

A STUDY OF SMOKING HABITS OF INDIVIDUALS
(Progress Report)

D. G. Horvitz
George Foradori

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PROGRESS REPORT

SMOKING PROJECT

INTRODUCTION

This report covers details of the research designs employed and the results of preliminary analyses of the data collected to accomplish the first two objectives of this project. These objectives are:

1. To develop a standard measure of the amount of current smoking by individuals, and
2. To develop a questionnaire for measuring the amount of current smoking, and to test its accuracy against the standard.

Research in connection with the first objective is hereafter referred to as Phase I; that in connection with the second objective as Phase II.

PHASE I

Introduction

Research aimed at accomplishing the first objective of this project was confined to a comparison of two semi-objective instruments for measuring daily cigarette smoking by individuals. The two instruments were developed cooperatively with personnel of the Richmond Research Laboratory of the American Tobacco Company. The first of these instruments consists of a three digit counter attached to the case of a Zippo cigarette lighter. The counter is activated by a pin each time the cover of the lighter is closed following use. An accurate count of the cigarettes smoked by an individual during a specified time period can be obtained with the lighter-counter provided the subject is sufficiently motivated to light each of his own cigarettes and no others unless he lights one of his own at the same time. It is presumed that the lighter would not be used to relight cigarettes which may have gone out inadvertently. The second instrument tested consists of a pocket size can with a small

covered hole (of diameter slightly larger than the diameter of a cigarette) through which the butt of each cigarette smoked is deposited. It is to be noted that use of the lighter-counter occurs at the beginning of the smoking process, whereas use of the butt can occurs at the end.

Design of the Study

An experiment designed to compare the lighter-counter and butt can was carried out with the Richmond Research Laboratory personnel during the period May 23, 1956 to June 14, 1956. Basically the experimental design was of the single changeover type in which each subject used either the lighter-counter or the butt can or both instruments to obtain 24 hour counts of cigarettes smoked for a period of 14 days⁽¹⁾ and then switched instruments for a second period of 9 days.⁽²⁾ Designating use of the lighter-counter alone by A, the butt can alone by B and simultaneous use of both counting devices by AB, each subject was assigned one of the following nine possible combinations for the two periods:

Period I	Period II
A	A
A	B
A	AB
B	A
B	B
B	AB
AB	A
AB	B
AB	AB

Initially, 96 of the Research Laboratory employees who reported themselves to be cigarette smokers on a questionnaire⁽³⁾ administered two weeks prior to the

(1) May 23, 1956 through June 5, 1956

(2) June 6, 1956 through June 14, 1956

(3) This was the questionnaire used by the Bureau of the Census in February 1955 to measure smoking habits of the nation. This questionnaire is hereafter referred to as the X questionnaire. A copy is included in the Appendix.

advent of the experiment were used as subjects for the comparison. The 96 individuals were first classified by sex and race yielding 63 white males, 18 white females and 15 non-white males. Next, the subjects in each sex-race group were ordered according to the average number of cigarettes smoked per day as reported on the questionnaire. The sex-race groups were then subdivided into blocks of 9 subjects by taking the first 9 from each ordered list, the second 9, etc. This procedure resulted in 7 blocks of white males, 2 blocks of white females, 1 complete block of non-white males, and a second block of 6 non-white males, the individuals in each block constituting a relatively homogeneous group with respect to reported cigarette smoking levels. Within each block (with the exception of the last mentioned) the 9 counting device combinations for the two periods were assigned to the subjects at random.

Both mimeographed and verbal instructions on the use of the counting devices were given to the subjects.⁽⁴⁾ These included requests to avoid checking on their own daily smoking by lifting the masking tape covering the counter face on the lighter-counter or by counting the cigarette butts collected in the butt cans.

Data Collection

Each subject was assigned a reporting time (between 8:00 A.M. and 4:00 P.M.) for purposes of recording the counter reading and collecting the cigarette butts for the previous 24 hours. The same daily reporting time for each subject was maintained throughout the period of the study. The reporting times were arranged such that 3 subjects (one A, one B, one AB) in the same block reported every ten minutes. The 3 sets of subjects within a given block were assigned consecutive ten minute reporting periods.

The lighter-counters were read and their operation checked each time a subject reported.⁽⁵⁾ The contents of the butt cans were emptied into appropriately identi-

(4) A copy of the mimeographed instructions is included in the Appendix.

(5) See record form A in Appendix.

fied paper bags and later counted and weighed on a laboratory beam scale. The weights were recorded to the nearest tenth of a gram by type of cigarette (i.e. 70 mm. or 85 mm. non-filter or 85 mm. filter). Seven of the subjects smoked a mixture of cigarette types, and weights were obtained only for the first four days of the study for these individuals. The weight of the tobacco consumed was obtained by subtracting the weight of the butts from the weight of the whole cigarettes.⁽⁶⁾ The latter figure was computed by multiplying the number of butts by the average production weight of the particular brand and type of cigarette.⁽⁷⁾

Preliminary Data Analysis

It was impossible to retain the symmetry of the design discussed above since 8 of the 96 subjects originally expected to participate were not available for reasons of illness, vacation, etc. An additional 9 subjects participated in only a portion of the study, leaving a total of 79 subjects for analysis. Differences in average smoking level among the groups assigned the three cigarette counting devices were accounted for in the analysis, therefore, by adjusting the observed smoking levels according to the regression on reported smoking levels. The latter information was obtained for all but one of the 79 subjects on a questionnaire⁽⁸⁾ administered just prior to Period I. Such an adjustment undoubtedly would have added little to the validity and precision of the final comparisons if the original design symmetry had been maintained. The original design would have permitted smoking level differences among the blocks to be removed in testing for differences among the counting instruments.

