N76-16767

DEMOGRAPHIC AND PSYCHOLOGICAL VARIABLES AFFECTING TEST SUBJECT EVALUATIONS OF RIDE QUALITY

Nancy C. Duncan and Harold W. Conley

Hampton Institute

SUMMARY

Two ride-quality experiments, similar in objectives, design, and procedure were conducted, one using the U.S. Air Force Total In-Flight Simulator and the other using the Langley Passenger Ride Quality Apparatus, to provide the motion environments. Large samples (80 or more per experiment) of test subjects were recruited from the Tidewater Virginia area and asked to rate the comfort (on a 7-point scale) of random aircraft motion typical of that encountered during STOL flights.

Test subject characteristics of age, sex, and previous flying history (number of previous airplane flights) were studied in a two by three by three factorial design. Correlations were computed between one dependent measure, the subject's mean comfort rating, and various demographic characteristics, attitudinal variables, and the scores on Spielberger's State-Trait Anxiety Inventory.

An effect of sex was found in one of the studies. Males made higher (more uncomfortable) ratings of the ride than females. Age and number of previous flights were not significantly related to comfort ratings. No significant interactions between the variables of age, sex, or previous number of flights were observed.

Of the demographic and attitudinal variables, the only ones which correlated to the mean comfort ratings were attitude toward flying and the state anxiety score (a measure of the person's anxiety level during the test flight or ride).

In both experiments there was a high degree of reliability between the ratings of the same motion, when these motions were repeated after a relatively short time interval.

INTRODUCTION

Most investigations of the human response to, or sensitivity to, motion have used as subjects a small number of people selected primarily because of their availability, not because they represented a population of interest (ref. 1). The results of the studies reviewed by Hanes showed that threshold values of even one-degree-of-freedom sinusoidal motion differed considerably.

Hanes suspected a relationship between individual (subject) characteristics and responses to motions. If identifiable subject variables, such as age, sex, flight experience, are significantly related to subjective comfort ratings of motions, then these variables would have to be considered when conducting tests to determine ride comfort levels. The Hampton Institute researchers decided to test for such relationships by initiating a series of tests with the following objectives:

(1) To determine the relationship of the age, sex, and previous flying experience of the test subject to his comfort ratings of aircraft motion via an experimental design

(2) To determine the effect of other demographic and attitudinal variables via a correlation design

(3) To assess the anxiety level of each participant and its contribution to his reported comfort

In order to accomplish these objectives two experiments were conducted. One involved the U.S. Air Force Total In-Flight Simulator (TIFS) and the other, the Langley Passenger Ride Quality Apparatus (PRQA), a ground-based simulator. These two experiments provided the opportunity to test a wide range of frequencies and various degrees of freedom of motion. A detailed description of the TIFS and the PRQA and their performance characteristics is found in references 2 and 3, respectively.

The two experiments discussed in this paper had, in addition to common objectives, similar design and procedure which are described.

SUBJECTS

Paid volunteers were recruited from the Tidewater Virginia area which consists of the cities of Hampton, Newport News, Norfolk, and Virginia Beach. The ages of the subjects ranged from 18 to 75 and the number of previous flights from 0 to over 50. The subjects also represented a relatively large variation in income, occupation, and education level.

Due to limitations of the time and cost involved, the subjects were not "trained" in the use of the scale used to rate motion. One consideration in selecting subjects is whether they should be trained in the use of the scale used to rate the motion environment, for it is possible that people make major changes in the way they use the scale over the first few experimental sessions. If the subjects then become quite consistent in the way they use the scale, it is advantageous to the researchers since it increases the reliability and decreases the variability of the data obtained using these subjects.

References 4 and 5, for example, have used a small number of trained subjects to collect data on the passenger acceptance of the motion of commuter airlines.

EVALUATION PROCEDURE

All subjects were informed of the importance of basing their ratings on the comfort or discomfort of the vibrations and not variations or changes in vibration, or other factors such as temperature and noise.

Individual, subjective comfort ratings were recorded by means of a hand-held paper scoring sheet attached between a revolving cardboard disc and clipboard. The disc was designed to prevent the subjects from seeing their ratings of previous ride segments.

A 7-point rating scale, with associated numerical integers, as well as semantic labels, was used by each subject to indicate his level of comfort or discomfort.

For the purpose of analysis, however, the 7-point rating scale was converted back to a 5-point scale in order to make direct comparisons of subject responses across simulators, since other simulator experiments had been or were being conducted by means of a 5-point scale, and also to have the data available to other experimenters who were using only the 7-point scale.

A preliminary study confirmed our hypothesis that the test subjects' frequency of using the two extreme values on either end of the 5-point scale would not change if the rating scale were enlarged to a 7-point scale which includes the categories of somewhat comfortable and somewhat uncomfortable. A comparison of the two scales follows:

5-point scale	Rating	7-point scale	Converted 5-point scale
5	Very uncomfortable	7	5
4	Uncomfortable	6	4
	Somewhat uncomfortable	5	3.5
3	Acceptable (neutral)	4	3
	Somewhat comfortable	3	2.5
2	Comfortable	2	2
1	Very comfortable	1	1

EXPERIMENTAL DESIGN AND PROCEDURE

Subject characteristics (variables) which were thought more likely to contribute to different ratings of the same motion were selected and the experiments designed to detect any such effects. Consequently, the variables of age, previous flying experience, and sex were studied using an experimental design, that is, a two by three by three factorial experiment in which people were selected to fit into the following cells:

Previous Number of Airplane Flights

		0 to 3	4 to 9	10+
	18 to 25			
Age	26 to 45			
	46+			

Approximately equal numbers of males and females were placed in each group.

Prior to the simulator experience each participant in the study filled out a questionnaire which asked for demographic information (age, height, weight, education, income, occupation, sex), previous flying history (number of flights, type of plane, frequency per year, susceptibility to motion sickness), and attitude about flying (is it enjoyable, is it preferred over other means of transportation, is it safe). The responses to these questions were used to determine whether any of these demographic, attitudinal, or experiential variables were significantly correlated to the comfort rating of random aircraft motion. The questionnaire was designed to be quite similar to that used by the University of Virginia research team to survey users of commercial short-haul airlines (passengers filled out the survey while on board a flight) as well as potential users in a ground-based survey (ref. 6).

Since our test subjects were given no practice trials or other experience in the use of the rating scales, subjects were exposed to two "rides," the second of which was identical in whole or in part to the first and separated by a 30- to 60-minute interval. This procedure allowed us to check for consistency of responding.

A post-ride questionnaire provided an overall evaluation of each subject' reaction to the simulator experience. The third questionnaire, Spielberger's (ref. 7) State-Trait Anxiety Inventory (STAI) was administered to determine the amount of anxiety experienced while in the simulator (state-induced anxiety), and the amount of anxiety generally experienced by the subject (trait anxiety).

TIFS STUDY

Test Subject Profile

Eighty people participated in the Hampton Institute experiments on TIFS. Although the primary criteria for selection of test subjects were those of age, sex, and previous flight experience, our large subject pool allowed us to include people from many income and education levels and from a wide variety of occupations. The responses to the pre-questionnaire were used to compile a profile of the test subjects which included 41 females and 39 males. Figures 1 to 6 give the distributions for the demographic variables of age, sex, education, number of previous airplane flights, occupation, and income.

The distribution for each of these variables approximates that for the general flying public except for sex and income. (See ref. 6.) The general flying public is comprised of 75 percent, not 50 percent, males and has a median income of $22 000.

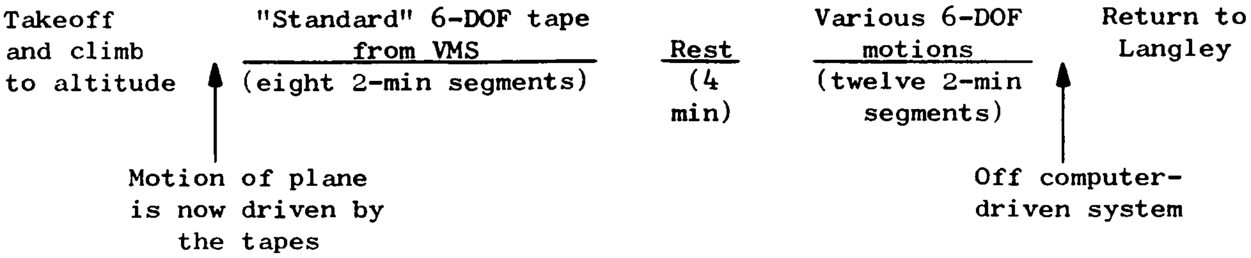
In response to the question about attitude toward flying, 76 percent said they enjoy it, 14 percent feel uneasy, 4 percent fear flying, and 6 percent were not sure (fig. 7). A ground-based sample of over 500 regular users of commercial airlines (ref. 6) had the following distribution: 60 percent enjoy flying, 35 percent have no strong feelings, and 4 percent dislike it. Responses to a questionnaire handed out during commercial flights (ref. 6) showed that 45 percent of that sample of 750 like flying. The TIFS test subjects consisted of a higher proportion of people who enjoy flying than either of these samples, a result to be expected when using people who volunteer to be part of a research program of this type.

TIFS Ride Environment

Investigators at the University of Virginia have measured the motion environment of a variety of STOL aircraft used by commercial airlines (ref. 4). They recorded 2-minute segments of the aircraft's motion at random intervals throughout a flight. The segments ranged from smooth, straight-and-level flight through extreme turbulence. Two investigators rated each segment for comfort with a 5-point rating scale (very comfortable to very uncomfortable). This data base was used to provide the motion environment for the TIFS aircraft.

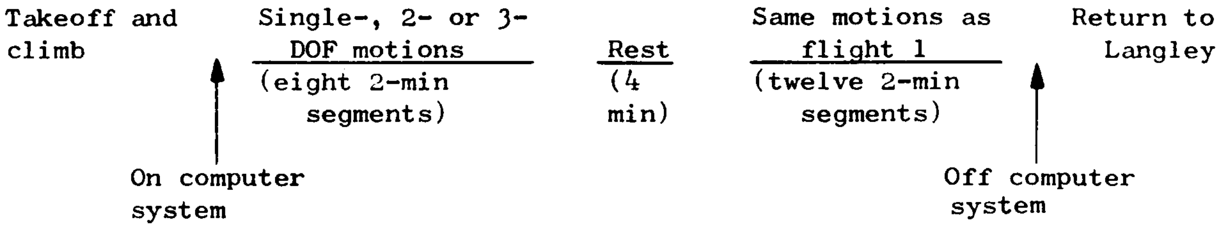
Since the interest was in simulating the whole range of comfort conditions, the inflight comfort ratings were used to construct the motion environment for the flights. "Typical" (as determined quantitatively from g_{rms} and deg/sec values) segments were selected from those which had been given a subjective rating of 1, 2, 3, 4, and 5, that is, from very comfortable to very uncomfortable. The segments were then strung back-to-back to produce an uninterrupted flight approximately 50 minutes in duration.

Previously, a 16-minute tape (constructed as described in the preceding paragraph) had been used to drive a 6-degree-of-freedom (DOF) Langley-based simulator, the Visual-Motion Simulator (VMS), and comfort ratings of the motion had been collected. This 16-minute "standard" tape was also included as part of the TIFS study to see if responses to it would be the same whether the subject was on the ground or in the air. The motion environments of the TIFS flights were as follows:



Flight 1

The first 16 minutes of flight 2 consisted of single-, 2- or 3-DOF motions in an attempt to determine the way in which people integrate multiple-DOF motions. The remaining 24 minutes of programed motion (segments 9 to 20) were the same as that of flight 1.



Flight 2

The g_{rms} values for the linear DOF and deg/sec values for the angular DOF actually produced by TIFS are given in tables 1 and 2. Table 1 presents the means and standard deviations of the motion components of the 6 first flights. Table 2 gives the same values for segments 9 to 20 of the 4 second flights. Data from the first 8 segments containing 1, 2, or 3 DOF are now being analyzed.

Segments 9 to 20 of flights 1 and 2 were programed to be identical, but, as tables 1 and 2 reveal, the mean values for each DOF for each segment were close but not exactly the same. A Spearman's ρ was calculated for each DOF by comparing the means of segments 9 to 20 of flight 1 to those of flight 2. As table 3 shows, there was a high positive correlation for each of the 6 DOF, indicating that the motion of flights 1 and 2 were indeed quite similar.

Test Procedure

Subjects assembled at the NASA facilities at Langley were told the purpose of the experiment and instructed how to rate the motion. This part of the procedure, as were as many others as possible, was standardized so that all subjects were given the same information and/or experience. After being informed that they might be video taped, subjects were seated on the plane according to a prearranged seating plan which randomly assigned people to seats.

