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Activity, Time and Subjective Happiness: An Analysis Based on an Hourly Web Survey

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Activity, Time, and Subjective Happiness: An Analysis Based on an Hourly Web Survey [†]

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Abstract

This paper investigates how people's happiness depends on their current activities and on time. We conducted an hourly web survey, in which 70 students reported their happiness every hour on one day every month from December 2006 to February 2008. This method is an extension of the experience sampling method (ESM), since it uses mobile phones and personal computers. Our new method has the same strength of ESM in that it can measure real-time happiness data and thus avoid reflection and memory bias. Using our new method, we can obtain diurnal happiness data of respondents and also grasp their behavior at each of their reporting times over 14 months. Analyzing the data of our survey, we found (a) happiness significantly depends on activities, hours, and months, (b) while most of the time-variation of happiness is attributable to the time pattern of activities, happiness varies predictably with the hour in a day, even when activities are controlled for, and (c) while activities affect both genders similarly, there are gender gaps in the diurnal happiness pattern after controlling for activities.

JEL classification number: I31

Keywords: happiness, hourly web survey, ESM, mobile phone, Japan

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1. Introduction

For a long time, it has been a convention in happiness studies to ask "All things considered, how satisfied are you with your life as a whole these days?" (The World Values Survey) or "Taken all together, how would you say things are these days? Would you say that you are very happy, pretty happy, or not too happy?" (The General Social Survey). These questions ask people to evaluate their own life or make a global retrospective judgment (Kahneman and Krueger, 2006). To answer these questions, respondents reflect on their life from various viewpoints. Some of them might *predict* their happiness, considering their home and work situations and comparing these with those of other people, reaching a conclusion such as "considering various elements, I should be happy, even if I don't feel so." In a word, it is known that memory and reflection often differ from current feelings (Kahneman, 1999).

To escape from reflection and memory bias, the experience sampling method (ESM) has been developed. ESM refers to a method of data collection in which participants respond to repeated assessments at different moments over the course of time while functioning within their natural settings (Scollon et al., 2003). ESM typically uses beepers to alert respondents to fill in questionnaires at a randomly determined time. A merit of ESM is that it measures "point-instant utility" (Kahneman, 1999), which may be close to “instantaneous utility” in economics, and is free from memory bias. On the other hand, “overall” happiness is more difficult to relate to the concept of utility in economics.[1] A demerit of ESM is that it is a costly method, and burdens respondents, which may cause a selection bias problem.

Two methods have been developed associated with ESM. The first is ecological momentary assessment (EMA), in which measurement is concerned not just with the participant’s momentary subjective experience, but also with elements of the environment related to momentary experience (Stone at al. 1999). For example, Steptoe et al. (2005) asked 228 individuals to report their happiness every 20 minutes during a workday, and measured the level of cortisol, an adrenal hormone related to the risk of obesity, hypertension and autoimmune conditions, every two hours. From these data, the authors found that subjects’ happiness ratings were significantly inversely correlated with their cortisol levels. This line of studies is expected to establish a foundation for measuring objective happiness. However, EMA is more costly and puts a heavier burden on subjects than ESM.

The other new method is the daily reconstruction method (DRM) proposed by Kahneman et al. (2004a), in which respondents first revive their memories of the

[1] Kimball and Willis (2006) dispute both the idea that happiness and utility have no relation and the idea that they are the same, and postulate a more complex relationship between the two. Happiness may thus be related to, but not identical to, instantaneous utility of the type found in most economic models.

previous day by constructing a diary consisting of a sequence of episodes, then describe each episode by answering questions about the situation and about the feelings that they experienced, as in ESM. Compared with ESM, DRM has the advantages of low costs to the investigator and low burden on subjects. Kahneman et al. (2004a,b) show that the diurnal cycles of affect and tiredness produced by DRM and ESM are quite similar. Atz (2013) reports a low recall bias for the DRM. Thus, DRM might be a good substitute for ESM, although more studies are necessary to confirm this (Diener and Tay 2014, Tay et al. 2014).

