative test of the relationship between these two sets of judgments is provided in Table 8. This table shows the percent of mean subject responses within a given fraction of the standard deviation of the passenger responses on a given flight. Thus, over all flights, 87% of the mean subject responses were within one standard deviation of the mean passenger response. In terms of the original comfort scale response units, 62% of the subject judgments are within half a unit (0.5) of the passenger means, while 97% are within one unit (1.0). Thus, the correspondence of subject and passenger judgments is quite good.

Individual differences for the passengers. The comfort ratings were also considered in light of individual differences, i.e., characteristics of the passengers which might relate to how they perceive the comfort of the flight. Those subject differences which were reflected in their ratings would provide important bases for sampling subjects for future

studies. In examining the global distribution of judgments for a particular type of person, it is assumed that types of people are randomly distributed across flights, that is, that type of person is not confounded with particular flight experiences, as would happen if all the women sampled were on particularly bad flights. Some obvious bases for stratifying passengers are age, sex, income level, occupation, previous flight history, attitude toward flying, and purpose of trip.

Two partitions of the age variable were explored; one involved three age categories (≤ 35, 36-54, and ≥ 55), the other 6 age categories (under 20, 20-29, 30-39, etc.). In neither case did the distribution of comfort judgments change with age level. Table 9 shows the latter contingency table.

The distribution of comfort ratings does not depend on the sex of the respondent. The frequencies on which Table 10 is based do probably represent samples from the same underlying population.

Table 11 shows the comfort response distributions based on purpose of trip. The chi square value for this table is not significant, although there seems to be a slight tendency for those traveling for personal reasons to give more favorable ratings and those traveling for other reasons to give less favorable ratings than business travelers. Table 12 relates sex to purpose of trip, and displays a strong relationship between these variables. The men in this sample travel primarily for business reasons, the women mostly for personal reasons.

Income level is not systematically related to the distribution of comfort judgments, and no clear differences result from occupation. Professional-technical persons tend to be somewhat less critical than managers. Most other occupation categories have too few cases to imply firm conclusions.

Table 9. Distributions of comfort responses by age of respondents*

	Comfort Ratings					
	1	2	3	4	5	N
Under 20	8	32	40	17	3	60
20 - 29	5	31	39	21	5	108
30 - 39	5	32	37	22	3	219
40 - 49	8	32	37	20	3	210
50 - 59	6	33	38	17	6	108
60 and over	5	28	39	21	7	43

*Table entries are percent of row total.

Table 10. Distribution of comfort responses by sex*

	Comfort Ratings					
	1	2	3	4	5	N
Men	5	33	39	19	4	587
Women	9	26	37	23	5	81

*Table entries are percent of row total.

Table 11. Distributions of comfort responses by purpose of trip*

	Comfort Ratings					
	1	2	3	4	5	N
Business	5	31	39	20	5	591
Personal	8	37	34	18	3	120
Other	7	26	32	35	0	31

*Table entries are percent of row total.

Table 12. Purpose of trip by sex*

	Purpose of Trip			
	Business	Personal	Other	N
Male	86.6	9.5	3.9	588
Female	32.1	60.3	7.7	78

*Table entries are percent of row total.

Attitudes toward flying. Passengers were partitioned according to their attitudes toward flying. This item allowed four alternative responses: loves flying, no strong feelings toward flying, dislikes flying, or I fly because I have to. Very few respondents indicated that they dislike flying. However, some respondents may have negative feelings toward flying, but feel that "I fly because I have to" is the most descriptive response alternative. When comfort ratings were examined as a function of attitude (see Table 13), a systematic trend was observed: those who love to fly usually give more positive ratings than those who have no strong feelings, and both of these groups are generally more comfortable than those who fly because they have to. The raw chi square for the frequency table was significant at $p \leq .005$. Attitude toward flying is clearly a potent variable influencing comfort ratings. Further, "I fly because I have to" seems to involve a negative connotation as reflected in the comfort ratings.

As may be seen in Table 14, sex is unrelated to attitude toward flying. Both men and women seem to have predominantly favorable attitudes.

Flight history. As previously discussed, the in-flight sample contains predominantly highly-seasoned travelers. Only 16 passengers of the 758 had never flown before, while 570 had flown 10 or more times in the last two years. Table 15 shows the influence of number of times flown on comfort ratings. No statistically-significant trends emerge from this data, but those who have had few flights (0-3) appear to be more critical than those who have had more. However, the small sample sizes in these categories make these data the least reliable in the table.