Ten to twelve test subjects participated in each flight. Subjects were selected so that an equal number of males and females, an equal number of inexperienced (0 to 9 previous flights) and experienced (10+ previous flights) air travellers, and all ages were represented on each flight. The purpose of this selection procedure was to make certain that differences in the motion of the aircraft due to natural turbulence or any change in procedure due to weather conditions were equally distributed across the subject variables of age, sex, and previous flying history.

After the airplane had climbed to altitude and begun straight and level flights, the test tape was engaged. Subjects were instructed when to begin an evaluation interval and when to record the comfort rating over the airplane's public address system by one of the experimenters. Twenty-second portions of each 2-minute segment were selected for rating by the test subjects. The interval between ratings thus varied from 90 to 120 seconds. During the 4-minute rest period of flight 1, the state section of the STAI was passed out to the test subjects with instructions to answer it according to how they were feeling at that time. Post-questionnaires were distributed and answered as the plane taxied in after each flight. The trait side of the STAI was administered after the second flight.

Although 80 subjects participated in the TIFS experiments, only 58 were used in the experiments reported in this paper. Changes in scheduling due to weather conditions permitted only 40 of these to ride a second flight.

Two passengers on each flight were video taped so that nonverbal cues of anxiety could be measured to see if these cues correlated with the passengers' self-report, that is, did they appear to be anxious even if they would not admit to so feeling.

Results

The means and standard deviations of the comfort ratings of the 58 people who experienced flight 1 and the 40 who took a second flight are given in table 4. In order to obtain a second (repeated) measure of the subjects' rating of a stimulus, segments 9 to 20 on the second flight were programed to be identical to the corresponding segments on flight 1. Such a procedure provides a test for reliability of responding (ref. 8), a test not previously reported in the ride-quality literature. The data were first analyzed for the group as a whole. A Spearman's ρ correlation coefficient was calculated which compared the means of the ratings of segments 9 to 20 of flight 1 to those of flight 2 ($\rho = 0.937$, significant at the 0.01 level), which indicated that mean comfort ratings were consistent across flights, at least for the relative rankings of the segments.

Reliability of responding was also measured by using the mean comfort rating for each subject (SCR). The SCR is the mean of a subject's rating of segments 9 to 20. For those 40 people who experienced both flights, the Kendall correlation coefficient for the SCR of flight 1 to that of flight 2 was 0.53, significant at the 0.001 level, again demonstrating that untrained people can and do make consistent judgements of the comfort levels of motion.

The variables of age, sex, and previous number of airplane flights were analyzed two variables at a time by using an unweighted analysis of variance (ANOVA) for unequal N's (ref. 9). The dependent measure used for this analysis was the SCR for flight 1. The results of the ANOVA, which are presented in table 5, show that there were no significant main effects of the variables of age, sex, and previous number of flights or significant interactions of these variables. If there is a relationship between these variables and the subjective assessment of the motion encountered in flight, it is a more subtle effect than can be detected by using a mean of 12 responses (the SCR). For example, younger people might rate turbulent segments as more uncomfortable than older ones do but rate the smooth-and-level flight as less comfortable. The use of the SCR which averages the response to all segments would cancel ou such an effect. A more detailed analysis of the data which will look for such effects is currently underway.

Inspection of figures 8 to 10, which show the means for each of the 20 segments of flight 1 for males and females for the different age groups and fo those with different amounts of flying experience, respectively, demonstrates the most striking characteristic of the results of our TIFS investigation: the consistency with which the test subjects rated the ride quality of our test motions. The same segments, for example, were rated as being less than comfortable or acceptable (9, 12, 15, 17) by all the various subject classifications

Correlation coefficients of various demographic and attitudinal variable with the SCR of flight 1 were computed by using the SPSS statistical package (ref. 10) which gives both the Spearman's ρ and the Kendall's τ values. (See table 6.) The only significant correlation was that of SCR and feelings about flying (possible feelings were enjoy, uneasy, dislike, fear, and will not). Negative feelings about flying are therefore significantly associated with a higher mean rating of the comfort of the ride.

The Spielberger State-Trait Anxiety Inventory is a two part questionnair designed to measure (1) a person's present level of anxiety (his state of anxiety) and (2) his usual or typical level of anxiety (trait). Possible scores for each part range from 20 (very low anxiety) to 80 (very high anxiety). The mean trait score for the 58 people who rode the first TIFS flight was 32.38 (SD = 7.87), and the mean state score was 28.32 (SD = 8.13). The state score is lower than the trait score indicating that the subjects as a group were <u>less</u> anxious during flight 1 than they usually are. It seems likely that the novelty of being paid to take an airplane ride and of being a part of an NASA experiment were positive factors which reduced anxiety for most subjects. Observation of the nonverbal behavior of the 2 subjects per flight who were video taped confirmed their self reported lack of anxiety.

Although the test group as a whole had low anxiety levels on board fligh 1, some of the people did report moderate to high state anxiety levels. The Kendall test of significance did indeed show a significant, positive correlati

($\tau = 0.193$, $p < 0.05$) between state anxiety and the SCR. There was no correlation between the trait score for each subject and his SCR ($\tau = 0.007$).

PRQA STUDY

Subjects

A total of 85 subjects provided data for the PRQA study. As for the TIFS study, age, sex, and flight experience were the primary subject variables investigated. A comprehensive breakdown of these is presented in figures 11, 12, and 13.

Apparatus

The PRQA is capable of reproducing 3 DOF of the ride motion recorded from an actual vehicle. These three motions are vertical, lateral, and roll with high frequency and low amplitude capability. See reference 3 for detailed characteristics.

Procedure (PRQA Ride Environment)

Six subjects were tested simultaneously on the PRQA. Each subject was exposed twice (ride 1 and ride 2) to a 15-minute motion tape with 10 consecutive "ride segments" of selected motions. These motions were input with 2 DOF - lateral and vertical - obtained from recordings of random Taxi, Takeoff, Inflight, and Touchdown motions from actual STOL flights.

These motions were recorded by engineers in the Noise Effects Branch of the Langley Research Center; thus, they were not the same motions as used in either the VMS or the TIFS study. Consequently, a "one-to-one" comparison may not be made between the two studies regarding "ride comfort levels." In addition, it is important to note that the accompanying airplane sounds were not used with the PRQA study.

Each segment consisted of 60 seconds of motion with the middle 20 seconds serving as the "test portion." Segments 3 and 8 were the only segments with inputs of identical motion. A taped command of the words "Begin" and "Rate" signaled these 10 test portions per ride. A 30-second section of smooth flight preceded the first segment and separated all other segments.

There was an approximate 30-minute interval between ride 1 and ride 2, during which time a post-flight questionnaire and Anxiety Rating Scale were completed. The subjects were not informed that rides 1 and 2 were identical. Neither were they informed of the type of motion nor the sequencing.

Results and Discussion

Figure 14 shows the mean g_{rms} (acceleration at seat) value per segment. This value was obtained by averaging the g_{rms} values for all six seats per segment.

Figure 15 presents the mean comfort rating for ride 1 and ride 2 for eac segment. The corresponding standard deviation values are located to the right of each bar. In six of the segments the mean comfort rating was higher for ride 2 than for ride 1. The mean <u>increase</u> for these six segments was 0.128. The remaining 4 segments had a lower mean comfort rating for ride 2, amounting to a mean <u>decrease</u> of 0.062. Thus, the overall change in mean comfort rating from ride 1 to ride 2 amounted to a mean <u>increase</u> of 0.052. This consistency in rating between segments of ride 1 and ride 2 yields a Spearman's Rank Correlation of 0.94, which is significant at less than the 0.001 level. As these differences were relatively small and probably due (in this experimental procedure) to random factors, the mean for all 20 segments was used as the mean comfort rating.

Figure 16 represents the mean comfort rating per g_{rms} value. Again, a Spearman's Rank Correlation between these two variables yields a ρ of 0.94. It should be noted early in the discussion that only two of these mean ratings even reached the "somewhat uncomfortable" level; thus these motions were collectively experienced as being <u>not</u> uncomfortable.

Figure 17 shows the mean comfort rating for the three flight experience groups. In all ten segments the 4 to 9 flight experience group had the highest mean comfort rating. Figure 18 displays the mean comfort rating for the three age groups. In all segments, except 6 and 8, the 18 to 25 age group had the highest mean comfort rating.

Figure 19 displays the mean comfort rating for both sexes. In all segments the males have a higher mean comfort rating. It should be noted, howeve that this mean difference becomes very small on segments 2, 5, and 10. Figure 14 earlier presented these as the segments with the three highest g_{rms} value A comparison of the "difference" or "similarity" in ratings by the sexes conti gent upon g_{rms} values is shown in figure 20. When the RMS values are below 0.04 the males have considerably higher mean ratings than the females. Howeve when the RMS values are above 0.05 the mean ratings are only slightly higher for the males than the females. It is highly possible that females are more tolerant of certain vibrations than males. Thus, in this study, a certain RMS value -- or some other value -- had to be reached before a sex difference in responding to motion was negated.

Figure 21 shows the absolute difference in mean comfort rating between the sexes for RMS values. The 7 segments below the 0.04 RMS value have a mean difference rating of 0.41 between the sexes, whereas, the corresponding mean difference for the three segments with RMS values above 0.05 is 0.04. A Spearman's Rank Correlation yields a ρ of -0.76 between these RMS values an differences in ratings according to sex.

Figure 22 displays the mean comfort rating for both males and females pe flight experience category. Flight experience is divided into three categorie for the reduction of data. The three categories are (1) 0 to 3, (2) 4 to 9, and (3) 10+ actual airplane rides. In all three flight experience categories, the males had a higher mean comfort rating than the females. A two-way unweighted analysis of variance with unequal N's yields a significant main effect for sex, but not for flight experience. Neither was there a significant interaction effect. See table 7.

Figure 23 shows the mean comfort rating for males and females for the three age groups. A two-way unweighted analysis of variance yields neither a significant main effect nor interaction effect. Again, however, the male mean comfort rating was higher on all three categories.

Figure 24 presents the mean comfort rating for the three flight experience categories per age group. Again, the ANOVA yields no significant effects. It is interesting to note here that the subjects with ten or more flights, regardless of age category, were highly similar in their ratings.

Correlation coefficients between the mean subject comfort rating and (1) various demographic variables as well as (2) anxiety score measures are found in table 8. The only two significant correlations are between mean subject comfort rating and (1) weight and (2) state anxiety score. Closer scrutiny of the data could show that there is no independent relationship between weight and comfort rating. It is highly probable that the underlying relationship is between sex and comfort rating.

CONCLUDING REMARKS

Two experiments were conducted to determine whether age, sex, and/or flight experience, along with other demographic and attitudinal variables, in addition to anxiety levels, play a significant role in influencing a person's "comfort rating" of typical STOL aircraft motions.

It is again important to note that in all cases, the data were analyzed by using only mean values. Consequently, the conclusion must be considered in this frame of reference. When large and small differences are averaged, the resulting average yields only a moderate difference. Thus, with the relatively wide range of motions, actual subject differences in comfort ratings per segment may have been cancelled out when averaged over the 20 segments.

The only primary subject variable to significantly influence mean comfort ratings was the sex of the subject. This, however, was found only in the PRQA study, and only with motions having g_{rms} values (acceleration at seat) less than 0.04. These results could indicate that males are more sensitive to minimal RMS values, whereas females are more tolerant of these same motions. The TIFS study had 8 out of 20 segments with vertical g_{rms} values greater than 0.04. Thus, those motions may have obscured a sex difference, since the mean comfort rating of all 20 segments (the SCR) was used as the dependent measure.

Because it is possible that interactions exist between the demographic variables, it is recommended that factors such as education, occupation, and income should not be neglected when selecting subjects for ride quality studies.

A significant correlation between attitude toward flying and mean comfort rating may indicate that those subjects who have a positive attitude were more tolerant of typical STOL aircraft motion than those having negative attitudes toward flying.

There is an indication that a person's anxiety level at the time of flying, that is, anxiety generated as a result of being in an aircraft, affects his SCR to aircraft motion. This is supported by the significant correlation between a person's state anxiety score and his respective SCR. No significant correlation was found between a person's usual anxiety level (trait) and his SCR.

REFERENCES

1. Hanes, R. M.: Human Sensitivity to Whole-Body Vibration in Urban Transportation Systems: A Literature Review. APL/JHU-TPR 004, Johns Hopkins Univ., May 1970.

2. Schoonover, W. Elliott, Jr.; and Dittenhauser, James: Ride Quality Testing Under Controlled Flight Conditions. AIAA Paper No. 75-987, Aug. 1975.