This study essentially follows ESM, but has the following distinguishing features. First, we utilize a web survey, in which subjects access a website by personal computer or mobile phone.[2] The conventional ESM cannot confirm that subjects really fill in forms when they receive a beep, which damages the reliability of the results of ESM (Scollon et al., 2003). In our web survey, the timing of the answers by subjects is automatically recorded in the database, which allows no cheating. In addition, most members of the younger generation in Japan always carry their mobile phones, which have featured internet connection and email since 2006. Thus, this method puts less of a

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[2] Recently, papers using smartphones for ESM have been published. MacKerron and Mourato (2013) and Doherty et al. (2014) investigate how happiness relates to natural environments, using the Global Positioning Systems (GPS) and other functions of smartphones. The former study reports that happiness is greater in natural environments. In Atz (2013) respondents report their happiness level using smartphones.

burden on respondents when they report while outside, while bringing beepers and forms is a burden to subjects (Scollon et al., 2003).

Second, we do not beep respondents at random time, but trust them to report whenever they want to. However, we made the following stipulations: Respondents should start reporting within three hours after waking up and should report more than ten times during the day, and the consecutive reports should be separated more than 50 minutes. Thus, our method is "interval-contingent sampling" in a broader definition of ESM (Scollon et al., 2003).[3] Making a beep would have caused a problem because our subjects, as university students, attend classes. If we followed the conventional ESM method with a beeper and "signaling sampling," few students would have joined our survey. Using mobile phones, on the other hand, our subjects probably report while in class. However, this removes some of the randomness of "signaling sampling."

Third, our survey collects data for a continuous period of 14 months, and our subjects choose one day every month and make a report on that day. Meanwhile, ESM typically constrains respondents for a week.[4] Thus, our survey offers a unique longitudinal dataset.

Using data from 70 Japanese students for a period of over a year, this paper

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[3] Usual ESM uses "signal-contingent sampling."

[4] There are some exceptions. For example, Clark and Watson (1988) collected data for 90 days.

examines how happiness depends on activities, and investigates patterns of variation in happiness during a day, a week and a year. Though previous studies including Kahneman et al. (2004a) reported that happiness changes with time during a day, they did not adjust for the effect of the activity being undertaken at the time of data collection. Thus, their results might merely indicate a time pattern of activity performed in a day, which in turn affects happiness. It is interesting to know whether or not happiness changes along with time, even controlling for subjects' activities; we investigate that question in this paper.[5]

The rest of this paper is structured as follows. In section 2, we explain our survey. In sections 3 and 4, we investigate how happiness depends on activity and time, respectively, where time means hour of the day, day of the week, and month of the year. In section 5, we run a regression to identify the effects of activities and of time. Section 6 concludes.

2. Our survey

2.1 Outline of the survey

We recruited 70 undergraduate and graduate students of Osaka University and

[5] In addition, panel data has to the advantage of identifying the relationship of happiness with activity and time while adjusting for individual effects.

requested them to report every day their happiness and evaluation of personal and macro news (how good or bad they are) arriving on that day. We call this "daily survey." We also ask them to choose one day every month on which to report their happiness and what they were doing just before reporting, once during every hour during that day. We call this "hourly survey." This paper only uses the data of hourly survey on the sample from December 1, 2006 to February 18 2008. Respondents were requested to start reporting within three hours after waking up and to report more than ten times a day, where each two consecutive reports should be separated by more than 50 minutes.[6] Those reports that did not satisfy these conditions were discarded. Students could answer using a mobile phone or a personal computer.[7]

The hourly survey consists of two questions: Q1. How happy do you feel now? Please rate it on a scale from 0 (very unhappy) to 10 (very happy).