(6) See record form E in Appendix.

(7) Lucky Strike (70 mm) 1.080 gms/cig., Pall Mall (85 mm) 1.246 gms/cig., Filter-tip Tareyton (85 mm) 1.233 gms/cig.

(8) This was the questionnaire (except for minor changes) developed for testing in Phase II and is hereafter referred to as the Y questionnaire. A copy is included in the Appendix.

In addition to the data losses incurred through loss of subjects, certain of the daily counts were lost through lighter-counter failures or failure on the part of the subject to use the assigned counting device as prescribed. The latter losses were highest on week-ends. The extent of these data losses is indicated below.

a. Analysis of Adjusted Daily Group Means

A separate analysis for each day of the experiment was carried out as the data became available. The pertinent data are summarized in Table I. It is to be noted that the number of observations for these analyses varied from day to day and among counting devices. Reasons for this variation were mentioned above.

Since the symmetry of the original design (blocks of 9 individuals of comparable smoking level) was not maintained, direct comparison of the daily averages for each counting device could lead to false conclusions. It is apparent that the number of cigarettes smoked on a given day, as recorded by a given measuring instrument, reflects among other things the smoking level of the individual. In order to account for differences in smoking level among the three groups of subjects (i.e. to put the groups on a common basis), the average daily counts were adjusted by means of a co-variance analysis to the group response average as reported in Question 13 of the Y questionnaire administered just prior to Period I of the test.

Table I shows the adjusted group means for each day. For any given day, the average number of cigarettes smoked as recorded by each device is directly comparable. The possible comparisons are shown in the columns headed (A-B), (A-AB) and

Table I

OBSERVED AVERAGE NUMBER OF CIGARETTES SMOKED BY DAY AND
COUNTING DEVICE ADJUSTED FOR REPORTED SMOKING LEVELS

Date	<u>No. Observations</u>			<u>Adjusted Means</u>			<u>Differences</u>		
	A	B	AB	A	B	AB	(A-B)	(A-AB)	(AB-B)
Period I									
Wed. May 23	20	28	23	26.43	22.62	22.77	3.81	3.66	0.15
Thurs. May 24	25	31	25	25.06	22.02	23.07	3.04	1.99	1.05
Fri. May 25	25	31	22	27.22	20.14	20.04	7.08	7.18	-0.10
Sat. May 26	22	31	22	22.78	17.12	21.44	5.66	1.34	4.32
Sun. May 27	22	30	18	22.61	17.74	21.20	4.87	1.41	3.46
Mon. May 28	22	30	25	26.79	21.89	21.68	4.90	5.11	-0.21
Tues. May 29	23	30	26	24.32	19.25	21.37	5.07	2.95	2.12
Wed. May 30	24	28	21	25.63	20.05	23.38	5.58	2.25	3.33
Thurs. May 31	26	29	26	26.78	21.28	25.11	5.50	1.67	3.83
Fri. June 1	24	28	20	23.94	18.58	24.47	5.36	.53	5.89
Sat. June 2	21	28	19	23.13	16.36	23.05	6.77	.08	6.69
Sun. June 3	22	28	19	23.80	17.56	23.35	6.24	.45	5.79
Mon. June 4	27	28	23	27.19	22.04	23.75	5.15	3.44	1.71
Tues. June 5	26	28	24	26.98	22.73	25.02	4.25	1.96	2.29
Period II									
Wed. June 6	26	27	23	25.67	21.47	24.13	4.20	1.54	2.66
Thurs. June 7	28	27	21	24.19	22.32	22.17	1.87	2.02	-0.15
Fri. June 8	27	27	18	26.34	21.97	22.23	4.37	4.11	0.26
Sat. June 9	27	26	17	21.78	19.77	21.27	2.01	.51	1.50
Sun. June 10	27	26	18	24.52	19.49	22.59	5.03	1.93	3.10
Mon. June 11	26	26	23	25.28	22.15	22.23	3.13	3.05	0.08
Tues. June 12	26	26	23	25.32	21.78	23.22	3.54	2.10	1.44
Wed. June 13	26	26	21	25.62	23.40	22.57	2.22	3.05	-0.83
Thurs. June 14	23	26	20	27.52	24.03	23.58	3.49	3.94	-0.45

(AB-B)⁽⁹⁾ Examination of these columns reveals the most striking differences to occur between A and B, the lighter-counter and the butt can. Statistically, the daily lighter-counter averages were significantly greater than the butt can averages on every

(9) The counts used in the analysis for the AB group were the averages of the separate device counts, i.e. the lighter-counter and the butt can.

test day during Period I; on 12 of these days at the 95% significance level or higher and at the 90% level on the two remaining days. The smallest (A-B) difference in this period is 3.04 cigarettes and the largest 7.08 cigarettes.

Analysis revealed significantly greater average cigarette smoking counts for the A group as compared to the AB group on 6 of the 14 days in Period I. It is to be noted that the (A-AB) differences were smaller than the (A-B) differences on all but two days in the first period. All but one of the (A-AB) difference were positive in this period.

The (AB-B) comparisons were found to be statistically significant on 6 days in Period I, with only two of the 14 differences negative. It is to be noted that with but three exceptions, May 25, May 28, and June 1, the rank order of the daily group means was A, AB, B.