3. Clevenson, Sherman A.; and Leatherwood, Jack D.: On the Development of Passenger Vibration Ride Acceptance Criteria. Shock & Vib. Bull., Bull. 43, Pt. 3, U.S. Dep. Def., June 1973, pp. 105-111.

4. Kuhlthau, A. R.; and Jacobson, I. D.: Analysis of Passenger Acceptance of Commercial Flights Having Characteristics Similar to STOL. Canadian Aeronaut. & Space J., vol. 19, no. 8, Oct. 1973, pp. 405-409 and M-1 - M-6.

5. Jacobson, Ira D.; and Rudrapatna, Ashok N.: Flight Simulator Experiments To Determine Human Reaction to Aircraft Motion Environments. Rep. ESS-4039-102-74 (NASA Grant No. NGR 47-095-202), Univ. of Virginia, July 1974. (Available as NASA CR-140055.)

6. Richards, L. G.; and Jacobson, I. D.: Ride Quality Evaluation. 1. Questionnaire Studies of Airline Passenger Comfort. Ergonomics, vol. 18, no. 2, Feb. 1975, pp. 129-150.

7. Spielberger, C. D.; Gorsuch, R. L.; and Lushene, R. E.: STAI Manual for the State-Trait Anxiety Inventory. Consulting Psychologists Press, 1970.

8. Neale, J. M.; and Liebert, R. M.: Science and Behavior. Prentice-Hall, Inc., 1973.

9. Kirk, Roger E.: Experimental Design: Procedure for the Behavior Sciences. Brooks/Cole Pub. Co., 1968.

10. Nie, N. H.; Bent, D. H.; and Hull, C. D.: Statistical Package for the Social Sciences. McGraw-Hill Book Co., Inc., 1970.

TABLE 1. MOTION ENVIRONMENT OF FIRST FLIGHTS (N = 6)
MEANS AND STANDARD DEVIATIONS OF EACH RATED SEGMENT

SEGMENT	*LONG ACC g's	LAT ACC g's	VERT ACC g's	ROLL RATE deg/sec	PITCH RATE deg/sec	YAW RATE deg/sec
1	.0018	.0024	.0069	.0960	.0424	.0251
	.0007	.0003	.0008	.0238	.0051	.0040
2	.0015	.0242	.0161	.8447	.1054	.2137
	.0003	.0010	.0025	.0222	.0148	.0124
3	.0014	.0029	.0087	.1114	.0571	.0267
	.0007	.0008	.0043	.0487	.0323	.0071
4	.0029	.0214	.0229	.9427	.2398	.2343
	.0021	.0020	.0142	.1625	.0428	.0501
5	.0027	.0160	.0160	.4007	.1586	.1387
	.0010	.0032	.0066	.0606	.0266	.0334
6	.0014	.0082	.0081	.6973	.0635	.0745
	.0007	.0006	.0019	.1377	.0162	.0637
7	.0020	.0032	.0088	.1990	.0523	.0578
	.0011	.0014	.0024	.1816	.0262	.0739
8	.0015	.0235	.0162	.9732	.1085	.1345
	.0001	.0092	.0046	.3100	.0307	.0522
9	.0045	.0196	.0928	.9490	.2663	.2879
	.0004	.0017	.0107	.0327	.0155	.0094
10	.0017	.0039	.0082	.1330	.0411	.0352
	.0016	.0026	.0046	.0682	.0145	.0251
11	.0034	.0100	.0498	.8749	.1475	.1405
	.0014	.0007	.0049	.0232	.0085	.0128
12	.0054	.0388	.1086	1.3942	.3647	.5172
	.0008	.0056	.0106	.2039	.0344	.1057
13	.0031	.0064	.0122	.3322	.0676	.1108
	.0019	.0017	.0059	.1780	.0163	.0751
14	.0048	.0093	.0505	1.3727	.2439	.3378
	.0010	.0009	.0052	.0479	.0096	.0171
15	.0038	.0660	.0559	1.7393	.3037	.4001
	.0007	.0974	.0071	.0773	.0046	.0159
16	.0017	.0032	.0075	.1180	.0475	.0251
	.0009	.0009	.0022	.0276	.0215	.0052
17	.0080	.0434	.1281	1.3820	.3511	.6288
	.0025	.0035	.0108	.3677	.2068	.0530
18	.0026	.0055	.0171	.2907	.0634	.0667
	.0013	.0007	.0016	.0087	.0054	.0034
19	.0045	.0081	.0583	.5194	.2137	.1330
	.0013	.0009	.0075	.0267	.0321	.0109
20	.0042	.0206	.0945	.9388	.2773	.2869
	.0008	.0015	.0117	.0061	.0235	.0101

* Upper value is mean value. Lower value is the standard deviation.

TABLE 2. MOTION ENVIRONMENT OF SECOND FLIGHTS (N = 4) MEANS AND STANDARD DEVIATIONS OF EACH RATED SEGMENT

SEGMENT	*LONG ACC g's	LAT ACC g's	VERT ACC g's	ROLL RATE deg/sec	PITCH RATE deg/sec	YAW RATE deg/sec
9	.0052	.0199	.0925	.9305	.2705	.3029
	.0011	.0015	.0110	.0572	.0152	.0097
10	.0021	.0046	.0067	.2323	.2264	.0672
	.0016	.0048	.0031	.2847	.3883	.0614
11	.0034	.0090	.0475	.8417	.1454	.1430
	.0006	.0010	.0060	.0313	.0049	.0079
12	.0064	.0376	.1108	1.4185	.3538	.5145
	.0008	.0077	.0175	.0538	.0268	.0970
13	.0015	.0050	.0104	.2461	.0511	.0883
	.0005	.0011	.0011	.0901	.0064	.0249
14	.0048	.0089	.0495	1.3483	.2540	.3430
	.0004	.0004	.0057	.0775	.0163	.0237
15	.0045	.0263	.0560	1.6425	.2927	.4053
	.0006	.0022	.0068	.0718	.0068	.0132
16	.0017	.0049	.0092	.2308	.0421	.0479
	.0005	.0028	.0064	.1727	.0109	.0375
17	.0084	.0399	.1168	1.3438	.3335	.6543
	.0019	.0055	.0189	.4599	.2015	.2040
18	.0025	.0063	.0182	.3241	.0567	.0734
	.0007	.0015	.0029	.0492	.0077	.0164
19	.0050	.0086	.0604	.5389	.2075	.1345
	.0007	.0015	.0069	.1009	.0071	.0131
20	.0050	.0210	.0927	.9021	.2741	.2955
	.0002	.0023	.0125	.0323	.0136	.0078

* Upper value is mean value. Lower value is the standard deviation.

TABLE 3. CORRELATIONS OF THE MOTION COMPONENTS OF FLIGHTS 1 AND 2

	ρ Value	Significance Level
Mean Vertical Acceleration	.993	.01
Mean Lateral Acceleration	.965	.01
Mean Longitudinal Acceleration	.909	.01
Mean Roll Rate	.986	.01
Mean Pitch Rate	.888	.01
Mean Yaw Rate	1.000	.01

TABLE 4. COMFORT RATINGS FOR FLIGHTS 1 AND 2

	FLIGHT 1		FLIGHT 2	
SEGMENT	MEAN	SD	MEAN	SD
1	1.92	0.80		
2	2.77	0.74		
3	1.98	0.71		
4	2.98	0.71		
5	3.12	0.76		
6	1.82	0.67		
7	1.85	0.74		
8	3.06	0.80		
9	3.66	0.95	3.36	0.71
10	1.86	0.80	1.72	0.76
11	2.70	0.82	2.22	0.74
12	3.76	0.87	3.65	0.68
13	1.96	0.84	1.79	0.75
14	2.48	0.77	2.66	0.64
15	3.47	0.81	3.44	0.83
16	1.72	0.70	1.81	0.87
17	3.83	1.03	3.72	0.98
18	1.84	0.75	1.97	0.78
19	2.03	0.72	2.00	0.71
20	3.09	0.85	3.24	0.74

TABLE 5. SUMMARY OF 3 BREAKDOWNS OF TWO-WAY UNWEIGHTED ANALYSIS OF VARIANCE FOR MEAN COMFORT RATINGS (UNEQUAL N'S PROCEDURE)

SOURCE	SS	df	MS	F
Sex	0.014	1	0.014	0.044
Flights	0.355	2	0.177	0.548
S × F	0.876	2	0.438	1.352
Error	16.866	52	0.324	
Sex	0.227	1	0.227	0.662
Age	0.292	2	0.146	0.426
S × A	0.292	2	0.146	0.426
Error	17.816	52	0.343	
Flights	0.240	2	0.120	0.346
Age	0.208	2	0.104	0.299
F × A	1.127	4	0.282	0.810
Error	17.057	49	0.348	

TABLE 6. CORRELATIONS BETWEEN MEAN SUBJECT COMFORT RATING OF FLIGHT 1 AND SOME DEMOGRAPHIC VARIABLES

Variables	N	Kendall's τ	Spearman's ρ	Significance Level
Age	58	0.047	0.062	NS
Income	55	0.031	0.036	NS
No. Previous Flights	58	0.019	0.021	NS
Feelings About Flying	57	0.224	0.279	<.05
No. of Flights/Year	46	0.015	0.018	NS
Education	58	-0.068	-0.088	NS

TABLE 7. SUMMARY OF 3 BREAKDOWNS OF TWO-WAY UNWEIGHTED ANALYSIS OF VARIANCE FOR MEAN COMFORT RATINGS (UNEQUAL N'S PROCEDURE)

SOURCE	SS	df	MS	F
Sex	1.913	1	1.913	5.335*
Flights	2.205	2	1.102	3.074
S × F	0.376	2	0.188	0.525
Error	28.331	79	0.359	
Sex	1.316	1	1.316	3.549
Age	1.083	2	0.541	1.461
S × A	0.171	2	0.086	0.231
Error	29.279	79	0.371	
Flights	1.582	2	0.791	2.240
Age	1.593	2	0.796	2.255
F × A	2.778	4	0.694	1.966
Error	26.845	76	0.353	

*$p < 0.05$

TABLE 8. CORRELATIONS BETWEEN MEAN SUBJECT COMFORT RATING AND SOME DEMOGRAPHIC VARIABLES AND ANXIETY MEASURES

Variables	N	Kendall's τ	Spearman's ρ	Significance Level
Age	85	-0.072	-0.092	NS
Flight Experience	85	-0.020	-0.022	NS
Education	85	-0.135	-0.171	NS
Occupation	85	0.018	0.027	NS
Weight	85	0.159	0.226	<.05
State Anxiety Score	80	0.225	0.301	<.01
Trait Anxiety Score	85	0.034	0.052	NS

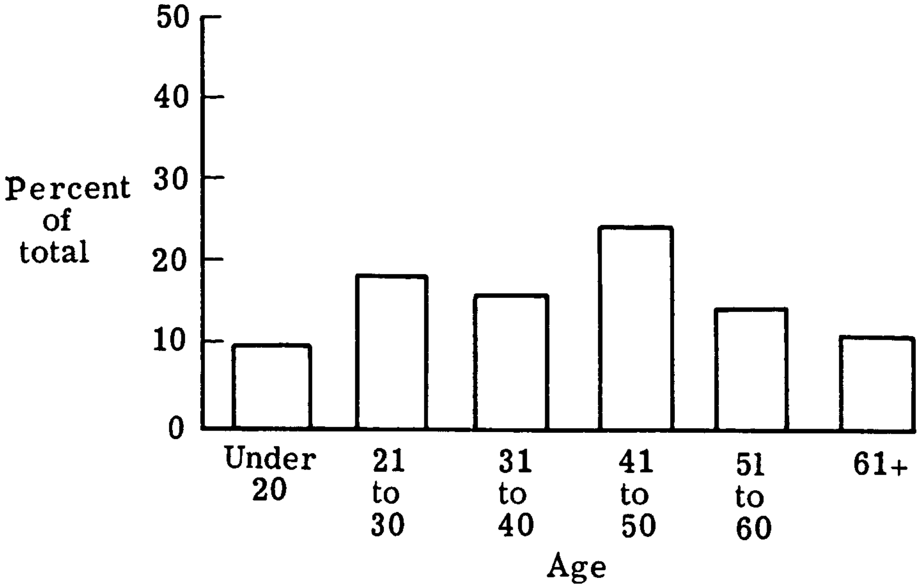


Figure 1.- Age distribution (TIFS).

