"DAY-OF-WEEK" DIFFERENCES AND IMPLICATIONS FOR TIME-USE RESEARCH

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Since the end of World War II, developments in interviewing practices, sampling design, coding processes, and data collection technology have enabled researchers around the world to refine the time-use survey (TUS) methodology.[1] Yet, each TUS still has several data collection and sampling issues to negotiate. For example, when selecting the mode of data collection, designers must consider that respondents who engage in more activities outside the home are less likely to be available for contact by an interviewer. Consequently, if the survey is not a self-administered paper instrument, there may be an increased possibility of nonresponse bias due to non contact, since the probability of obtaining a time-use interview has a direct relationship with the respondent's own use of time (Scheuch, 1972). The field procedures for pursuing nonresponse and reassigning interviews when a respondent is not available to report about a pre-assigned day (*i.e.*, the "designated day") will affect the quality of estimates. For example, if a respondent has been randomly assigned to report about Tuesday activities, but cannot be contacted on the next day (Wednesday) for an interview, should the respondent be reassigned to report on the Tuesday of the following week? Or is it acceptable to shift everything forward by one day, so that the respondent would then be called on the next immediate day (Thursday) to attempt an interview about a new "designated day" (Wednesday) as a substitute for the originally assigned Tuesday? Such substitutions of assigned reporting days could potentially reduce the size of the survey nonresponse rate. But would such relaxation of the rules of random pre-assignment introduce other problems for the production of accurate estimates on the use of time?

Common practice across time-use surveys shows that there is no firm agreement on the rigor with which respondents should be held to their originally assigned reporting day. This study is an attempt to understand whether some flexibility may be tolerated in the re-assignment of reporting days, by examining the different daily activity profiles produced by a recent American TUS and comparing those profiles using an "index of similarity" (Converse, 1972; Harvey et al., 1984).

Study Design

One of the recent national time-use studies is the 1992-1994 survey conducted by the University of Maryland's Survey Research Center (Triplett, 1995) on behalf of the U.S. Environmental Protection Agency (EPA). The target population was persons living in telephone households within the 48 contiguous states. Respondents were selected using a two-stage Mitofsky-Waksberg random digit dial sample design stratified by four census regions. Respondents provided one Saturday report, one Sunday report and two weekday reports of their activities. The study combined two years of data collection with the sample distributed evenly by calendar quarter. Within households, the "Next Birthday" method of selection was used to select one random adult respondent. In households consisting of adults plus children under 18 years of age, one child was randomly selected 60% of the time; the other 40% of the time an adult was selected at random. There was an overall response rate of 63%,[2] yielding 6,316 interviews for weekdays and 3,070 interviews for weekends for a total of 9,386 diaries reporting on the activities of the previous 24-hour period. The current paper focuses only upon the activity patterns of the adults and, therefore, uses the interviews from the 7,408 respondents 18 years-of-age and older for the analysis.

The first step in the current analysis was to look for differences among types of respondents interviewed on different days of the week. If such differences exist by day-of-week, it might be argued that differences in activity profiles are created because clusters of respondents with similar household composition or some other shared characteristic were more likely to be interviewed on the same day. This, in turn, might bias the estimates and mask any true "day-of-week" patterns for the general population.

Upon examination, there were some differences in the distributions of key demographic variables across different days of the week, indicating that different proportions of various subgroups were interviewed on different days. But the differences were statistically significant for only three of the seven variables investigated. These included "having children under 18 in the household" ($X^2 = 13.55$, $p = .04$), "employment status" ($X^2 = 22.34$, $p = .04$), and "age" ($X^2 = 51.39$, $p = .05$).[3] That is to say, respondents fitting the subcategories within each of

these three variables were not interviewed at the same rate across the seven days of the week and the differences are of a magnitude that could lead to analytic error when looking at daily estimates of time-use.