The relation of sex to flight history is shown in Table 16. Women do have less flight experience than men. Table 17 relates attitude toward

Table 13. Distributions of comfort responses by attitude toward flying*

	Comfort Ratings					
Attitude Toward Flying	1	2	3	4	5	N
Loves flying	11	37	32	17	3	338
No strong feelings	2	30	44	21	3	255
Dislikes flying	0	20	20	60	0	5
Have to fly	1	25	42	24	8	153

*Table entries are percent of row total.

Table 14. Distributions of feelings about flying by sex*

	Love Flying	No Strong Feelings Toward Flying	Dislike Flying	Have to Fly	N
Male	44.0	34.9	.7	20.4	588
Female	49.4	29.6	.0	21.0	81

*Table entries are percent of row total.

Table 15. Distributions of comfort ratings by flight history*

	Comfort Ratings					
Times Flown	1	2	3	4	5	N
None	6	25	38	25	6	16
1 - 3	5	26	29	38	2	42
4 - 6	11	34	31	18	6	71
7 - 9	4	25	49	20	2	55
10 or more	5	33	39	19	4	570

*Table entries are percent of row total.

Table 16. Distributions of flight history by sex*

	Times Flown					
	None	1-3	4-6	7-9	10+	N
Male	1.4	4.1	8.1	6.1	80.4	591
Female	7.4	17.3	18.5	13.6	43.2	81

*Table entries are percent of row total.

Table 17. Distributions of attitude toward flying by flight history*

Times Flown	Love Flying	No Strong Feelings Toward Flying	Dislike Flying	Have to Fly	N
0	41.2	41.2	0	17.6	17
1 - 3	46.7	28.9	4.4	20.0	45
4 - 6	62.0	28.2	0	9.9	71
7 - 9	38.2	49.1	0	12.7	55
10+	43.4	33.1	.5	23.0	562

*Table entries are percent of row total.

flying to flight history. Here no significant differences emerge. These two factors appear to be independent. People who fly often show no greater tendency to "love flying" than those who seldom fly.

Not surprisingly, frequency of flying is related to income level. Figure 6 shows the percent of people at each income level who have flown 10 or more times in the past two years. The relation is approximately linear up to the 30,000-dollar-income range, then flattens out.

Willingness to fly again. Passengers were asked to indicate their willingness to fly again in light of the flight they had just experienced. Presumably, how willing a passenger is to take another flight would depend on how comfortable he was on the flight he has just experienced. Table 18 clearly shows a relationship between the comfort rating for this trip and a person's willingness to fly again. The chi square for this table is highly significant, and the contingency coefficient is .56; gamma is .68. The nature of this relationship is illustrated by Figure 7. Here the eager to fly again and have no doubt categories were pooled, and the resulting percentages were plotted against comfort ratings. This can be viewed as a percent-satisfied curve. One can clearly predict the percent of passengers willing to fly again from their comfort ratings. The message to the airlines is, if you wish to have over 90% of your passengers with no doubts about flying again, provide a flight which yields a comfort rating of two or better.

Table 19 relates number of previous flights to willingness to fly again. Not much relationship is present; the contingency coefficient is .19, although those passengers with 6 or fewer flights are somewhat more dubious than those with 7 or more.