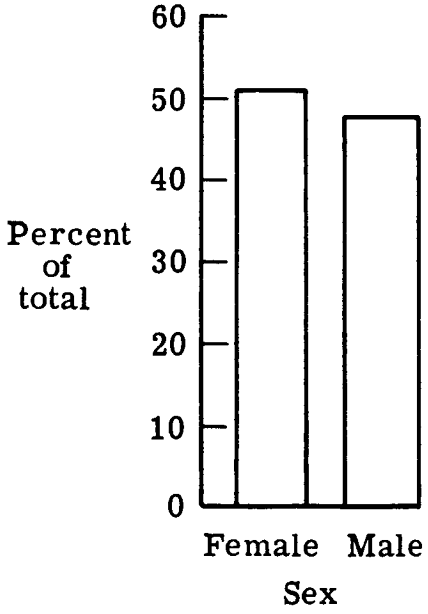


Figure 2.- Sex distribution (TIFS).

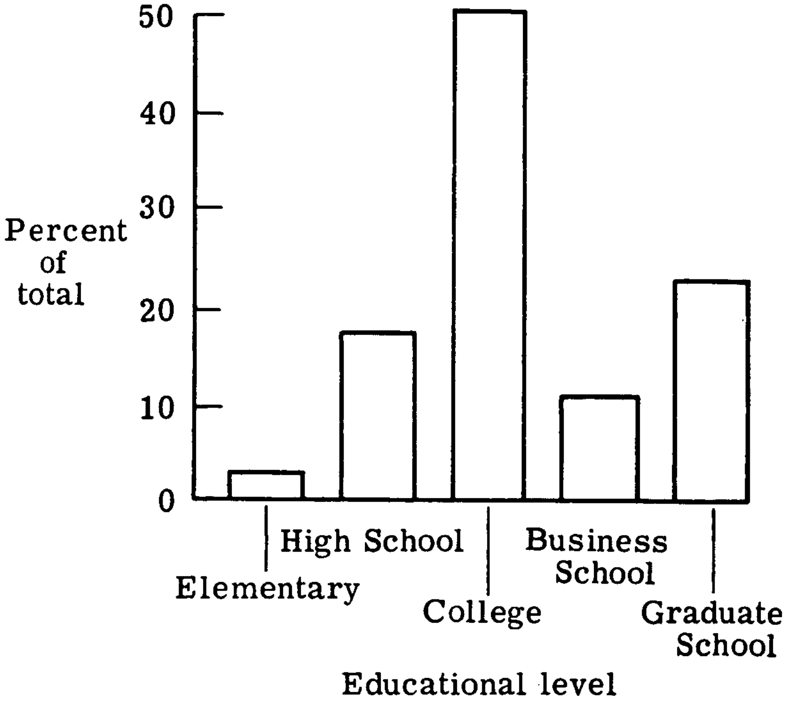


Figure 3.- Education distribution (TIFS).

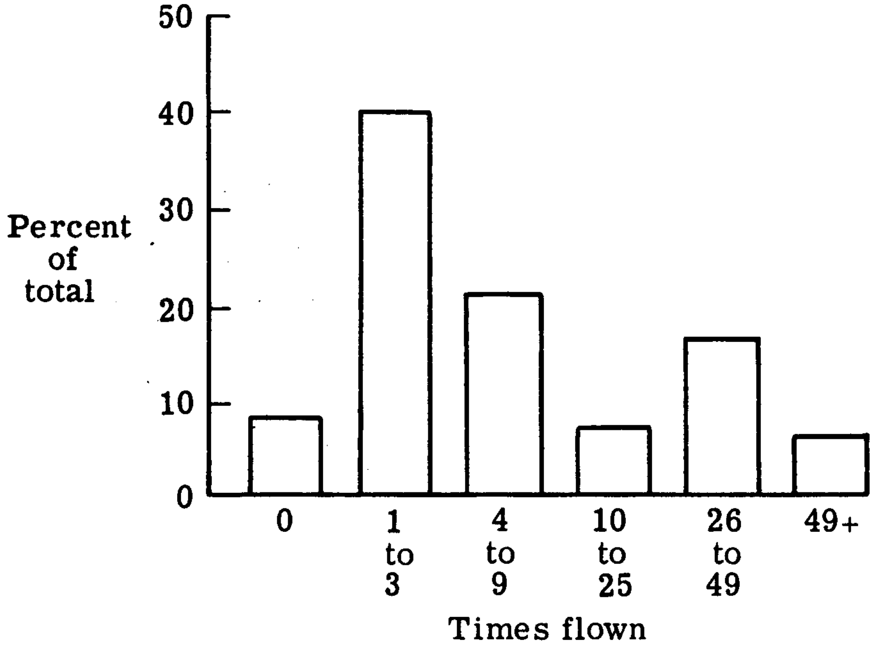


Figure 4.- Flight experience (TIFS).

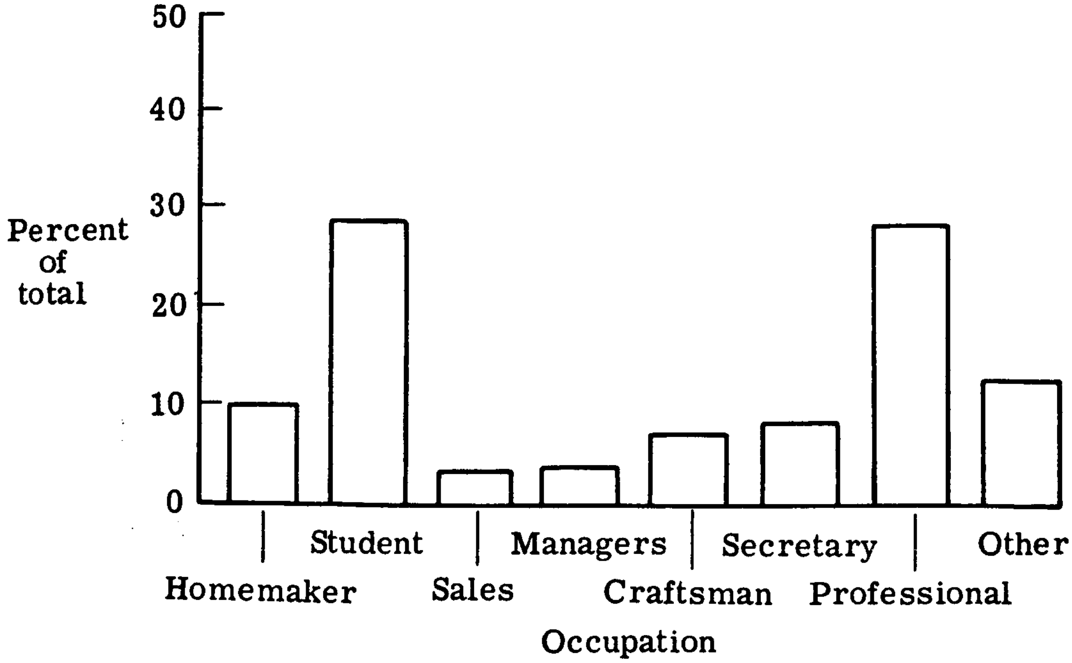


Figure 5.- Occupation distribution (TIFS).

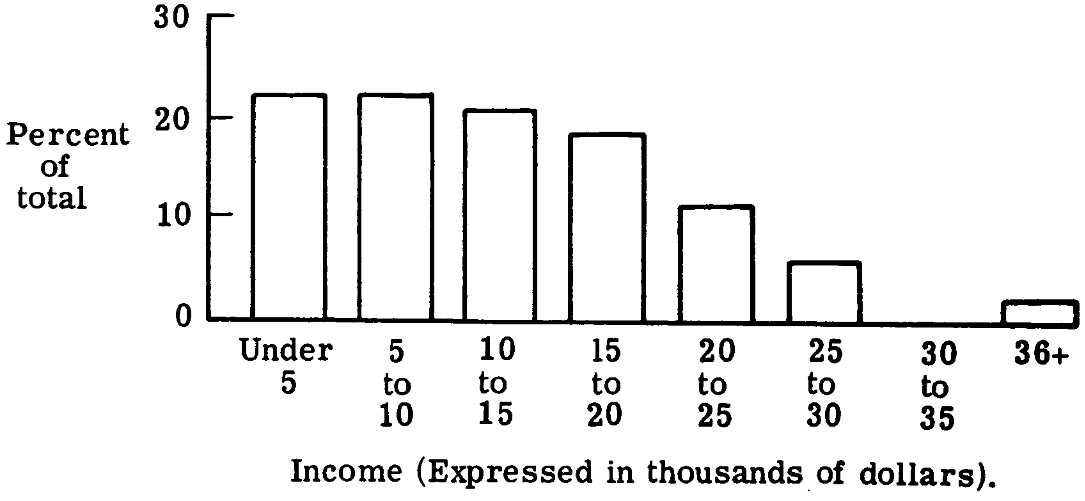


Figure 6.- Income distribution (TIFS).

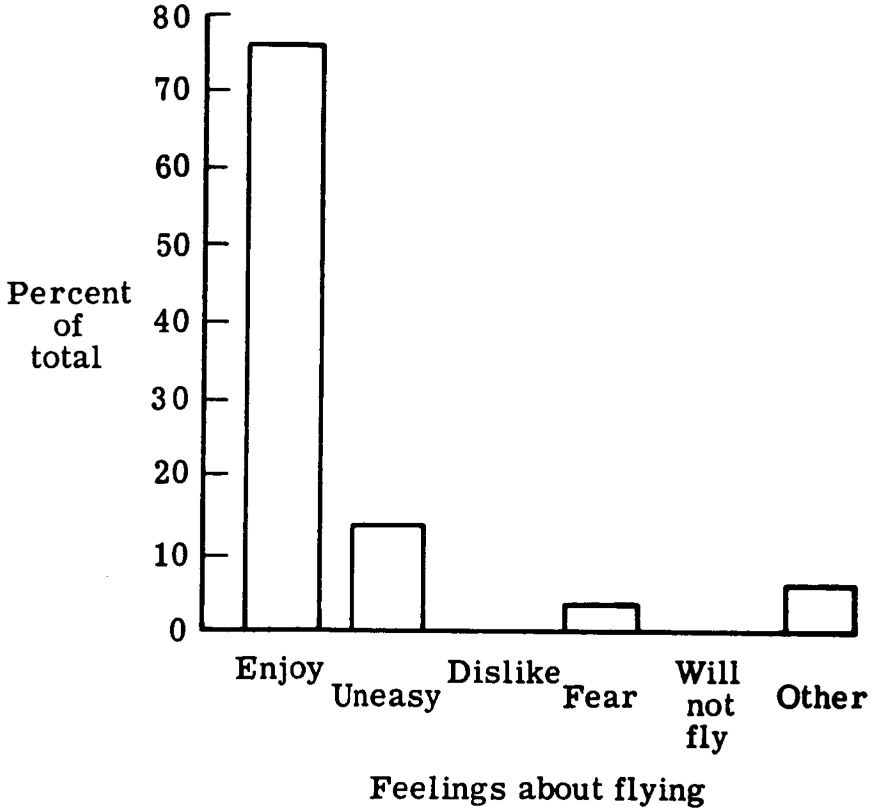


Figure 7.- Attitudes towards flying distribution (TIFS).