The comparisons for Period II confirm the general picture obtained in the first period although the magnitude of the differences decreased slightly. The A, AB, B rank order of the daily averages occurred on 6 of the 9 test days. The (A-B) differences were statistically significant on 6 of the days, the (A-AB) differences on 2 days and the (AB-B) differences on only one day. It should be noted that the variation in cigarette consumption among individuals using the same counting device precluded demonstration of daily group mean differences of 2.5 cigarettes or less as statistically significant with only 20 to 28 observations per group.

b. Pooled Analysis of Group Means

A pooled analysis of co-variance was carried out for each period separately to obtain adjusted counting instrument means and to test the differences among these means. A total of 78 individuals who

had participated throughout the experiment and who had also filled out both the X and Y questionnaires prior to Period I were included in this analysis. Of the 1092 possible observations during Period I, 59 or 5.5 percent of the total, were missing due mainly to lighter-counter failures. Only 13 or 1.9 percent of the possible total of 702 observations for Period II were lost, however. Values were estimated for the missing observations (in order to simplify the analysis) based on those observed for the particular individual and counting device.

Table II shows the principal adjusted group means and mean differences obtained from this analysis. A consistent pattern in the counting instrument means (and hence the differences) is evident for the two periods. For these subjects, the lighter-counter recorded an average of approximately 3.4 cigarettes more smoked per day than the butt can. The average for individuals using both counting devices simultaneously was closer to the average for the butt can alone, the difference being less than one cigarette.

Of additional interest is the absence of any evidence to indicate a change in smoking habits of the 78 subjects for the two periods. Period differences have not as yet been analyzed for these data, but a partial analysis in which the original blocking of the subjects was used (where possible) reaffirmed the results in Table II and in addition revealed period differences to be non-significant statistically.

Table II

OBSERVED AVERAGE NUMBER OF CIGARETTES SMOKED PER 24 HOURS
BY COUNTING DEVICE AND PERIOD ADJUSTED FOR
REPORTED SMOKING LEVELS

<u>Counting Device</u>	<u>Period I</u>	<u>Period II</u>
Means		
A	25.30	25.47
B	21.85	22.11
AB	22.52	23.02
Differences		
A-B	3.45	3.36
A-AB	2.78	2.45
AB-B	0.67	0.91

c. Analysis of Unadjusted Group Means

It is of interest to compare the actual average daily smoking counts obtained from the various instruments with the averages reported by the subjects in Question 13 of the Y questionnaire (Y13) prior to the experiment. The data for these comparisons are shown in Table III. The observed smoking means in this table are the unadjusted averages for the 78 subjects (with missing values supplied) referred to in the previous sections. Included in the table are the average responses obtained to Y13 immediately following the completion of the data collection for Period I. The differences between group means for the same period should not be compared in Table III without adjustment for smoking level differences.

Table III

COMPARISON OF OBSERVED AVERAGE NUMBER OF CIGARETTES

SMOKED PER 24 HOURS WITH AVERAGE RESPONSE

TO QUESTION 13 OF Y QUESTIONNAIRE (Y13) BEFORE

AND AFTER PERIOD I

Group	Counting Device		No. of Subjects	Observed Smoking		Reported Smoking (Y13)	
	Period I	Period II		Period I	Period II	Prior to Period I	After Period I
1	A	A	9	32.79	33.05	35.67	33.22
2	A	B	9	25.46	21.48	25.11	24.67
3	A	AB	9	18.72	17.48	18.56	18.78
4	B	A	10	21.21	25.50	24.40	22.20
5	B	B	10	24.49	24.97	28.30	25.60
6	B	AB	8	22.82	23.85	28.80	25.00
7	AB	A	10	19.84	21.97	22.80	21.30
8	AB	B	8	17.95	16.60	21.25	18.63
9	AB	AB	6	23.35	24.25	26.67	24.50

Examination of Table III reveals that with but two exceptions (Groups 2 and 3), the averages of the questionnaire responses prior to Period I were higher than the Period I averages recorded using one of the various counting techniques. In only one instance (Group 4) were the Period II averages higher than the average responses prior to Period I. It is interesting to note further that the differences between the average prior responses and the average cigarette counts in Period I for the groups using the lighter-counter (A) are +2.88, -0.35, and -0.16 respectively.

whereas the corresponding differences in the case of the butt can (B) are +3.19, +3.81, and +5.98 respectively.

The average responses to Y13 obtained after Period I were all closer to the Period I observed averages than the average prior responses with one exception (Group 2). Evidently the subjects underwent a learning process during the experiment. Further examination of the Table III data indicates the subjects tended to learn the average count revealed by the device being used and not necessarily their own actual average smoking level.

The data for groups 1, 5 and 9 in Table III provide a quick estimate of the extent of the average change in smoking level of the subjects from Period I to Period II. The Period I 24 hour mean for the subjects in these groups was 27.21 cigarettes; the Period II mean was 27.71 cigarettes for an estimated period difference of 0.50 cigarettes.

Discussion

The analyses presented above represent only a partial summarization of the information available in the data collected during Phase I. A more complete summarization will appear in the final report. It is appropriate here to mention some of the rationale which led to the choice of the lighter-counter as the most expedient for use as the standard measure in testing the various questionnaire techniques in Phase II.

The following conclusions regarding the performance of the cigarette counting devices tested in Phase I can be drawn with varying degrees of confidence.

1. If individuals tend to underestimate their current average daily cigarette smoking, the lighter-counter will have a

smaller measurement bias than the butt can alone or both devices together.

2. If individuals tend to correctly estimate their current average daily cigarette smoking, the lighter-counter will again have the smallest measurement bias.
3. If individuals tend to overestimate their current cigarette smoking, nothing definite can be said regarding the relative accuracy of the cigarette counting devices tested without some knowledge of the magnitude of the response bias.