The second step in the analysis was to sum the total time spent by all respondents performing various activities on each day of the week. These totals were used to compare the activity profiles for each pair of days across the week using the Szalai T formula:

$$T = \sqrt{\frac{\sum_{i=1}^{k}\left(\frac{a_i/24 - b_i/24}{a_i/24 + b_i/24}\right)^2}{k}}$$

where "a" represents the total time spent in activities 1...n for the first comparison day, "b" represents the total time spent in activities 1...n for the second comparison day, and "k" is the total number of activities being compared across days (Harvey et al., 1984; Converse, 1972). This formula is frequently used to compare time-use data because it is scaled to the 24-hour day and is able to take into account the relative contributions of long activities as compared to short duration activities. That is to say, a one-hour difference in the duration of a lengthy activity (*e.g.*, sleeping), contributes less to the overall estimate of differences between two days than would a daily one-hour difference in a typically short activity (*e.g.*, brushing teeth).[4] This produces an index of similarity between pairs of days, ranging from 0 if the same amount of time is spent doing exactly the same activities on both days to 1 if the days are totally dissimilar and none of the same activities are reported on both days.[5] This step in the process was conducted for (a) the total sample, (b) those with and without children under 18 years of age, (c) those respondents employed full-time, part-time, and unemployed, and (d) respondents aged 18-34, 35-54, and 55 years or older. This was necessary because of indications that respondents were interviewed at uneven rates on different days of the week, raising the possibility that subgroup differences might be driving the patterns of "day-of-week" similarity. An additional analysis was conducted for those ages 65 and older.

The final step was to use the information about the similarity of days to guide decisions on aggregating data. New time-use estimates were then computed using data from similar days. The activity means and variances are presented to show the effect of reporting output based on the different temporal patterns emerging from the "day-of-week" comparisons.

Findings

An examination of Tables 1 through 4 shows that there are differences in time allocation across pairs of days. While the differences are not dramatic, they range from a maximum similarity of 0.30 when comparing Wednesday and Thursday for all adult respondents (see Table 1) to a maximum dissimilarity of 0.65 when comparing Friday and Sunday (see Table 2) for adult respondents with children under 18 years-of-age. Unfortunately, looking at a single T-value, such as the Friday/Sunday comparison just cited, has no self-evident meaning on its own. The meaningfulness of such comparisons must accumulate by examining the calculations of the T-value across several comparisons (Converse, 1972). For this reason, sets of comparisons will be presented as a matrix of values and discussed in terms of their relative similarity (*i.e.*, low values) or dissimilarity (*i.e.*, high values).

In short, the Szalai T-Index of differences in activity profiles for the day-by-day comparisons seen in Tables 1 through 4 suggests the following patterns:

1. There are consistent differences in time allocation for Friday versus the rest of the week, Saturday versus the rest of the week, and Sunday versus the rest of the week. This overall pattern holds for the total sample (weighted and unweighted), those with and without children under 18 years of age, those employed full-time, the unemployed, and for the three age groups (18-34, 35-54, 55+).

    - In Table 1, Sunday is more different from Friday than from any other day of the week; Saturday is also more different from Friday than from any of the other six days.

    - In all four tables, Monday through Thursday generally show more similarity to each other (.30 to .50) than they do Friday through Sunday (.42 to .59), except among those who are employed part-time or have children under 18.

2. Those with children under 18 show more day-by-day dissimilarity (*i.e.*, higher T-values) than those without children under 18.

3. Those employed part-time show more day-by-day dissimilarity than those employed full-time and the unemployed. The dissimilarity of days for part-time employees is such that each day appears rather unique.

4. Looking at the three age subgroups (18-34, 35-54, 55+) seen in Table 4, most of the same patterns appear as for the total sample (Table 1).[6]

By reducing the matrix of similarities into a single continuum of differences, it is possible to rank order the composite differences. In this case, summing the T-values for the six day-by-day comparisons yields an index ranging from 0 to 6 (*e.g.,* Monday versus Tuesday plus Monday versus Wednesday plus Monday versus Thursday etc.).[7] Using the T-values for the total sample of adults, the following rank-order emerges.

	Unweighted	Weighted
Friday	2.89	3.00
Sunday	2.83	2.97
Saturday	2.60	2.73
Tuesday	2.45	2.59
Wednesday	2.34	2.57
Monday	2.33	2.49
Thursday	2.25	2.47

Thus, Friday shows the most "global" dissimilarity (*i.e.*, highest summed T-values) and Thursday shows the most similarity (*i.e.,* lowest summed T-values) when compared with the other six days. This further reinforces the unique activity patterns of Friday as compared with all of the other six days and possibly sets it apart as non-equivalent with either weekdays (*i.e.,* Monday through Thursday) or weekend days (*i.e.,* Saturday or Sunday), when considering potential substitutions. However, as mentioned earlier, looking at a single T-value has no self-evident meaning on its own. The meaningfulness of such comparisons must emerge by ordering the T-values in relationship to each other (Converse, 1972) and considering rank order.