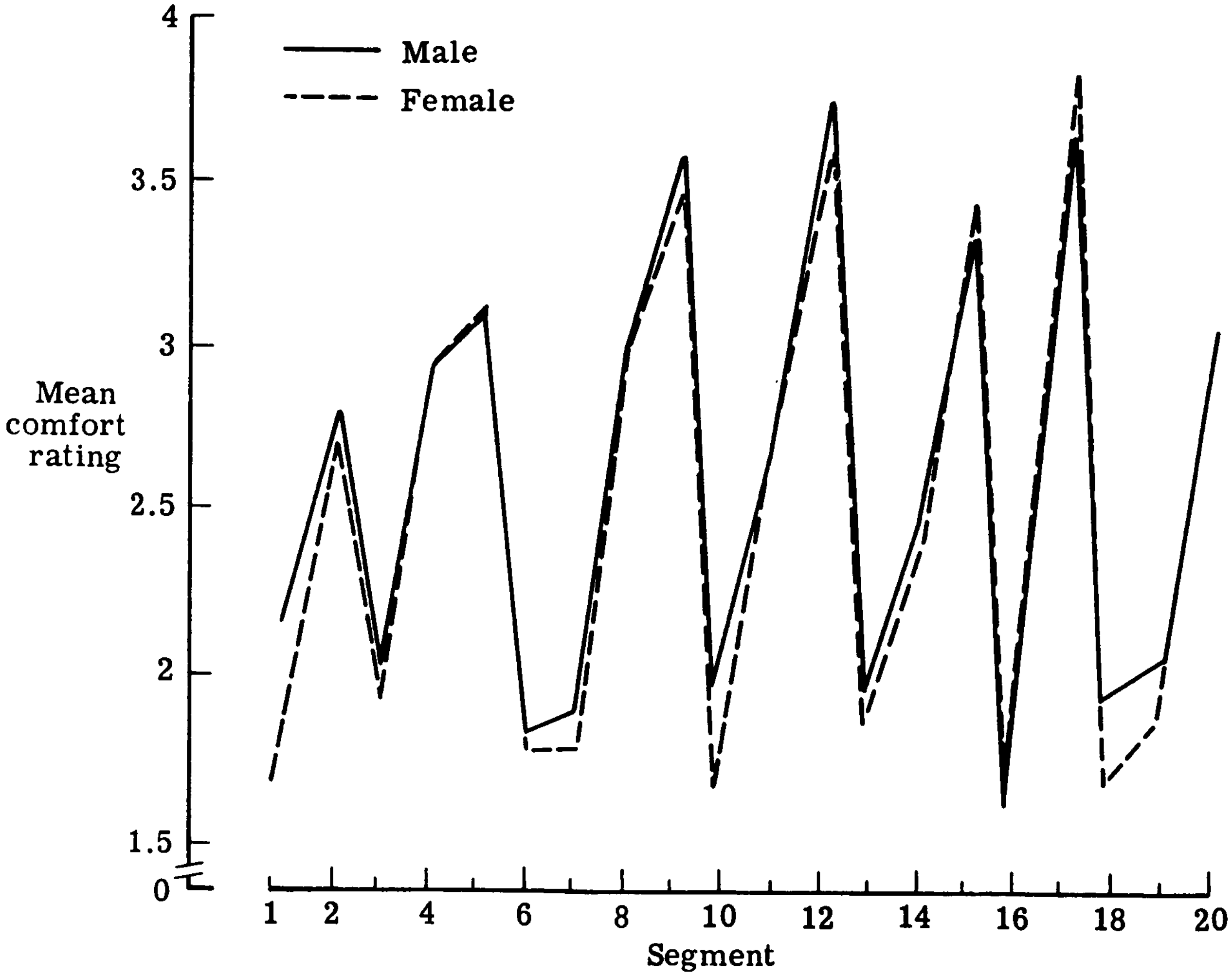


Figure 8.- Mean comfort rating as a function of sex (TIFS - flight 1).

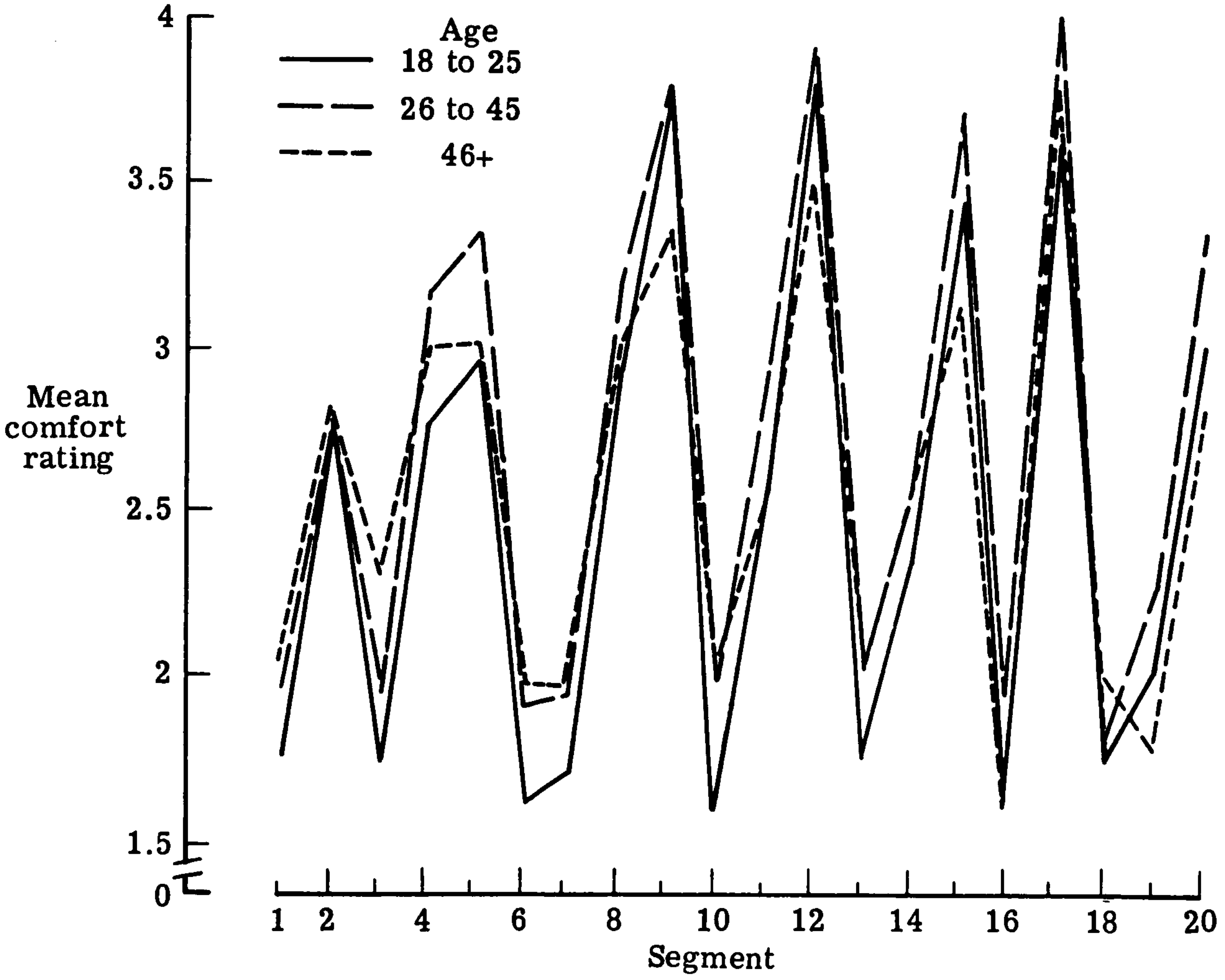


Figure 9.- Mean comfort rating as a function of age (TIFS - flight 1).

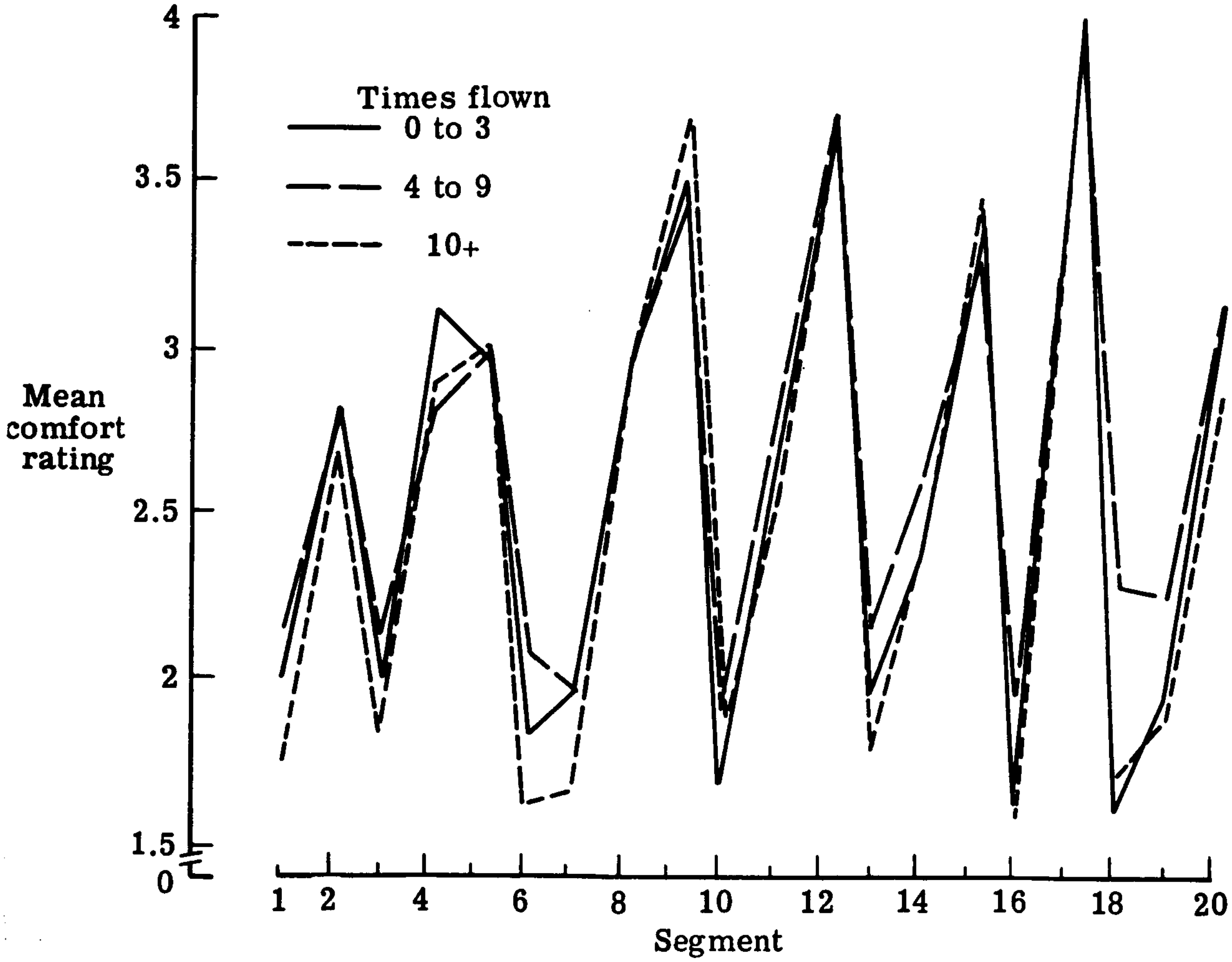


Figure 10.- Mean comfort rating as a function of flight experience (TIFS - flight 1).

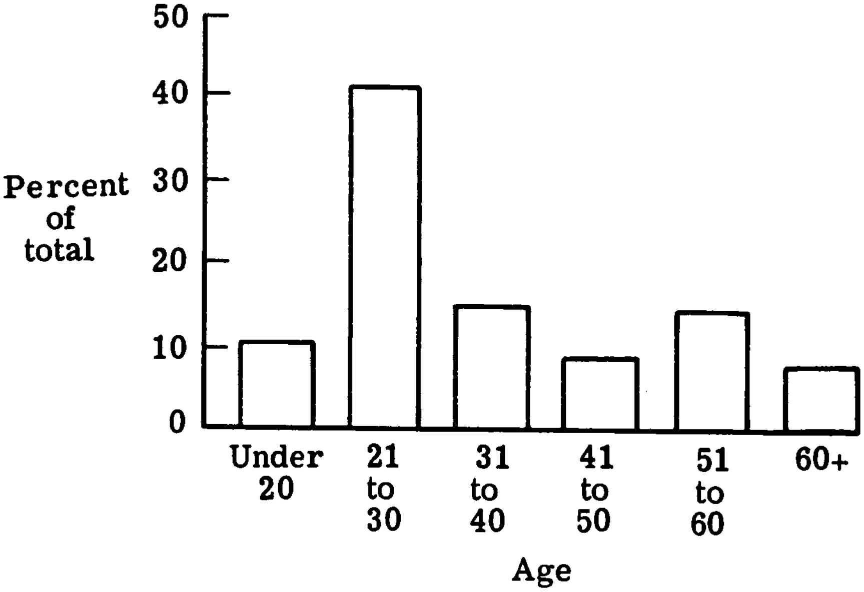


Figure 11.- Age distribution (PRQA).

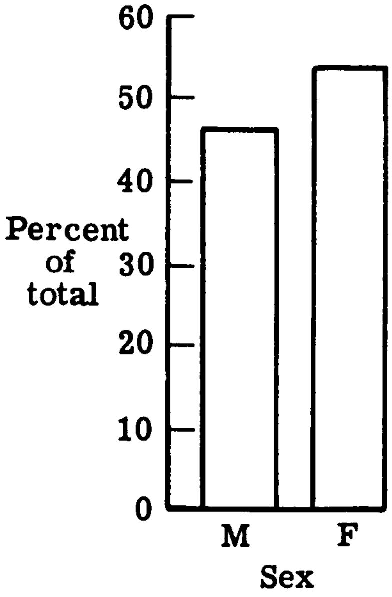


Figure 12.- Sex distribution (PRQA).