Q2. What were you doing just before now? Choose one of the following options:

1. Studying (alone), 2. Attending a class, a seminar, or a group study, 3. Commuting to the university, 4. Side job, 5. Club or circle, 6. Exercise, 7. Date (including by phone), 8. Enjoying time with friends (including by phone), 9. Enjoying time with family members (including by phone), 10. Watching TV or playing a game, 11. Doing internet or email,

[6] This method is called "interval-contingent sampling" in the broader definition of ESM (Scollon et al., 2003).

[7] In Japan, most mobile phones were advanced enough to connect to the internet even before the advent of smartphones.

12. Preparation for or cleanup after meals, 13. Household chores, 14. Meals, 15. Drinking, 16. Smoking, 17. Shopping, 18. Driving, 19. Playing pachinko (a Japanese gambling game), 20. Going out for things to do, 21. Taking a rest, 22. Sleeping, 23. Other

2.2 Payment schedule

Subjects were paid 160 yen (about $1.60) per answer for a daily survey. Those who answered more than 22 days for the daily survey and answered the hourly survey more than once a month were paid a 1300 yen a bonus for this month, and those who answered more than 27 days and the hourly survey received a 2600 yen bonus for the month.

2.3 Response rate

We obtained 8536 answers for the hourly survey. The response rate is 8536/ 9800=87%. The response rates for the daily survey and hourly surveys were around 90% and 80%, respectively. Although selection biases are often pointed out as a demerit of ESM, the current study is therefore free from this problem

3. Activities and happiness

The number of observations and average happiness for each activity are summarized in Table 1. Here, we reclassify the 23 activities into 15 categories, since some activities were reported too rarely to compute reliable averages. In reclassifying, we were careful to incorporate similar categories into one, whose averages do not differ substantially. Specifically, we incorporated class and commuting (2 and 3), side job, clubs, and exercise (4, 5, and 6), enjoying time with family and friends (8 and 9), TV and internet (10 and 11), preparation for meals and household chores (12 and 13), drinking and pachinko (15 and 19), and shopping and driving (17 and 18).

Table 1 reveals interesting facts. First, the average happiness of all 8536 responses is 5.947, which is lower than the usual reported values of happiness for Japanese people. According to the annual survey conducted by Osaka University, the average happiness is around 6.2 (in 2007) and 6.32 (in 2003). The “Survey on the life preferences of people in Japan” conducted by the Cabinet Office reports similar results. While respondents are asked to evaluate their overall happiness in the annual survey, survey respondents are asked about their current feelings in the hourly survey. “Although retrospective evaluations are related to the real-time reports… retrospective reports are also susceptible to systematic biases” (Kahneman and Krueger, 2006). This may be evidence for the existence of retrospective biases. [8]

Secondly, the activities that entail considerably lower happiness than the average are attending classes, smoking, and sleeping. The result for attending classes is consistent with previous works, such as Csikszentmihalyi et al. (2003) and Bassi and Fave (2004).[9] Considering that attending classes is a kind of job for students, the result is also consistent with Kahneman et al. (2004b). It is interesting that spontaneous study brings about a higher level of happiness than attending classes.[10] The results support the assumption adopted in economics that job and leisure brings about negative and positive utility, respectively.

Watching TV and connecting to the internet leads to slightly lower happiness than the average, which is consistent with the observations of Frey et al. (2007), Csikszentmihalyi et al. (2003) and Bassi and Fave (2004).

It is widely known that smokers are unhappier than others (Gruber and Mullainathan 2005). However, the causality between happiness and smoking is not fully known. From this viewpoint, our survey is potentially interesting, because comparing happiness before and after smoking might have elucidated the causality. Unfortunately,

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[8] The result may merely imply that students of Osaka University are less happy than average people. However, since students are significantly happier than the average in the annual survey, this interpretation is questionable.

[9] Csikszentmihalyi et al. (2003) examine students of 6th, 8th, 10th, and 12th graders and Bassi and Fave (2004) examines adolescents aged between 15 and 18.