Although it was impossible to evaluate the exact bias in any of the semi-objective counting devices tested, it became evident during the course of the test that the butt can was not readily accepted by some of the participants, despite the generally high motivation level of the group. Use of the lighter-counter appeared to be influenced to a far lesser degree by subjective attitudes than the butt can. Apparently, then, the butt can is a negatively biased measuring device.

In light of the data and the greater objectivity apparent in the use of the lighter-counter, it was therefore concluded that the lighter-counter would also be most accurate in the case of over-estimation on the part of individuals of their true current average cigarette smoking. Accordingly, the lighter-counter was chosen as the best standard among the devices tested.

Analysis of Amount Smoked by Weight

While the lighter-counter was selected as superior to the butt can for measuring the number of cigarettes smoked per day, the butt can was not without advantages. Specifically, the contents of the butt cans supplied data through which information on the amount of tobacco consumed by weight was compiled.

Available data on number of cigarettes smoked and amount smoked by weight are shown for each period in Table VI for the 96 subjects initially available for the Phase I experiment. There are many items of interest in this table; only a few of the highlights will be mentioned here, however.

The average number of cigarettes smoked per day for the subjects in this study ranged from less than one cigarette to more than 70 cigarettes. Considerable day to day variation in the number of cigarettes smoked by many of these subjects is evident from the width of the ranges observed. It should be noted that the individual daily averages of the number of cigarettes smoked for the two periods cannot be compared for consistency in this table since different counting instruments were used in each period by approximately 2/3 of the subjects.

Analysis of the data on weight of the burned portion of the cigarettes smoked in each 24 hour period revealed no correlation whatsoever between number of cigarettes smoked and either the average number of grams of tobacco smoked per cigarette or the percent of cigarette smoked. This was the case for both periods of the experiment. On the other hand, and as expected, the average number of grams of cigarette tobacco smoked per day is highly correlated with number of cigarettes smoked. Individual smoking habits with respect to the length of the unsmoked cigarette butt and the length of the original cigarette tend to reduce this correlation, however. For example, in Period I subjects 48 and 72 both averaged 21.2 cigarettes per day, but the former smoked only an average of 9.1 grams of tobacco per day as compared with 16.6 grams for the latter. The percent of cigarette smoked by weight was 39.9 for subject 48, but 61.1 for subject 72. This and other

Table VI. Smoking Data: American Tobacco Company Laboratory Personnel

Ident. No.	Type Smoked	Period I: May 23 - June 5, 1956				Period II: June 6 - June 14, 1956			
		Ave/Day	Range	Ave/Cig. (gms)	% of Cig.	Ave/Day	Range	Ave/Cig. (gms)	% of Cig.
1		37.1	30-51			29.0	23-32		
2		35.1	29-55			35.9	31-44		
3*		26.7	20-46			24.6	13-31		
4									
5		26.6	23-32			29.2	26-34		
6		23.2	9-44			22.1	12-30		
7*									
8		47.4	37-54			50.1	42-55	.721	2.2
9	F	5.7	2-10			3.1	0-6		
10		21.2	12-30			28.3	23-34		
11	85	6.7	4-10			6.6	4-9	.681	4.5
12	70	55.3	39-66			42.1	33-51	.523	22.0
13***	F	51.2	15-77			21.6	8-29	.766	
14	85	32.2	21-43			28.2	20-37	.628	17.7
15	70	38.6	30-49			31.0	26-38	.483	15.0
16	70	24.3	18-33			19.0	17-23	.587	11.2
17	85	13.4	0-23			18.9	13-26	.584	11.0
18	85	3.3	0-9			0.8	0-3	.714	0.6
19	F	16.1	12-19			16.9	12-22	.715	12.6
20	85	7.0	3-29			1.2	0-4	.588	0.7
21	85	22.9	18-40			20.3	13-26	.773	15.7
22	85	19.3	13-26			15.7	12-22	.638	10.0
23	70	39.0	30-46			37.2	19-55	.598	22.2
24	85	41.5	32-50			38.3	24-51	.751	28.8
25***		45.0	34-63						
26	70	28.2	25-32			30.2	24-36	.429	12.9
27***	70	15.8	2-24			4.9	0-14	.581	
28	85	13.8	3-19			15.3	10-19	.718	11.0
29*									
30	70	22.6	18-26			23.6	19-30	.604	14.2