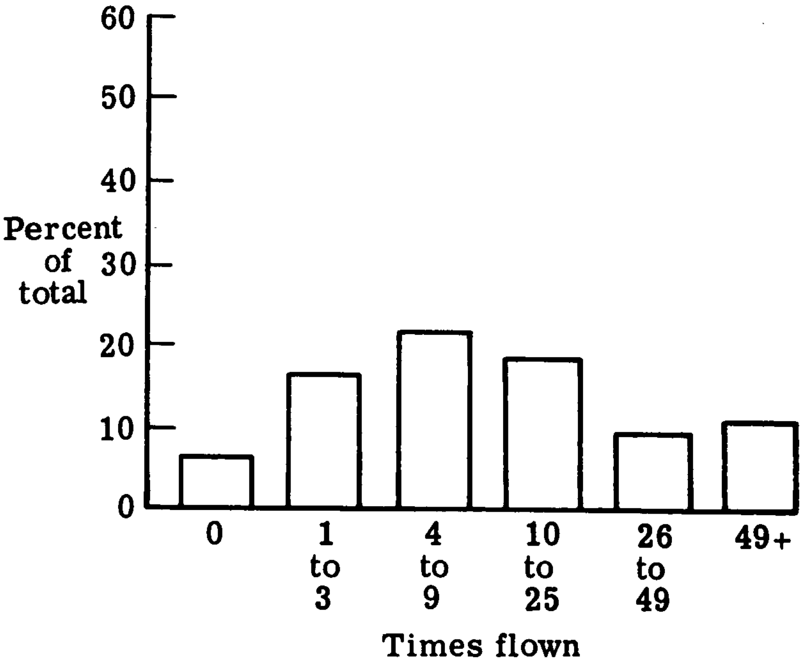


Figure 13.- Flight experience (PRQA).

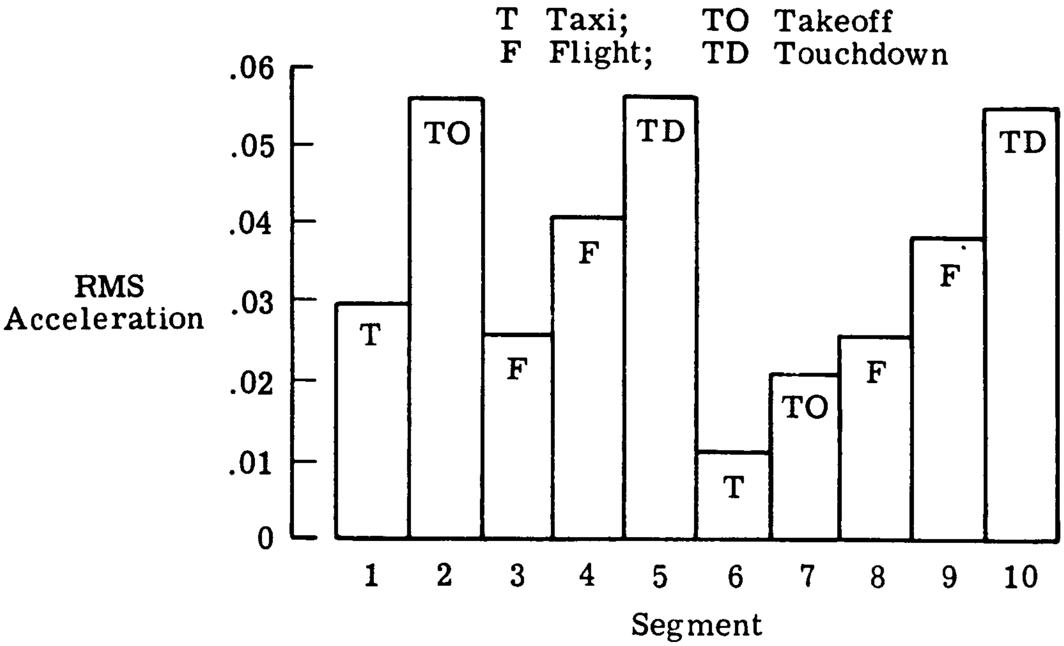


Figure 14.- Mean RMS acceleration.

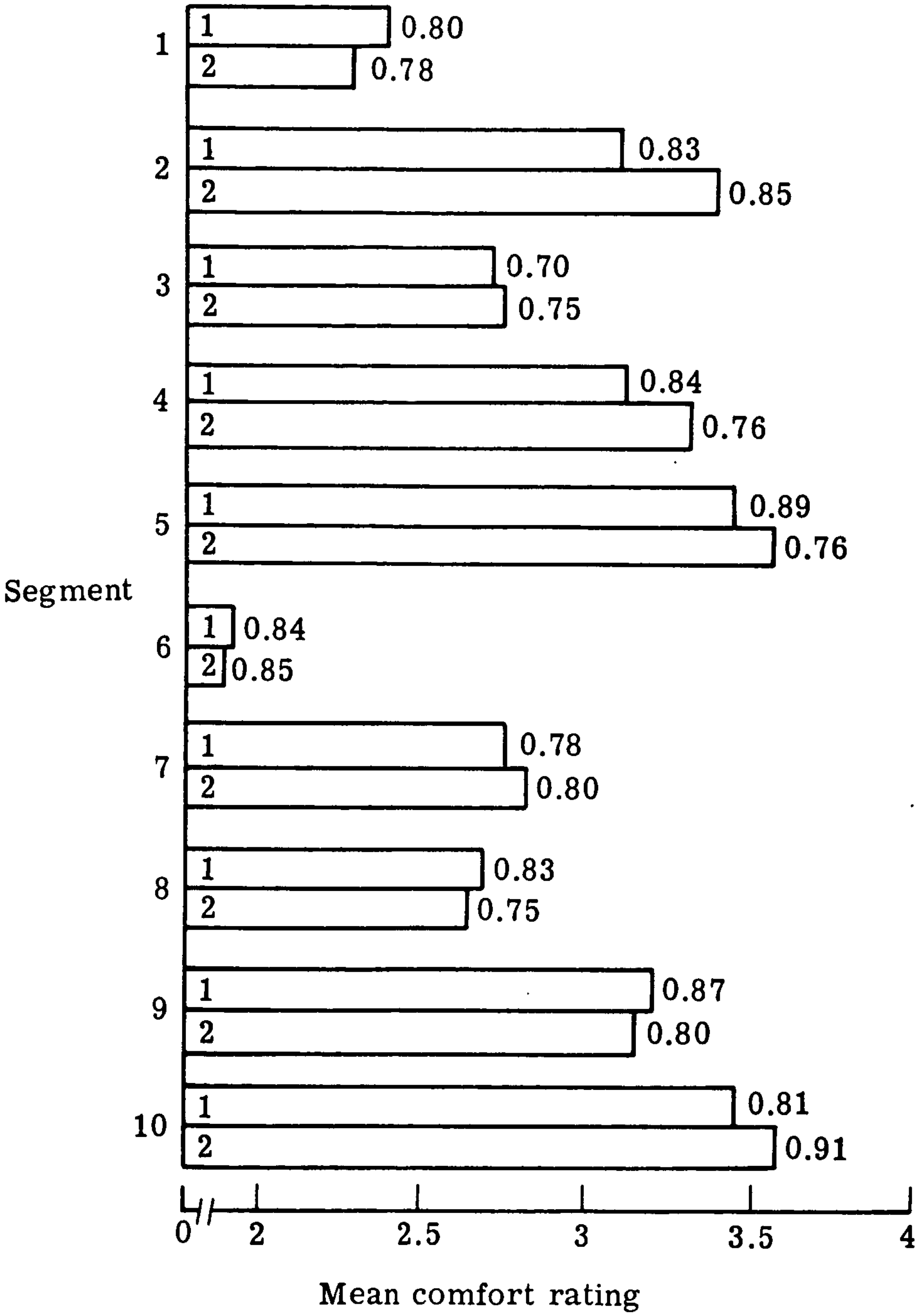


Figure 15.- Mean comfort rating for ride 1 and ride 2, and the corresponding standard deviation.

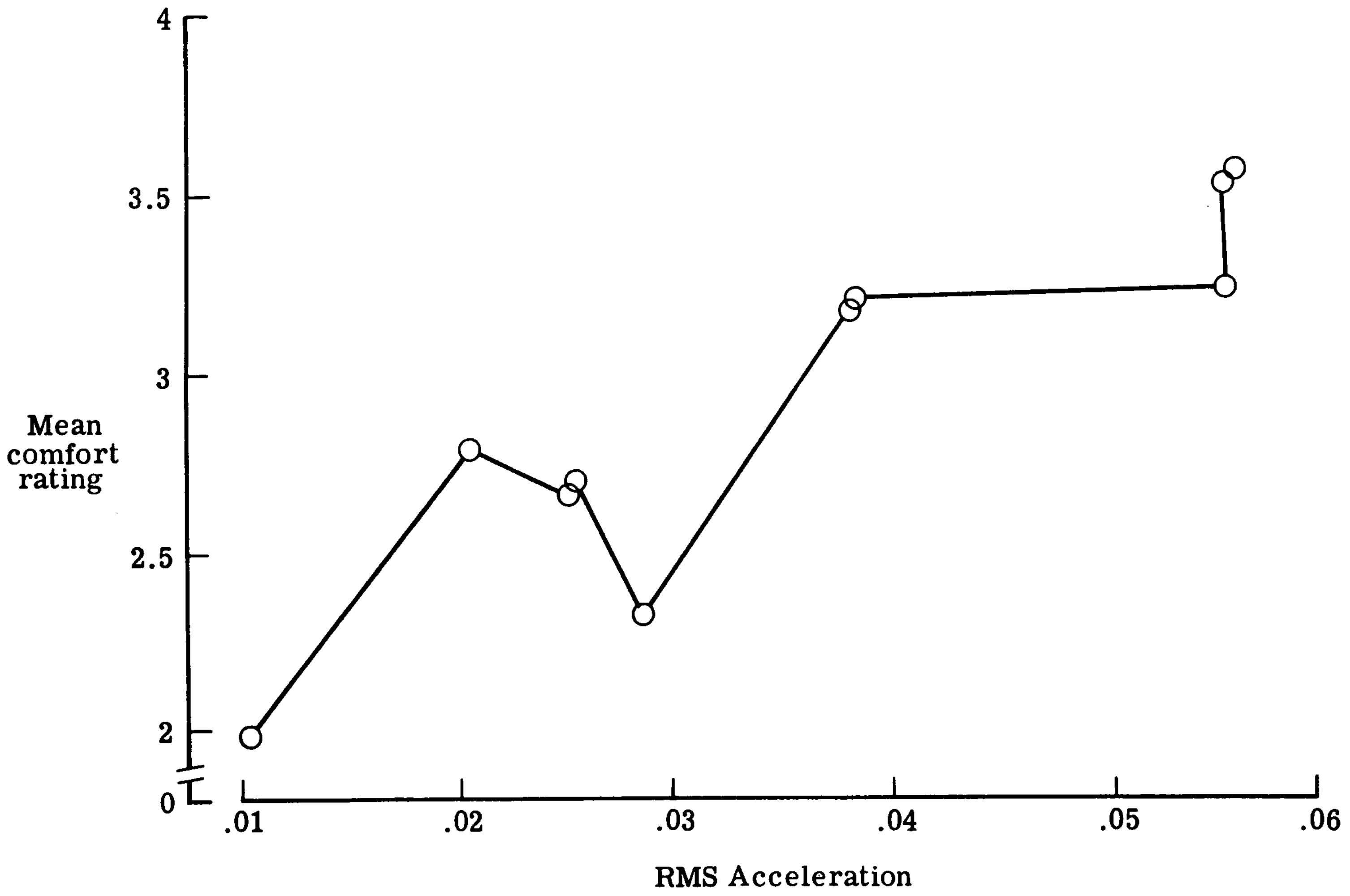


Figure 16.- Mean comfort rating as a function of RMS acceleration.