The question arises, however, does this reduction of the six day-by-day comparisons into a single global ranking of similarity obscure some of the more important complexities of daily variation? For instance, what if a day has very high similarity with half of the other days and very low similarity to the other half of the days? When reduced to a single report, will that day's rank equal a day having medium similarity across all comparisons? If so, what do the richer, day-by-day comparison patterns look like across all days of the week?

Looking at the total adults in Table 1, we find that the single "global" report that ranks Thursday as most similar overall to the other days of the week is driven by the fact that it appears to be somewhat similar to Monday, Tuesday, and Wednesday (.30 to .35) while showing only moderate dissimilarity with Friday, Saturday, and Sunday (.43 for all three comparisons). This is a different pattern than that displayed by Monday, the next in rank order of global similarity. Monday shows more similarity when compared with Tuesday through Thursday (i.e., highest dissimilarity being .33), but also displays greater dissimilarity when compared with Friday, Saturday, and Sunday (i.e., highest dissimilarity being .49). Likewise, Friday ranked highest in dissimilarity when compared with the rest of the days of the week by summing the comparisons. But Sunday (which ranks less dissimilar than Friday overall) shows more extreme dissimilarity when compared with Tuesday (.51) than does Friday (.49), which is masked in the single global ranking.

Considering the T-values shown in Table 1 and the global ranking of day-by-day comparisons, it seems reasonable to conclude that the assignment of "designated days" in a TUS cannot be a simple weekday versus weekend dichotomy. There seems to be evidence that the activity patterns of Friday appear to distinguish and separate that day from both the other weekdays of Monday through Thursday, (.43 to .49) and weekend days of Saturday and Sunday (.49 to .53). Likewise, Saturday and Sunday appear to show differences from each other (.42) and from Monday through Thursday (Saturday comparisons range from .42 to .43 and Sunday comparisons range from .43 to .51). Patterns of similarity between Monday through Thursday (.30 to .35) begin to percolate to the surface and raise the question of whether or not they could be considered equivalent days when allocating "day-of-week" assignments.

Applications

In an effort to examine the patterns shown by the Szalai T-Index of Similarities and the possible effect of allocating designated days in different ways, the next step is to examine actual activity estimates to see if day-of-week allocation may be optimally different for specific activities. To test the day-of-week differences in this way, unweighted means for the 10 primary groups of activities collected by the EPA TUS were calculated for different day-of-week designs: Design I included each individual day of the week, Design II included only Monday through Thursday, Design III included regular weekdays (Monday through Friday), and Design IV included the entire week (Monday through Sunday).[8] Variances were also computed as an indication of the within strata homogeneity of these designs. Table 5 summarizes the relative variability of these activity estimates by using the Coefficient of Variation defined as: $\frac{\sqrt{s^2}}{\bar{y}}$.

Comparing Designs II and III (Monday through Thursday versus Monday through Friday), the estimates for some activities show slightly more homogeneity when using Design II. These activities include organizational activities (4.22 versus 4.28), recreation (2.39 versus 2.43), education and training (4.25 versus 4.28), and childcare (3.38 versus 3.43). In addition, the estimates of personal care and passive leisure activities show no differences between the two designs. Taken together, the evidence suggest that Monday through Thursday may be treated as equivalent days when re-assigning those respondents who could not be contacted on their assigned day. It further suggests that the traditional focus upon "weekday" (Monday through Friday) versus "weekend" (Saturday and Sunday) estimates in the publication of reports may be a facile, but somewhat false, approach to the presentation of time-use information.

Summary

This study has analyzed the activity profiles of each day of the week in a series of T-comparisons, resulting in an index of similarity between pairs of days. These comparisons were made for all respondents and for subgroups that were interviewed at different rates across the days of the week. These latter comparisons were important for answering potential challenges to the generalizability of the findings.