[10] Csikszentmihalyi et al. (2003) report a similar result.

since the number of the observations of smoking is only 6, we cannot test this hypothesis with our data.

"Sleeping" means happiness upon waking up; we observe that people are less happy when they have just woken up. This is consistent with the fact that depressed people are in a worse condition in the morning.

Students are the happiest when they are dating, for which no explanation is necessary. Drinking makes people feel happier. Meals have a similar effect, even if not so strong as drinking. Enjoying time with family and friends makes people happier.

In the right-hand columns of Table 1, we show the results of Csikszentmihalyi et al. (2003), Bassi and Fave (2004), and Kahneman et al. (2004a). Since their classifications of activities are different from ours, the figures are rough comparisons at best. Still, one can see that the ranking of activities in our study by associated happiness is similar to those of Csikszentmihalyi et al. (2003) and Bassi and Fave (2004). It differs only slightly from the results of Kahneman et al. (2004b).[11]

4. Time and happiness

Time has cycles such as morning, afternoon, evening, and night during a day,

[11] This may be because their sample is of working women instead of students, or because they use DRM instead of ESM.

weekdays and weekends during a week, and seasons (months) during a year. Subjective happiness may fluctuate depending on these cycles; e.g., it is sometimes claimed that people living in the northern part of Europe are depressed during the long winter and enjoy themselves during summer. People seem more relaxed during holidays than on weekdays. In this section, we investigate the time patterns of happiness. Diurnal variation in happiness, among others, is interesting in this paper, because this cannot be investigated without an hourly survey.

4.1 Diurnal variation in happiness

In our web survey, the time an answer is sent is automatically recorded. Figure 1, which shows the number of observations during each hour, reveals that most responses were made during daytime, although some were made at night.

The average happiness in each hour during a day is depicted in Figure 2, along with 95% confidence intervals. The average happiness falls during night, reaching the lowest value at 7:00 in the morning. It then rises until 10:00. After staying at a constant level until 16:00, it goes up until 23:00. This pattern is similar to what Kahneman et al. (2004a) found, although the change in happiness is not significant for most cases.

The activities of students are considerably different between weekdays and holidays.[12] Specifically, they study less on holidays and spend more time on TV, meals, and shopping. This suggests that the diurnal variation in happiness may also be different between weekdays and holidays.

Diurnal variation in happiness on weekdays is shown in Figure 3. While it is similar to Figure 2, the fluctuation is clearer. In contrast, while diurnal variation in happiness on holidays shows a similar pattern, the fluctuation is more moderate (see Figure 4). In sum, happiness is the lowest in the morning and the highest in the evening, and this pattern is more salient on weekdays. These results suggest that the pattern of happiness may reflect, at least partially, the stress of preparation for study before 9:00 and the release from stress after 17:00.

The diurnal pattern of happiness has been investigated in several studies. Among others, Csikszentmihalyi et al. (2003) investigated 828 elementary school students with ESM, finding that "the first part of the day spent at school is less happy except for a peak at lunch time, followed by higher happiness in the afternoon when one is again free." Kanheman et al. (2004a) found that negative affect is the highest in the morning and declines after one returns home, reaching a low at 21:00. Studying 123 college students, Clark et al. (1989) report that positive affect rises from 6:00 to noon and stays

[12] In this paper, we define "holidays" as weekends plus holidays and define "weekdays" as weekdays excluding holidays.

at the level until 21:00, then declines consecutively until 6:00.[13] Egloff et al. (1995) report that positive affect is lowest in the morning, in the middle in the afternoon, and the highest in the evening. The results of these studies, including ours, are all consistent in that happiness declines during the middle of the night and recovers in the morning. They differ in the detailed movements, probably due to the difference in professions and age of the subject populations. For example, Csikszentmihalyi et al. (2003) show that happiness declines from 21:00 to 22:30., but this time for an elementary school student may be equivalent to the middle of the night for adults. Kahneman et al. (2004a) show that negative affect is high during working time for workers, while the pattern is not so clear in papers such as ours that study college students.