F I

Period II: June 6 - June 14, 1956

Ident. No.	Type Smoked	No. of Cig. Smoked		Amount Smoked (by weight)		Ave/Cig. (gms)	Ave/Day (gms)	% of Cig.
		Ave/Day	Range	Ave/Day	Range			
31*	M	30.6	22-40	.561	24.2	51.9	22.9	9-28
32**	70	43.2	31-55	.633	25.4	54.7	48.1	38-62
33	M	40.2	29-50	.613	17.5	49.2	46.2	35-54
34**	85	28.6	21-39	.469	13.3	43.4	33.8	31-41
35	70	14.8	6-23	.811	6.9	65.7	23.2	2-30
36***	F	16.4	4-28	.573	1.0	53.0	16.8	10-26
37	70	12.1	9-17	.610	13.4	49.4	2.4	0-7
38	85	1.6	0-6	.568	2.2	45.6	27.2	22-33
39	85	23.6	15-30	.630	15.8	51.0	7.3	6-11
40	F	3.5	0-12	.627	11.8	58.1	27.9	21-42
41	70	25.2	20-33	.670	19.9	62.1	22.0	18-31
42	70	17.6	12-25	.653	16.2	60.4	33.7	26-41
43	70	30.5	19-38	.563	16.0	45.2	29.7	23-40
44	70	28.7	16-46	.663	9.1	53.2	23.0	20-24
45	85	28.7	20-28	.499	12.9	46.2	14.2	7-21
46	85	24.1	14-31	.431	2.5	39.9	18.1	13-21
47***	70	24.1	16-30	.713	9.4	59.9	5.0	1-7
48	70	21.2	9-24	.588	1.7	47.2	12.9	7-17
49	F	18.1	1-7	.746	22.4	53.5	1.2	0-4
50	85	4.3	8-16	.659	28.5	69.0	28.0	22-32
51	85	12.6	0-9	.860	15.3	52.2	47.8	42-55
52	M	2.6	17-32	.650	20.8	47.1	28.8	20-35
53	85	26.1	35-53	.587	7.3	45.9	39.3	23-52
54	85	43.9	23-33	.652	16.9	52.9	26.4	21-39
55	85	26.1	21-44	.598	10.3	51.6	17.7	12-24
56	F	31.9	24-37	.646	7.3	45.3	3.2	0-9
57***	85	29.1	19-31	.556	19.8	54.7	17.8	13-26
58	85	26.2	15-21	.559	832	66.7	26.7	22-32
59**	70	18.6	0-6	.680				
60***	F	2.3	6-15					
61	85	10.7						
62*								
63**	M	17.4	8-25					
64	85	23.8	14-31					

Period I: May 23 - June 5, 1956

Ident. No.	Type Smoked	No. of Cig. Smoked		Amount Smoked (by weight)		Ave/Cig. (gms)	Ave/Day (gms)	% of Cig.
		Ave/Day	Range	Ave/Day	Range			
31*	M	30.6	22-40	.561	24.2	51.9	22.9	9-28
32**	70	43.2	31-55	.633	25.4	54.7	48.1	38-62
33	M	40.2	29-50	.613	17.5	49.2	46.2	35-54
34**	85	28.6	21-39	.469	13.3	43.4	33.8	31-41
35	70	14.8	6-23	.811	6.9	65.7	23.2	2-30
36***	F	16.4	4-28	.573	1.0	53.0	16.8	10-26
37	70	12.1	9-17	.610	13.4	49.4	2.4	0-7
38	85	1.6	0-6	.568	2.2	45.6	27.2	22-33
39	85	23.6	15-30	.630	15.8	51.0	7.3	6-11
40	F	3.5	0-12	.627	11.8	58.1	27.9	21-42
41	70	25.2	20-33	.670	19.9	62.1	22.0	18-31
42	70	17.6	12-25	.653	16.2	60.4	33.7	26-41
43	70	30.5	19-38	.563	16.0	45.2	29.7	23-40
44	85	28.7	16-46	.663	9.1	53.2	23.0	20-24
45	85	28.7	20-28	.499	12.9	46.2	14.2	7-21
46	85	24.1	14-31	.431	2.5	39.9	18.1	13-21
47***	70	24.1	16-30	.713	9.4	59.9	5.0	1-7
48	70	21.2	9-24	.588	1.7	47.2	12.9	7-17
49	F	18.1	1-7	.746	22.4	53.5	1.2	0-4
50	85	4.3	8-16	.659	28.5	69.0	28.0	22-32
51	85	12.6	0-9	.860	15.3	52.2	47.8	42-55
52	M	2.6	17-32	.650	20.8	47.1	28.8	20-35
53	85	26.1	35-53	.587	7.3	45.9	39.3	23-52
54	85	43.9	23-33	.652	16.9	52.9	26.4	21-39
55	85	26.1	21-44	.598	10.3	51.6	17.7	12-24
56	F	31.9	24-37	.646	7.3	45.3	3.2	0-9
57***	85	29.1	19-31	.556	19.8	54.7	17.8	13-26
58	85	26.2	15-21	.559	832	66.7	26.7	22-32
59**	70	18.6	0-6	.680				
60***	F	2.3	6-15					
61	85	10.7						
62*								
63**	M	17.4	8-25					
64	85	23.8	14-31					

similar examples in Table VI suggested a breakdown of the data on amount smoked by weight according to type of cigarette (e.g. 70 mm., 85 mm., filter).

The averages by type of cigarette for number of grams of tobacco smoked per cigarette and percent of cigarette smoked are shown for each period of the experiment in Tables VII and VIII. The data in these tables clearly indicate that the 70 mm. cigarette smokers smoked less tobacco per cigarette by weight on the average than either the 85 mm. or filter cigarette smokers. The averages for the latter smokers were in fair agreement since the filter cigarettes were also 85 mm. cigarettes in all cases and of similar initial weight for all practical purposes. These results indicate a tendency for the 70 mm. smokers, as a group, to leave unsmoked the same length of butt on the average as the 85 mm. and filter cigarette smokers.

Use was made of the highly significant regression relationship between grams of cigarette tobacco smoked per day and average number of cigarettes smoked to estimate the average weight consumed in grams for daily smoking of 10, 20, 30 and 40 cigarettes. These estimates are shown by type of cigarette for both periods in Table IX. Two facts stand out in this table. First, the regression line for the 70 mm. smokers is 3.11 grams lower than that for the 85 mm. smokers in Period I and 3.39 grams lower in Period II.⁽¹⁰⁾ On the other hand the regression lines for the 85 mm. and filter cigarette smokers differ by only 0.09 grams in Period I and 0.32 grams in Period II, their positions reversing for the two periods. Second, the estimates for each type of cigarette remained remarkably consistent for the two periods despite the fact that less than 2/3 of the subjects provided weight data for both periods.