Taken all together, these findings suggest that an American TUS may not be able to approach the "day-of-week" assignment simply as a weekday versus weekend dichotomy. Among the total adults, the activity patterns of Friday appear to distinguish and separate that day from both the other weekdays of Monday through Thursday (Szalai T values from .43 to .49) and the weekend days of Saturday (.49) and Sunday (.53). There are three major implications.

First, when assigning a "designated" reporting day, it may be unwise to equate Friday with the other weekdays. In other words, if a respondent has been pre-assigned to be interviewed on Tuesday about the activities of Monday, but cannot be contacted to make that report, it may be acceptable to try again on Wednesday to collect a Tuesday report or on Thursday to collect a Wednesday report or on Friday to collect a Thursday report, but a Friday report (collected on Saturday) would not be an equivalent substitution.[9] This has many ramifications for response rates and field procedures.

Second, the findings suggest that if part-time employees are a subgroup of interest for estimates, they may need to be over-sampled relative to other subgroups. Since those employed part-time experience more dissimilarity between days, this should be a taken into consideration when designing the sample. Likewise, other subgroups, such as those with children under the age of 18, may show the same overall patterns of Friday, Saturday, and Sunday variability as the rest of the population, but at a more extreme rate. The causes for this more extreme degree of dissimilarity may also need to be investigated and considered in the survey design.

Third, the varying activities that enter into the differing profiles for Monday through Thursday, Friday, Saturday, and Sunday, may mean that it is insufficient to simply provide weekday and weekend estimates for all activities. In particular, there may be negative effects on the variances when all activities are grouped into a "weekday" (Monday through Friday) report. That is to say, different activities may need to be reported in different temporal patterns.

Conclusion

For many people, even a cursory review of their daily activities will supply examples of how recent social changes have altered weekly routines. Increased work-time flexibility, 24-hour shopping on the Internet or at stores that are continuously open are changes that have affected the flow of activities across the seven days of the week. Consequently, researchers may no longer assume that the most important and meaningful time-use estimates for all activities are the traditional weekday and weekend reports. Nor is it possible for survey field operations to relax a rigorous assignment of "designated" reporting days to the extent that any day of the week may be substituted for another. There are also indications that certain patterns vary in different ways for specific activities and subgroups of respondents.

Finally, it should go without saying that the aims of the particular research project will drive the number and kinds of estimates that are made. And whatever kinds of reports are selected, some amount of information will always be lost because of the ways the data are classified and sorted. This is especially true with the TUS because of the enormous range of possibilities available for presenting the richness of human activity across time. That is to say, activities may be reported as single annual estimates, average monthly or weekly estimates, or even weekday and weekend estimates. But by examining activity differences across the temporal cycles, it is possible to identify differences that should be used to inform and direct the sampling, data collecting, and reporting decisions. In this way, the TUS can most fully serve as the meaningful and interesting social yardstick that it was created to be.

Notes

1. A time-use survey generally includes a sequential listing of all the activities a respondent did "yesterday" (if collected by telephone or face-to-face) or "today" (if collected by self-administered paper diary).

2. The overall response rate is here defined as the number of completed interviews over the total number of identified telephone households (Triplett, 1995).

3. Other variables that were investigated, but not found to be statistically different, were: Education, Gender, Census Region, and Race.

4. When using the Szalai T-comparison formula, it is necessary to delete all activity categories which have a zero total on both days being compared. If this is not done, the squared fraction after the summation sign will have the indeterminate value of $(0/0)^2$. The EPA TUS datafile contains a maximum of 91 activity categories ("k"). However, in these analyses after the deletion of the null activity pairs, "k" ranges from 78 to 91. For more information, see p. 118 in *Time Budget Research* by Andrew S. Harvey, Alexander Szalai, David H. Elliott, Philip J. Stone, and Susan M. Clark, 1984.

5. The 0 maximum similarity results when a/24 – b/24 has a value of zero for each and every activity category. The 1 for maximum dissimilarity arises when none of the activities reported on day "a" are reported on day "b" and vice versa.

6. In addition to these broad age categories, those respondents aged 65 and older were examined separately. As expected, the elderly respondents showed more extreme variation day-by-day, but with many of the same general patterns as found in the other age groups.