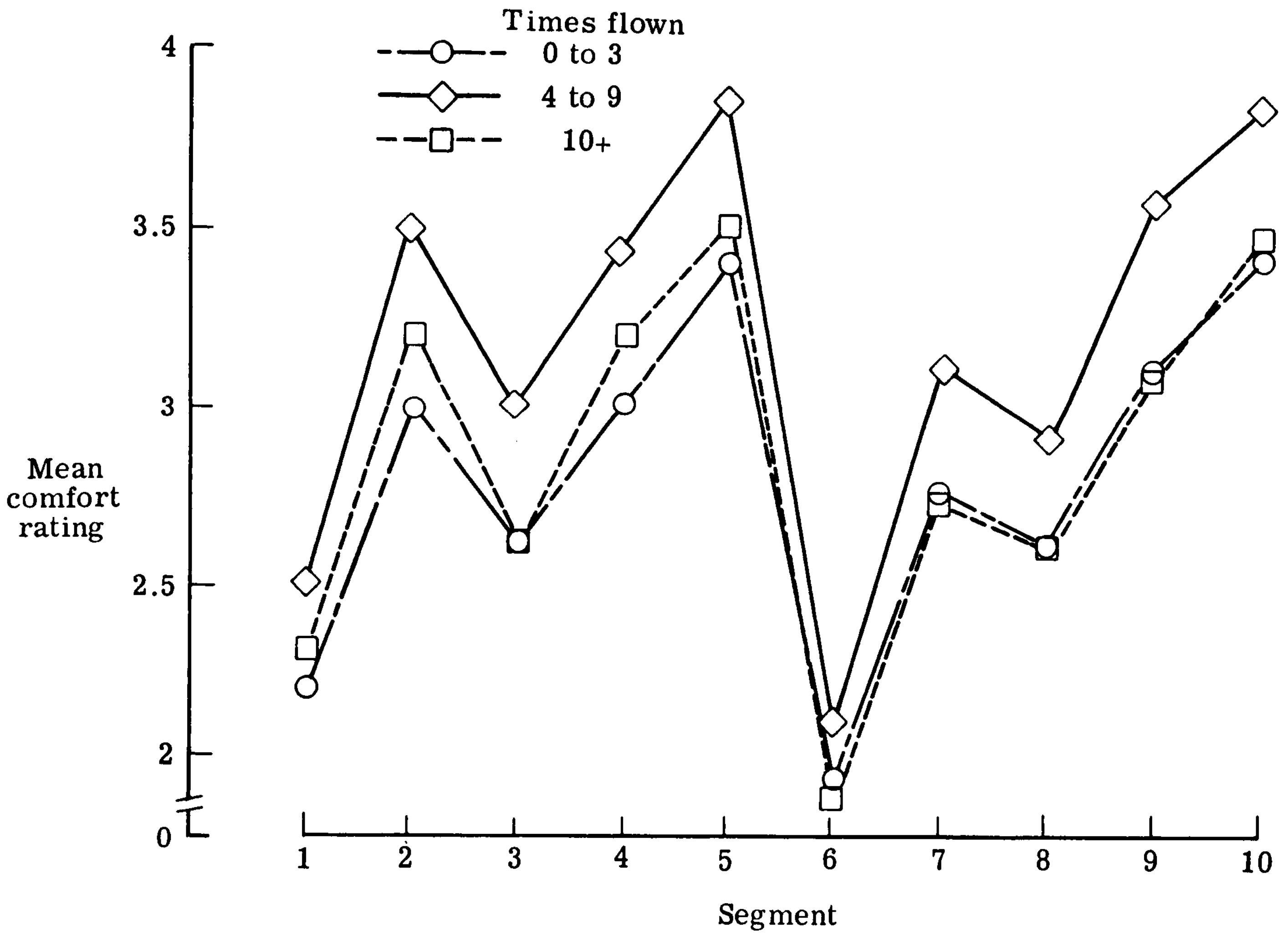


Figure 17.- Mean comfort rating as a function of flight experience.

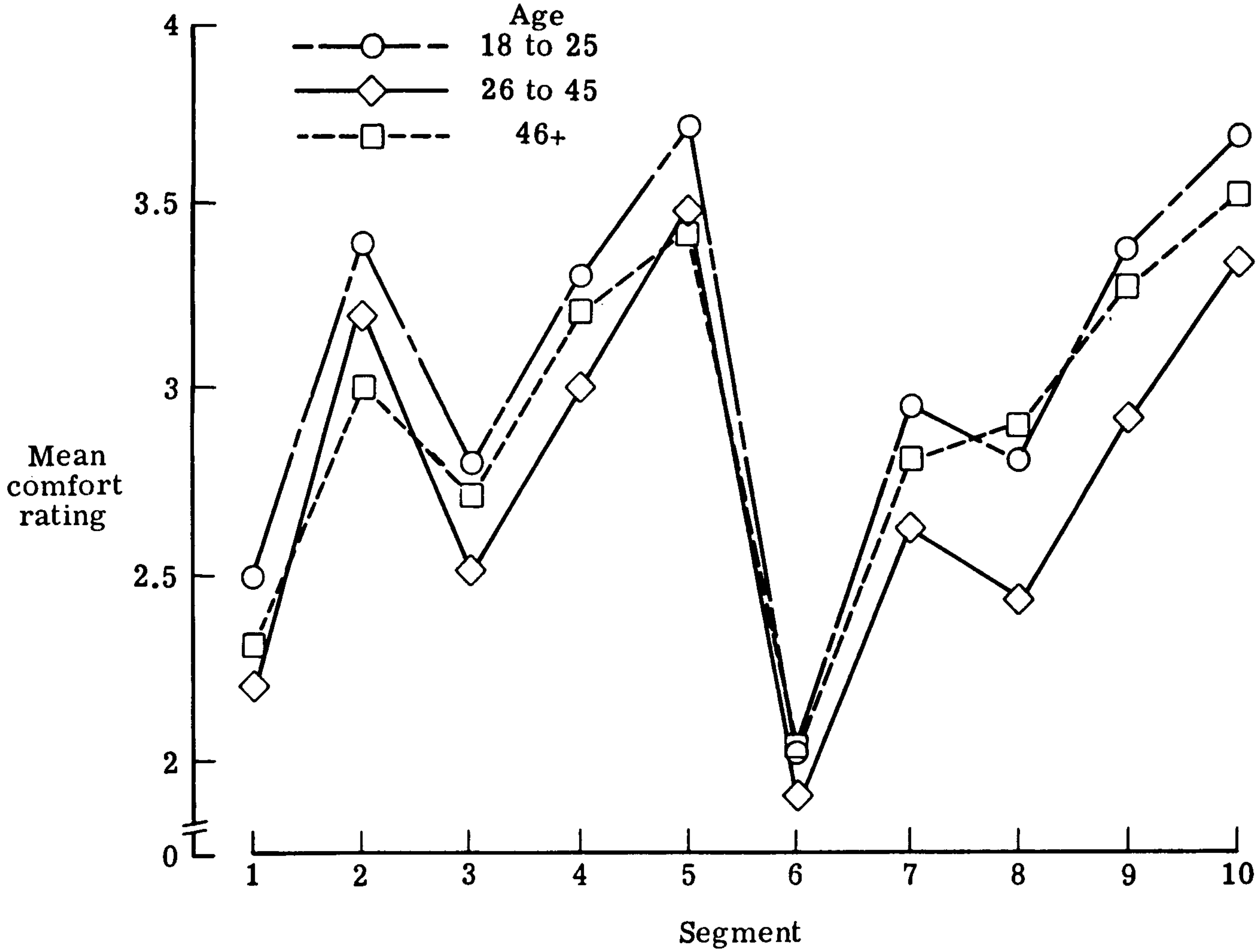


Figure 18.- Mean comfort rating as a function of age.

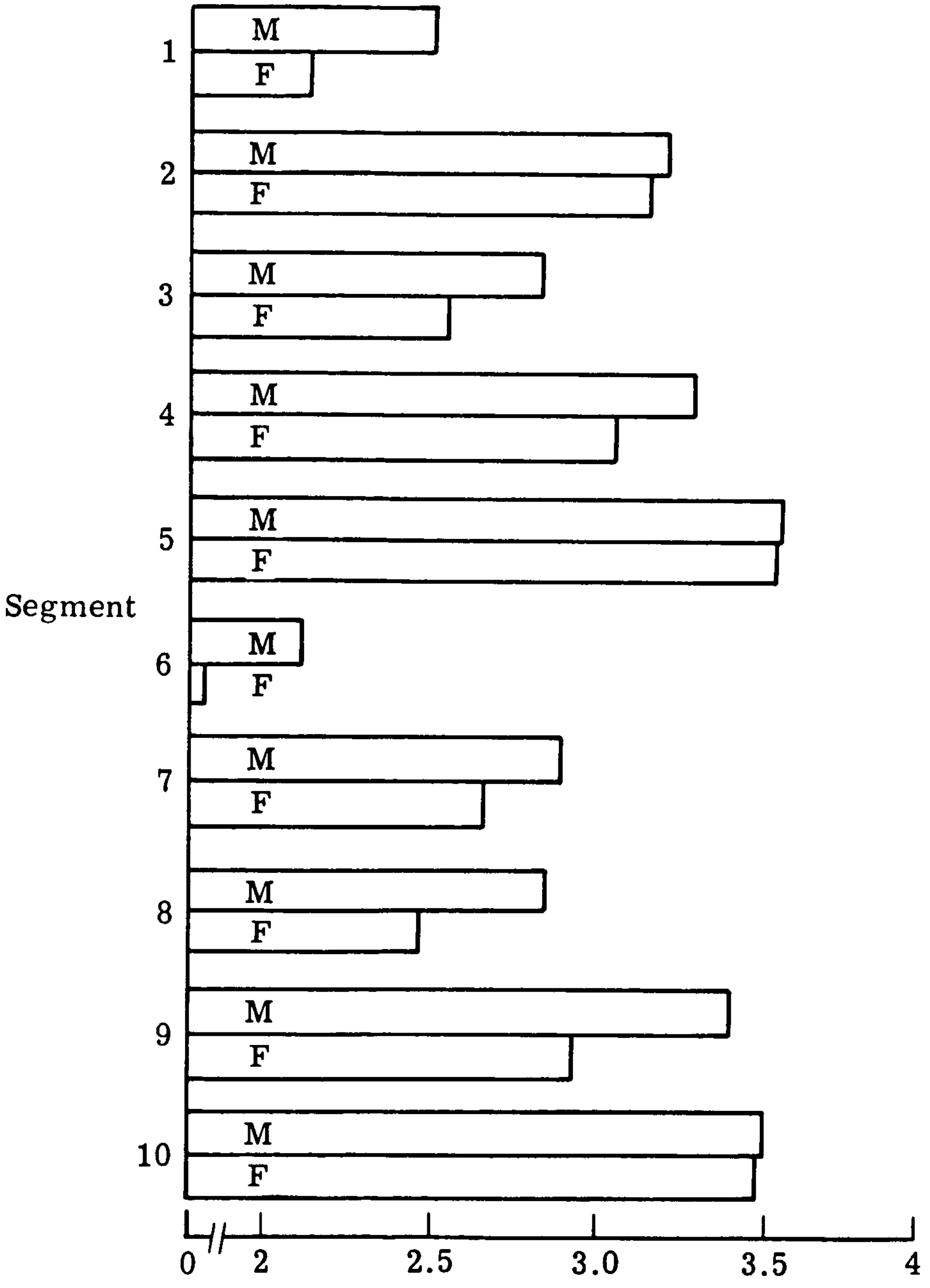


Figure 19.- Mean comfort rating as a function of sex.