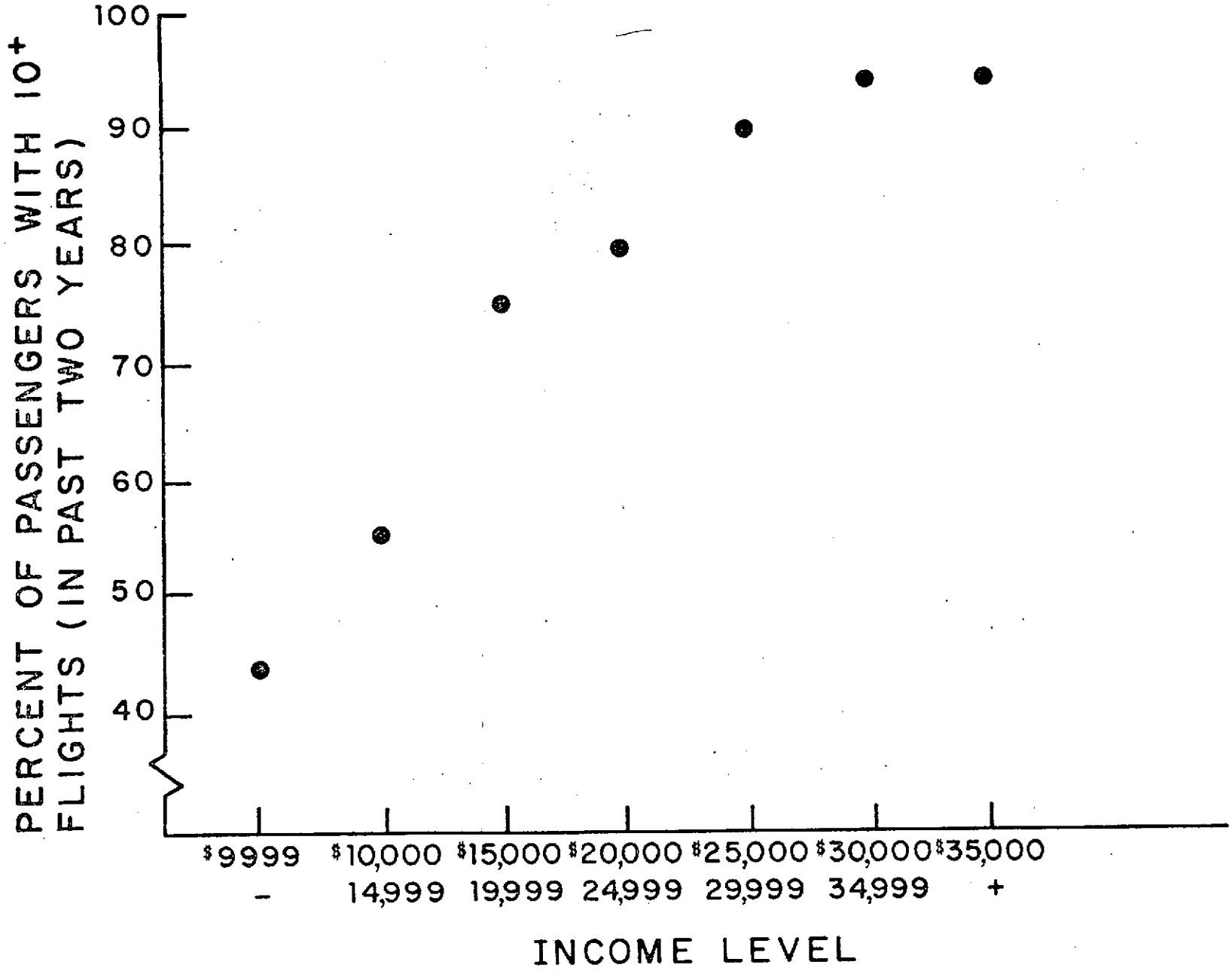

FIGURE 6. FLIGHT HISTORY BY INCOME

Table 18. Distributions of willingness to fly again by comfort level*

	Willingness to Fly				
	Eager	No Doubt	Some Doubt	Prefer Not	Never
Very comfortable	67	33	0	0	0
Comfortable	20	74	5	1	0
Neutral	8	73	12	6	1
Uncomfortable	3	49	29	17	2
Very uncomfortable	3	13	24	37	23

*Table entries are percent of row total.