7. For example, the unweighted value for Friday is obtained by adding the values for Friday versus Monday (0.49) and Friday versus Tuesday (0.50) and Friday versus Wednesday (0.47) and Friday versus Thursday (0.43) and Friday versus Saturday (0.49) and Friday versus Sunday (0.53). This produces the "global" Friday similarity rating of 2.89.

8. Estimates are not presented for a combined "Friday, Saturday, Sunday" period, since this is not generally considered a typical reporting cycle.

9. This is a common practice with some time-use surveys. The design for the EPA TUS used for this analysis required that each respondent provide 1 Saturday report, 1 Sunday report, and any 2 weekday reports (Monday through Friday as equivalent days).

References

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Table 1: Index of Day-of-Week Similarity Using Unweighted Data for All Adult Respondents

	Mon	Tues	Wed	Thurs	Fri	Sat
Tues	.33					
Wed	.31	.35				
Thurs	.31	.35	.30			
Fri	.49	.49	.47	.43		
Sat	.42	.42	.43	.43	.49	
Sun	.47	.51	.47	.43	.53	.42

Table 2: Day-of-Week Similarity for Adult Respondents: With Children < 18 of Age and Without Children < 18 Years of Age

With. Without	Mon	Tues	Wed	Thur	Fri	Sat
Tues	**.48** .38					
Wed	**.47** .37	**.49** .41				
Thur	**.46** .40	**.49** .39	**.45** .39			
Fri	**.55** .49	**.56** .51	**.60** .45	**.58** .46		
Sat	**.55** .44	**.56** .45	**.53** .48	**.56** .47	**.55** .52	
Sun	**.55** .49	**.60** .54	**.54** .49	**.59** .48	**.65** .53	**.54** .42

Table 3: Index of Day-of-Week Similarity Using for Adult Respondents: Employed Full-Time, Employed Part-Time, and Unemployed

Full *Part* ***Unem***	Mon	Tues	Wed	Thur	Fri	Sat
Tues	**.44** .47 **.46**					
Wed	**.43** .56 **.47**	**.46** .54 **.42**				
Thur	**.43** .51 **.41**	**.49** .53 **.39**	**.41** .58 **.46**			
Fri	**.55** .60 **.52**	**.56** .58 **.55**	**.55** .59 **.49**	**.51** .61 **.52**		
Sat	**.47** .58 **.51**	**.51** .58 **.55**	**.51** .62 **.50**	**.53** .59 **.52**	**.57** .59 **.53**	
Sun	**.51** .59 **.51**	**.57** .57 **.56**	**.53** .62 **.53**	**.55** .63 **.51**	**.61** .60 **.55**	**.42** .57 **.49**

Table 4: Index of Similarity for "Day-of-Week" Using Szalai T-Comparison. Data for Adult Respondents: Ages 18-34, Ages 35-54, and Ages 55+

18-34 *35-54* *55+*	Mon	Tues	Wed	Thur	Fri	Sat
Tues	**.41** .44 **.46**					
Wed	**.42** .42 **.49**	**.45** .46 **.46**				
Thur	**.45** .46 **.46**	**.45** .46 **.50**	**.41** .43 **.48**			
Fri	**.49** .61 **.59**	**.54** .59 **.56**	**.49** .57 **.56**	**.50** .56 **.56**		
Sat	**.50** .51 **.53**	**.56** .56 **.50**	**.56** .49 **.50**	**.54** .49 **.51**	**.52** .58 **.58**	
Sun	**.51** .56 **.57**	**.55** .57 **.59**	**.54** .53 **.57**	**.53** .52 **.55**	**.59** .64 **.63**	**.48** .48 **.52**

Table 5: Coefficient of Variation for Primary Activity Estimates Produced by 3 Different "Day of Week" Designs

	I	II	III
	Mon – Thur	Mon - Fri	Mon – Sun
Organiz-ational	**4.22**	**4.28**	4.75
Recreation	**2.39**	**2.43**	2.39
Education/ Training	**4.25**	**4.28**	3.48
Childcare	**3.38**	**3.43**	3.66
Housework	**1.34**	**1.35**	1.32
Personal Care	**0.24**	**0.24**	0.24
Passive Leisure	**0.82**	**0.82**	0.80
Paid Work	1.02	1.01	1.28
Purchasing Goods & Services	1.97	1.94	1.89
Social & Entertain-ment	2.35	2.27	1.95