The main conclusion to be drawn from this preliminary analysis of the weight data is that number of cigarettes smoked daily is not a sufficient measure for

⁽¹⁰⁾ The pooled regression over type of cigarette was used for each period.

Table VII

MEAN NUMBER OF GRAMS OF TOBACCO SMOKED PER
CIGARETTE BY TYPE OF CIGARETTE AND PERIOD

Type of Cigarette	No. of Subjects		Subject - Days of Observation		Mean/Cigarette (gms. smoked)	
	Period I	Period II	Period I	Period II	Period I	Period II
70 mm.	16	12	193	102	.545	.555
85 mm.	29	29	362	232	.677	.692
Filter	12	9	142	72	.666	.710
All types	57	50	697	406	.638	.661

Table VIII

PERCENT OF CIGARETTE SMOKED BY WEIGHT BY
TYPE OF CIGARETTE AND PERIOD

Type of Cigarette	No. of Subjects		Subject - Days of Observation		Percent of Cigarette Smoked by Weight	
	Period I	Period II	Period I	Period II	Period I	Period II
70 mm.	16	12	193	102	50.46	51.43
85 mm.	29	30	362	241	54.35	55.77
Filter	12	9	142	72	53.99	57.63
All types	57	51	697	415	53.20	55.03

Table IX

ESTIMATED GRAMS OF TOBACCO SMOKED PER DAY
FOR SEVERAL LEVELS OF DAILY CIGARETTE SMOKING
BY PERIOD AND TYPE OF CIGARETTE SMOKED

Period	Type of Cigarette	Smoking Level (cigarettes/day)			
		10	20	30	40
I	70 mm.	4.20	10.64	17.08	23.52
	85 mm.	7.31	13.75	20.19	26.63
	Filter	7.22	13.66	20.10	26.54
II	70 mm.	3.88	10.40	16.92	23.44
	85 mm.	7.27	13.79	20.31	26.83
	Filter	7.59	14.11	20.63	27.15

accurately classifying individuals according to cigarette tobacco smoked. It would appear necessary to know type (length) of cigarette smoked as well as average daily consumption. Further analysis of the data on amount smoked by weight will appear in the final report.

PHASE II

Introduction

The cost of using a daily counting device, such as the lighter-counter, to obtain an accurate measure of current smoking in large population groups would be prohibitive. For the most part previous studies of smoking habits have used the less expensive technique of personal interviews; but very little has been reported on the accuracy of the responses elicited by the various questionnaires employed. Research in this phase was directed, therefore, not only at the development of an improved questionnaire for measuring the amount of current smoking, but also at testing its accuracy against a semi-objective standard measure, namely, the lighter-counter.

Following study of a number of questionnaires used in a variety of smoking investigations, the Y questionnaire referred to in Phase I was developed. Several pre-tests were conducted and revisions made where necessary. Incorporated in this questionnaire were features aimed specifically at bringing to the respondent's attention various aspects of his own smoking habits. These features included questions regarding the least and greatest number of cigarettes smoked per day, smoking on week-ends, and smoking during various periods of the day prior to interview.⁽¹¹⁾

Since the questionnaire adopted by the U. S. Bureau of the Census for its 1955 smoking habits survey was to be used on one-half of the permanent factory and stemmery employees of the American Tobacco Company in the Phase III smoking survey, a study of its accuracy was included in the Phase II research. The Census questionnaire (referred to in Phase I and henceforth as the X questionnaire) differed from the newly developed Y questionnaire, aside from the special features of the latter mentioned above, in one major respect. The cigarette smoking respondents to the

(11) The questionnaire was designed with the intention that the day prior to interview would be a weekday.

Census questionnaire were required to respond to the question "How many cigarettes do you smoke a day on the average?," only by checking one of the following five classes:

1. Smoke once in a while, not every day.
2. Smoke less than 10 cigarettes (1/2 pack).
3. Smoke between 10 and 20 cigarettes (1/2 - 1 pack).
4. Smoke between 21 and 40 cigarettes (1 - 2 packs).
5. Smoke over 40 cigarettes (over 2 packs).

On the other hand the Y questionnaire required a numerical answer to this same question and all other questions dealing with number smoked. Evaluation of the accuracy of the X (Census) questionnaire was limited, therefore, to estimates of the amount of misclassification; a considerably more detailed analysis regarding the accuracy of the responses to the Y questionnaire was possible, however.

Design of the Study

A total of 60 office employees of the Richmond Branch were chosen to test the accuracy of responses to the X and Y questionnaires. The 60 subjects were classified by sex and then assigned at random to one of two groups. On June 8, 1956 the first group filled out the X questionnaire and the second group filled out the Y questionnaire. Two weeks later on June 22, 1956, each group filled out the alternate questionnaire. The entire group then underwent a 16 day lighter-counter test period. The decision to use 16 days was based on an average day-to-day cigarette smoking standard deviation of 5, determined from the Phase I data, and the desire to have the true lighter-counter smoking averages estimated within 2.5 cigarettes.

The lighter-counter readings were recorded and the lighter-counters checked at approximately the same time each day. Losses due to lighter-counter failures were minimal. However, 8 of the subjects were not available for the full 16 days of the test and the data analysis was based on the 52 subjects remaining.