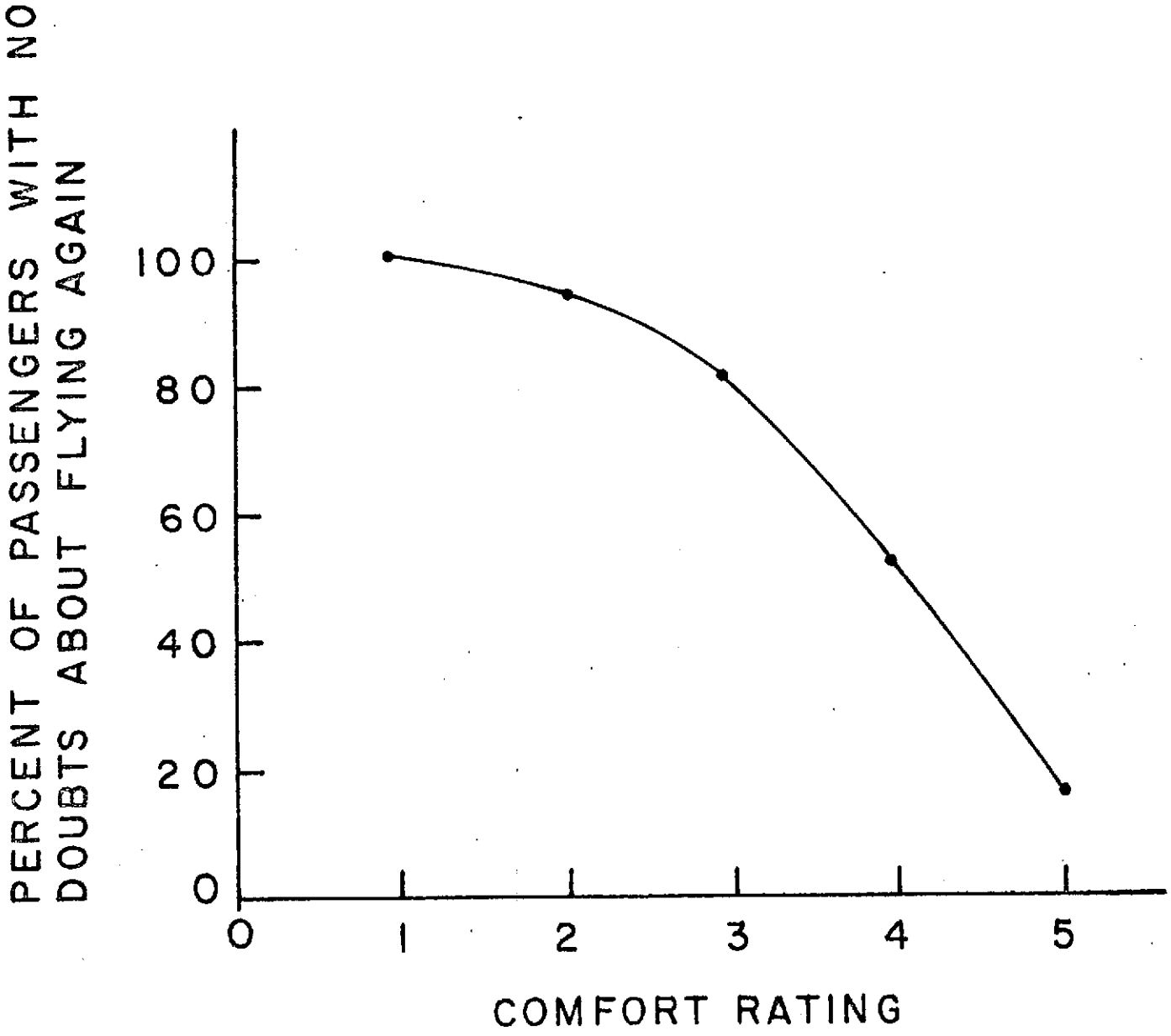

FIGURE 7. WILLINGNESS TO FLY AGAIN BY COMFORT LEVELS

Table 19. Distributions of willingness to fly again by flight history*

	Willingness to Fly Again					
Times Flown	Eager	No Doubts	Some Doubts	Prefer Not	Never	N
None	27	40	20	13	0	15
1 - 3	22	35	30	8	5	40
4 - 6	15	55	21	9	0	71
7 - 9	4	76	13	7	0	54
10 or more	14	66	10	8	2	562

*Table entries are percent of row total.

The theoretically most appealing predictor for willingness to fly again is rated comfort on this flight. A Pearson r of .53 was obtained for these two variables. A multiple regression analysis was also performed with four predictor variables: rated comfort, sex, feelings about flying, and times flown. Although significant B weights were obtained for rated comfort and feelings about flying, the multiple r was only .54. The gain in predictability from including 4 predictor variables was negligible.

In-flight activities. Passengers were asked to rate how difficult it was for them to perform each of four activities because of the motion of the flight. They had five alternative responses varying from "not at all difficult" to "impossible." The mean difficulty ratings over all flights and passengers were concentration ($\bar{X}$ = 1.75, se = .03), reading ($\bar{X}$ = 1.999, se = .04), writing ($\bar{X}$ = 2.51, se = .04), and sleeping ($\bar{X}$ = 2.52, se = .05). Thus, in general, concentration and reading are easier to perform in flight than writing and sleeping. This ordering of activities corresponds quite well to that obtained on the ground-based questionnaire.

How difficult various activities are to perform should be related to how comfortable the person trying to perform them is. Difficulty ratings for these four activities were correlated with comfort ratings using two measures of degree of relation. For each activity, gamma and the Pearson r, respectively, were computed to be: .62, .50 for concentration; .65 and .55 for reading; .64, .56 for writing; and .55, .49 for sleeping. Of course, given the sample size, all these coefficients are highly significant, one's ability to perform any of these tasks is related to one's level of comfort.

When the difficulty of performing these activities is related to times flown, only concentration shows a significant relationship.

Alternative air service. The final two items on the in-flight questionnaire concerned possible alternative air service. Passengers were asked whether they would use these services if available. For both the high-frequency shuttle service and the prop jet service, 92% of the passengers indicated that they would use such a service.