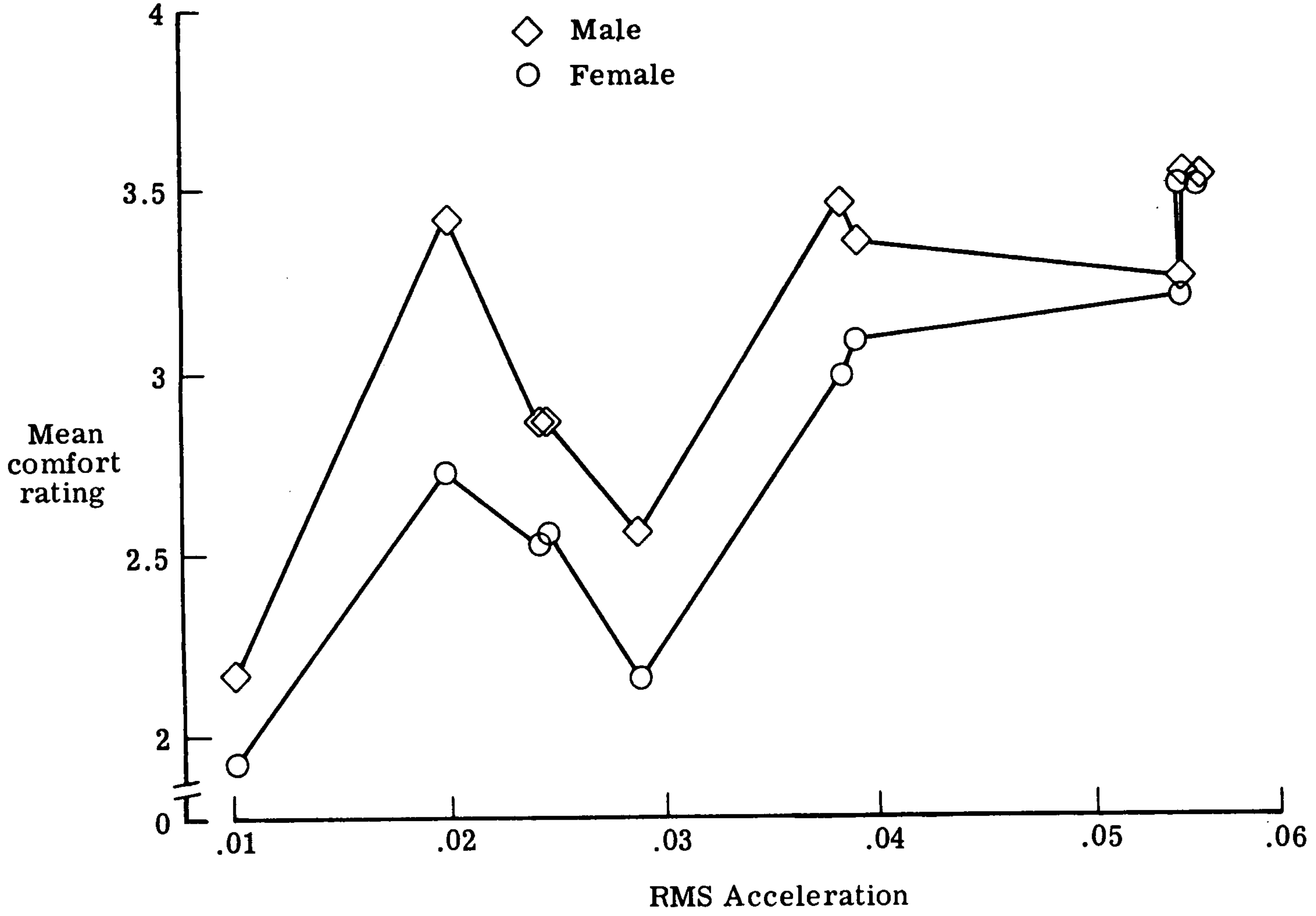


Figure 20.- Mean comfort rating as a function of sex and RMS value.

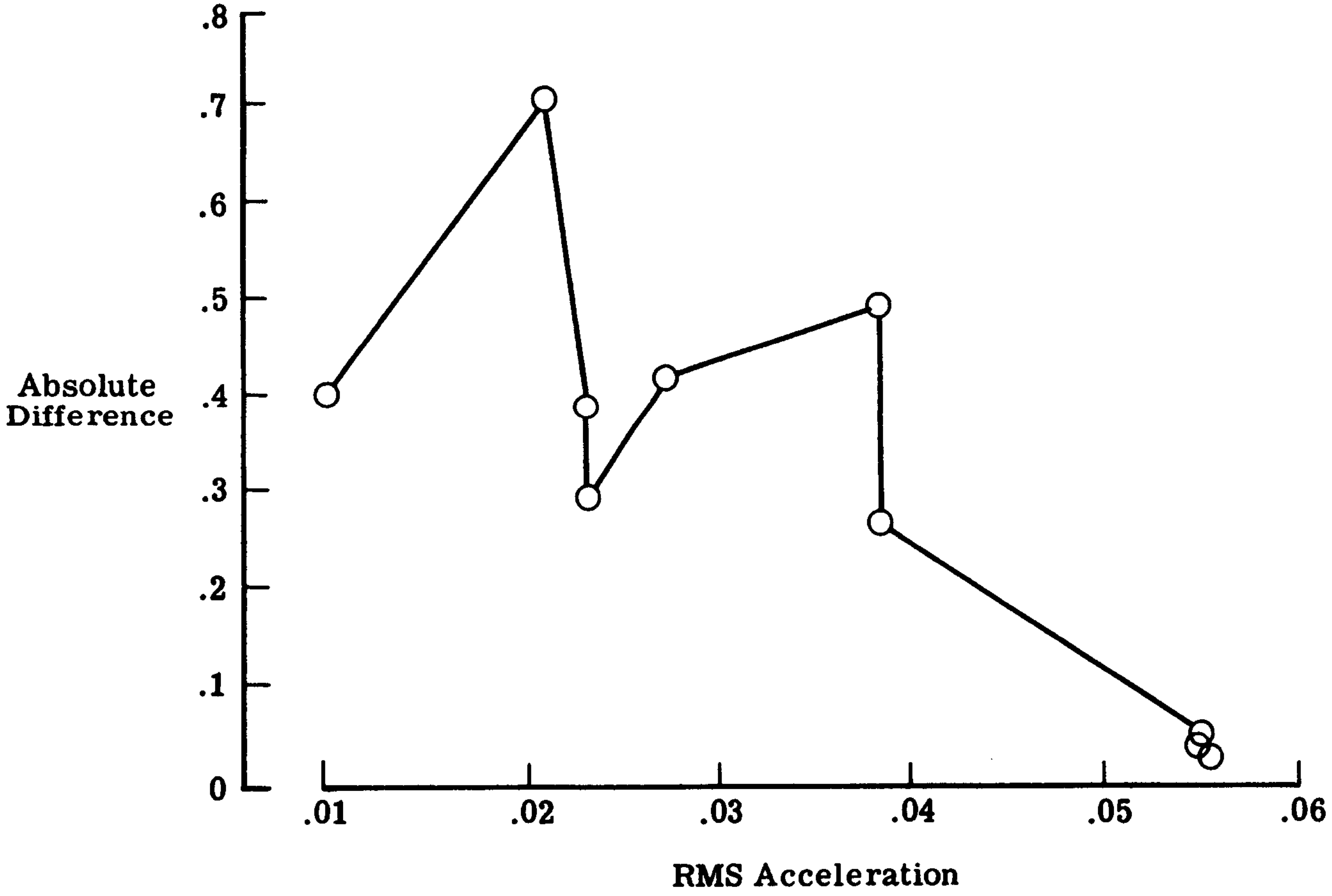


Figure 21.- Absolute difference in mean comfort rating between the sexes for RMS values.

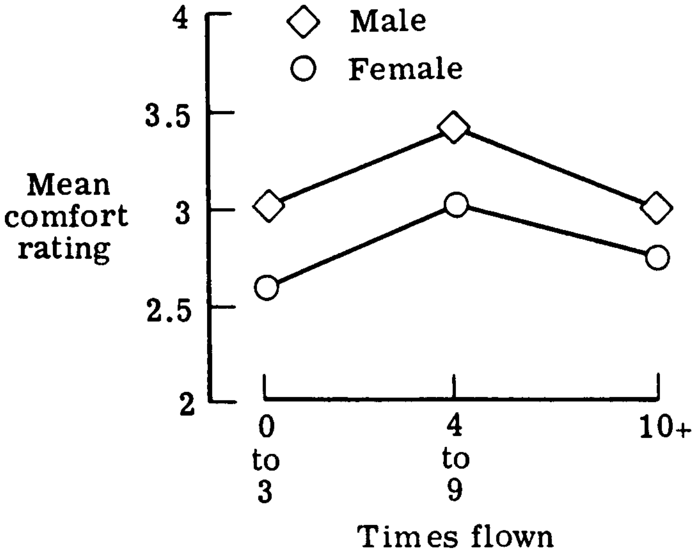


Figure 22.- Mean comfort rating as a function of sex and flight experience.

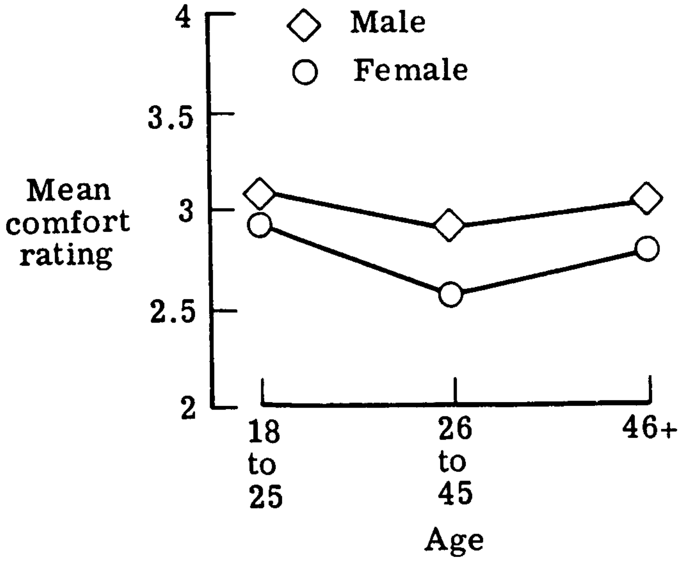


Figure 23.- Mean comfort rating as a function of sex and age.

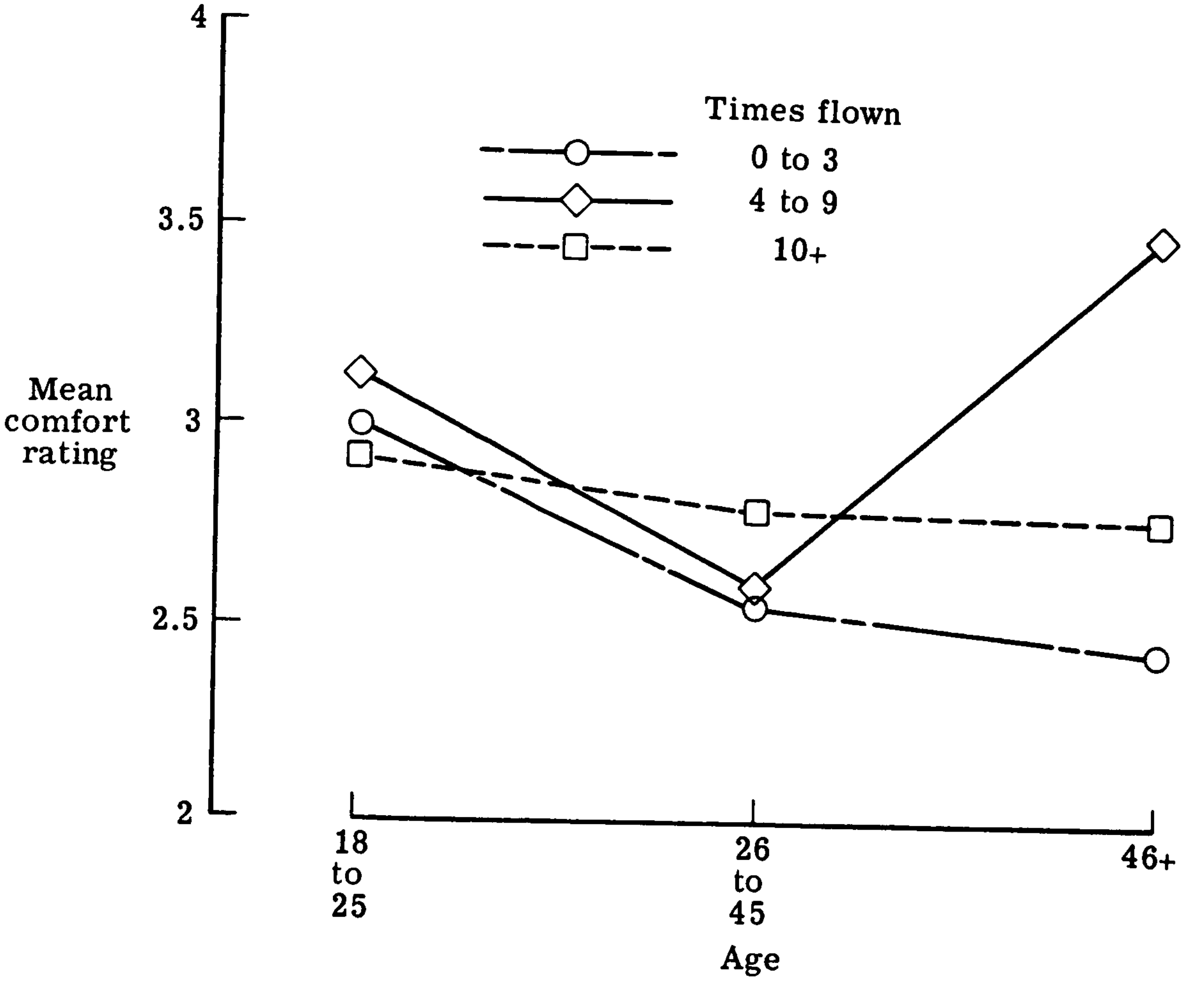


Figure 24.- Mean comfort rating as a function of flight experience and age.