Preliminary Data Analysis

a. Misclassification Rates

The current average daily cigarette smoking of each of the 52 subjects participating throughout the Phase II test were computed from the 16 days of lighter-counter readings. The subjects were then classified according to these daily averages into one of the four smoking classes used in the X questionnaire. These were classes (2) through (5) referred to above. Accepting the resulting classification as a standard, misclassification rates were computed for a variety of questionnaire cigarette smoking measures (obtained from responses to the X and Y questionnaires) by cross classification of these measures with the standard. The measures compared in this manner were (a) the response to question 1a of the X questionnaire (denoted by X), (b) the response to question 1 of the Y questionnaire (denoted by Y_1), (c) the response to question 13 of the Y questionnaire (denoted by Y_{13}), (d) the average response to questions 2 and 3 of the Y questionnaire (denoted by Y_m), and (e) one-seventh the sum of 5 times the response to question 4, the response to question 11 and the response to question 12 of the Y questionnaire (denoted by Y_c).

The misclassification rates were computed by expressing the ratio of the number of subjects misclassified to the total number of subjects as a percent. A preliminary comparison of these rates for the group of subjects filling out the questionnaires in XY order against the group filling them out in YX order indicated no detectable difference associated with order of questionnaire presentation. In view of this and the fact that the number of subjects was limited, 45 subjects who used the lighter-counter only in either or both of the two periods in the Phase I test were included in the final misclassification rate computations. The questionnaires had been presented to this latter group of subjects in XY order prior to Period I.

The resulting cross classifications for each of the 5 questionnaire measures against the standard (lighter-counter) measure for the total of 97 subjects are given in Table X. The highest misclassification rate (23.7%) was observed for the responses to question X, the lowest (17.5%) for the responses to question Y₁₃. The difference between these misclassification rates was not statistically significant, however. The number of subjects tested was insufficient to conclude with confidence that the observed difference (6.2%) in the rates of misclassification for the two questions was other than a chance difference, even though it might in fact be an accurate estimate of the true difference.

The cross classification tables reveal a tendency (for this particular set of class intervals) for light smokers as measured by the lighter-counter to classify themselves into a heavier smoking class, and for heavy smokers to classify themselves into a lighter smoking class.

One fairly conclusive fact revealed by the data in Table X is that even with a series of questions designed to elicit greater accuracy in response with respect to current smoking averages, the rate of misclassification with a set of rather wide class intervals is still greater than 10 percent. The validity of this conclusion does depend on the accuracy of the lighter-counter as a standard, of course.

A similar analysis of the data for the responses to the Y questionnaire using a different set of class intervals will appear in the final report.

b. Error Component Analysis

In studies concerned with estimating the average daily cigarette smoking of a particular segment of the population, it is helpful to know the magnitude of the various components entering into the total error of the estimate when a particular measuring instrument is used. If observations are made on a sample of the population with an instrument which measures without error, the

Table X

CLASSIFICATION OF QUESTIONNAIRE RESPONSES AGAINST AVERAGE DAILY
CIGARETTE SMOKING AS MEASURED BY THE LIGHTER-COUNTER

Response		Average Number of Cigarettes Smoked Daily				Misclassification
Question	Class	Less than 10	10 to 20	21 to 40	Over 40	Rate
X	< 10	12	2	0	0	$\frac{23}{97}$ or 23.7%
	10 to 20	7	23	8	0	
	21 to 40	0	1	36	3	
	> 40	0	0	2	3	
Y 1	< 10	12	0	0	0	$\frac{19}{97}$ or 19.6%
	10 to 20	7	25	7	0	
	21 to 40	0	1	38	3	
	> 40	0	0	1	3	
Y 13	< 10	14	0	0	0	$\frac{17}{97}$ or 17.5%
	10 to 20	5	25	7	0	
	21 to 40	0	1	38	3	
	> 40	0	0	1	3	
Y m	< 10	15	2	0	0	$\frac{19}{97}$ or 19.6%
	10 to 20	4	23	9	0	
	21 to 40	0	1	36	2	
	> 40	0	0	1	4	
Y c	< 10	14	1	0	0	$\frac{21}{97}$ or 21.6%
	10 to 20	5	23	9	0	
	21 to 40	0	2	36	3	
	> 40	0	0	1	3	

only component of error in the eventual estimate is that due to sampling. If the measuring instrument is not perfect, then either systematic errors or random measurement errors or both will be present, in addition to the sampling error. The daily smoking counts obtained with the lighter-counter in the Phase II test permitted a breakdown of the error components for various questionnaire measures derived from the Y questionnaire.

The analysis is based on an additive model of components for each questionnaire response. These components are (a) the true average daily smoking of the population group, (b) the deviation of the true average daily smoking of the individual responding from the true group average, (c) the bias in the response of this individual, and (d) a random response error which varies over occasions and individuals. With this particular model the variance of a response given by a randomly selected individual on a randomly selected occasion also has four components. These components and the notation used for their estimates in the analysis are:

- (1) the variance of the true individual daily smoking averages with estimate denoted by s_I^2 .
- (2) the variance of the individual response biases with estimate denoted by s_B^2 .
- (3) twice the covariance of the individual response biases with the deviations of the true average daily smoking of the individuals from the true group average with estimate denoted by $2s_{IB}$.
- (4) the variance of the random response errors, assumed to be the same for all individuals, with estimate denoted by s_E^2 .

The data collected by the lighter-counter provided the estimate s_I^2 if it is assumed that each day's counts are made without error. These data also provided an estimate of the day to day variance in individual smoking for the population group. This estimate is denoted by s_D^2 in the analysis. The

necessary estimates of the other components were obtained through a joint analysis of the lighter-counter data and the responses to the various questionnaire measures. Since each individual in the Phase II study responded to the Y questionnaire only once, it was not possible to obtain separate estimates for the variance of the individual biases and the random response error variance. The estimate of the sum of these two variance components has been denoted by $s_B^2 + s_E^2$.