4. Discussion

Part of the continuing University of Virginia/NASA program on ride quality involves simulation of vehicle motions with both ground-based and in-flight (model-following) simulators. These devices are limited in terms of the number of subjects who can be run at a time and in terms of the total number of runs that can be made. Both time and economic factors constrain the number of subjects that can be used in simulations. The comparisons of our test subjects' responses with the mean passenger responses were designed to assess how well a few test subjects could approximate passenger reactions. The results of these comparisons were very encouraging. Mean passenger judgments on commercial flights could be predicted with reasonable accuracy using the judgments of one or two test subjects. Using simulator runs with 4-6 test subjects per run, one can be fairly confident that the pattern of results will generalize to airplane passengers.

The analyses of individual differences in comfort ratings sought to identify those characteristics of passengers which influenced the distribution of judgments differentially. If such differentiating variables are isolated, they would serve as bases for stratified sampling of subjects for simulator studies. Most of the passenger variables examined in this study had little or no effect on the distribution of comfort judgments; such variables were age, income, occupation, and sex. Purpose of flight and number of previous flights did not yield statistically significant differences, but some marginal trends, which might be important if replicated, were observed. The influence of number of prior flights

seems to separate those with 4 or more previous flights from those with 3 or less. One problem with selecting naive subjects for a simulator study is that, if the simulation is good enough, simulator experience would function as flight experience and produce a seasoned air traveler; that is, the simulator experience would change the subject. Thus a constant turnover of naive subjects would be necessary. The major basis for stratifying subjects would seem to be attitude toward flying. This variable had the greatest influence on overall comfort ratings.

Certain kinds of variables were not included in this study. Tendency toward motion sickness may be important, and it appears as an item on a revised version of the in-flight questionnaire. Physical characteristics of the passengers, such as height, weight, somatotype, general state of health, etc., might be important, but these kinds of items are thought to be sensitive and/or to facilitate identification of the passenger, and therefore could not be included. However, it should be noted that physiological differences correlated with age and sex did not produce strong differences in distributions of judgments.

A revised in-flight questionnaire has been developed based on the results of this phase of the flight program. A set of items about the seat, seat comfort, and seat location have been added. Items on motion sickness and the use of medication are included. Some items separate commuter airlines from other commercial flights.

The item on attitude toward flying has been divided into two questions: one three-alternative attitude item; and a two-alternative "I fly because I have to" yes/no item. Further, safety and reliability have been deleted from the factors to be ranked as contributing to satisfaction. Everyone

thinks these are of greatest importance and thus no information is gained by including them for ranking.

The comfort rating scale has been expanded to 7 scale points. How many scale points should be used, of course, depends on the range of the variable to be studied and the fineness of a person's experience of it, but it also depends on the subject population to be used. College students can reliably use many scale points, as can our trained test subjects. The evidence suggests that the airline passengers can also reliably use more than the five points previously provided.

An expanded list of physical factors which might influence comfort is included for passenger reaction, and, for various activities, passengers are asked to indicate both how much time was spent doing them and which ones were difficult to do.

From a marketing point of view, the data reported above supply a satisfaction curve. The airlines can decide what percentage of their passengers they wish to have no doubts about flying again and the curve indicates what comfort rating must be maintained. Of course, how to maintain a given comfort level requires more information than the present paper supplies; the physical correlates of rated comfort will be covered in the next paper in this series.

On other items with marketing and design implications, respondents indicated much dissatisfaction with terminal services, and some dissatisfaction with seat comfort and with the cost of flying. A sizeable number of respondents indicated willingness to use alternative air services.

The psychological implications of this work follow from a developing theory of how people make comfort judgments and what those judgments relate to. A network of relations is emerging in which comfort is positioned

posterior to a set of physical inputs and their sensory representations and prior to various activities and evaluations. Comfort is seen as a theoretical state, indexed by a rating, which people use in evaluating aspects of their environment. Comfort depends upon the physical characteristics of the flight environment, and on psychological properties of the passenger. Passenger attitudes toward flying is a determinant of rated comfort. Comfort level in turn determines how difficult it is to perform various activities in flight, and it influences how willing a person is to fly again.

The authors wish to acknowledge the support of the National Aeronautics and Space Administration, Langley Research Center, under Grant NGR 47-005-181, for this research. A preliminary analysis of some early portions of this data was briefly reported in Kuhlthau, A. R. and Jacobson, I. D., 1973, Analysis of passenger acceptance of commercial flights having characteristics similar to STOL, Canadian Aeronautics and Space Journal, 19, 405-409.

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