The results of this type of analysis for the 52 office employees participating throughout the Phase II test are given in Table XI. Included in the table are the observed average response to each questionnaire measure (denoted by \bar{y}), the estimated net or average response bias of the individuals (denoted by \bar{B}) and the estimated variance of the questionnaire responses (denoted by s_Y^2).

A similar analysis was possible for the laboratory employees using the lighter-counter only in the Phase I experiment. The results of this analysis for the 27 subjects in this category during Period I are also given in Table XI, as well as the results of the analysis for the total group of 79 individuals.

The results of the analysis indicate that there is not much difference as regards the non-sampling or response error components in the various Y questionnaire measures under study. The individual biases tend to cancel out as revealed by the magnitude of the net bias \bar{B} . In terms of the group means, these net biases are of the order of 2.5 percent, however, which could be critical if greater accuracy were desired in the estimate of the mean of a particular population group and the results here are at all indicative. It is of interest to note that Y_1 and Y_{13} overestimate the group mean whereas Y_m and Y_c underestimate. The underestimate by Y_m was expected. The bias for Y_c had the happy chance circumstance of being estimated as zero (at least to two decimal places) for the 52 office employees. Sampling errors for the estimates of \bar{B} will be included in the final report and hence a final evaluation of the net bias in the various measures should be postponed.

Table XI

PRELIMINARY SUMMARY OF ESTIMATED MEANS, VARIANCES, AND RESPONSE ERROR COMPONENTS FOR SEVERAL QUESTIONNAIRE MEASURES OF AVERAGE DAILY CIGARETTE SMOKING

Test Group and Questionnaire Measure	No. of Subjects	No. of Test Days	\bar{y}	\bar{B}	s_y^2	s_I^2	s_D^2	$s_B^2 + s_E^2$	$2s_{IB}$
Office Personnel									
Y_1	52	16	19.85	0.17	121.51	112.25	23.94	17.18	- 7.92
Y_{13}	52	16	20.13	0.45	126.98	112.25	23.94	16.69	- 1.96
Y_m	52	16	19.10	-0.58	104.82	112.25	23.94	20.25	-27.68
Y_c	52	16	19.68	0.00	114.97	112.25	23.94	23.54	-20.81
Laboratory Personnel, Period I									
Y_1	27	14	26.96	1.30	186.42	170.19	29.38	18.62	- 2.38
Y_{13} pre	27	14	26.44	0.78	213.26	170.19	29.38	16.18	26.88
Y_{13} post	27	14	25.56	-0.10	174.33	170.19	29.38	6.00	- 1.94
Y_m	27	14	24.37	-1.29	174.17	170.19	29.38	14.91	-10.94
Y_c	27	14	24.93	-0.73	199.38	170.19	29.38	13.32	15.86
All Groups									
Y_1	79	14-16	22.28	0.55	153.13	138.08	25.56	17.57	- 2.50
Y_{13}	79	14-16	22.29	0.56	163.18	138.08	25.56	16.16	8.94
Y_m	79	14-16	20.90	-0.83	132.93	138.08	25.56	18.16	-23.30
Y_c	79	14-16	21.16	-0.57	149.10	138.08	25.56	19.67	- 8.66

The magnitude of the covariance term, $2s_{IB}$ for Y_m seems to be sufficient to rule out this questionnaire measure of average daily cigarette smoking, since a preferred measure would have no association between smoking level and individual response bias. A consistent picture is not revealed for the estimates $2s_{IB}$ as between the laboratory group and the office personnel. It is doubtful that the number of individuals in the test were sufficient for reliable estimates of the covariance component.

The estimates $s_B^2 + s_E^2$ are somewhat less variable, but again leave little in the way of choice as between the various measures. A preferred measure would have negligible individual response bias and random response error variances. If one of two questionnaire measures had a large \bar{B} but negligible response error variances and the second had a small \bar{B} but relatively large response error variances, the latter measure would be preferred. Since the estimates $s_B^2 + s_E^2$ are only of the order of 10 to 20 percent of the pure sampling variance estimate s_I^2 , the cost with Y_1 , for example, of the additional individuals necessary in a sample of a particular population group to achieve a specified precision in the estimate of the average daily smoking for the group would undoubtedly be negligible relative to the added cost of using a more accurate measure such as the lighter-counter. It should be noted in making this point that s_D^2 is greater than $s_B^2 + s_E^2$; but, on the other hand, if the desired accuracy is only slightly greater than the net bias \bar{B} of Y_1 , the situation as to cost would be reversed.

The results for the responses to Y_{13} made after Period I (i.e. Y_{13} post) as opposed to those made prior to Period I (i.e. Y_{13} pre) for the laboratory personnel are further evidence of the learning process referred to earlier. The net bias \bar{B} , $s_B^2 + s_E^2$, and $2s_{IB}$ all decreased markedly.

On the basis of the analysis to date, it seems reasonable to conclude that the single question Y_1 is best among the questionnaire measures tested. Although

there is little evidence in the data that Y_1 is superior to Y_{13} from a statistical standpoint, the latter is definitely inferior on the basis of the number of questions required of the respondent. A more conclusive statistical choice between the two measures will probably require additional testing with a considerably greater number of subjects in order that the response error components be estimated with sufficient precision. Further conclusions await the results of the analyses to be included in the final report. Details of the statistical model employed in the error component analysis will also be presented in the final report.

December 4, 1956