4.2 Diurnal variation in happiness controlling for type of activity

In the previous subsection, we examined how subjective happiness depends on the hour of the day. However, we did not identify the effect of the hour of the day separately from the effect of the time pattern of activity. It might be the case that happiness merely appears to depend on time of day because people have, by and large, a certain time pattern of activities in a day, on which happiness depends. If this is the case, happiness does not truly depend on time, once we control for activities. To test this hypothesis, we

[13] Negative affect shows the mirror pattern to positive affect.

run a regression that takes into account the effect of both activities and time of day.

We estimate following the equation:

$$Happiness_{i,t} = \sum_l \beta_1{}^l Dhour^l{}_{i,t} + \sum_l \beta_2{}^l Dactivity^l{}_{i,t} + \beta_3 Dweekday_{i,t} + \sum_l \beta_4{}^l Dmonth^l + c_i + \varepsilon_{it} \qquad (1)$$

where *i* stands for individual and *t* is the time when responses are made. Here, we added weekday dummy and month dummies as control variables. *Dweekday* is a dummy variable, which equals one if the response is made on a weekday and 0 otherwise. $Dactivity^l$ is a dummy variable that equals one if the activity is the *l*-th activity shown in Table 1 and 0 otherwise. $Dhour^l$ is a dummy variable that equals one if the response is made at *l*-th o'clock and 0 otherwise. c_i stands for the individual fixed effect and $\varepsilon_{i,t}$ stands for the error term.

Estimates of equation (1) by random effects model are presented in Table 2, since the Hausman test does not reject the null of the random effects model at the 5% level, and ordinary least squares (OLS) is rejected using the Breusch-Pagan test.[14] For estimation of equations (2) and (3) we use a fixed effect model, presented in Table 2, because the Hausman test rejects the null of the random effects model at the 1% level and OLS is rejected by F-test of the same constants.

[14] However, the estimates by fixed effects model were not substantially different from those in Table 3.

In the first column of Table 2, we present the estimation results in which the variables of *Dactivity* are excluded from eq. (1). The coefficients of the dummy variables of *Dhour* are negative from midnight to dawn, and get larger from 9:00 to midday. After that, they decline slightly until 17:00 and then go up rapidly until 19:00, maintaining that high level until 23:00. Happiness drops substantially at 24:00. Compared with 24:00, 19:00 is happier at the 1% significance level.

The coefficient of the weekday dummy is positive, but insignificant. Among the monthly dummies, March, April, May, August, and December are significantly happier. The results are reasonable, since in March and August our respondents, students, are on vacation, and April and May have good weather.

In the second column of Table 2, we present the estimation results of the equation that when the variables of *Dhour* are excluded from eq. (1).In this case the null of the Hausman test is rejected, so we adopt a fixed effects model.

In the third column of Table 2, the estimation results of equation (1) are shown. The coefficients of *Dactivity* are quite similar to those shown in the second column (refer to Figure 5, where both point estimates are depicted). On the other hand, the coefficients of *Dhour* are slightly different, in that they show greater happiness from midnight to 11:00 (refer to Figure 6, where both point estimates are depicted). However, the general pattern is similar: happiness is low in the early morning and goes up gradually from 9:00, then declines slightly in the evening, and becomes high again at night. 19:00 is happier than 24:00 at the 1% level, and the hours from 20:00 to 23:00 are happier than 24:00 at the 5% level.

These findings are summarized as follows: First, happiness depends on activities after controlling for time. Here, activity 14 (sleeping) is excluded from the regression and twelve activities out of 14 bring about higher happiness than “sleeping.” Small standard errors suggest that happiness differs significantly among the various activities.

Secondly, happiness during 19:00 to 23:00 tends to be higher than happiness at 24:00 after controlling for activities. Indeed, happiness from 19:00 to 23:00 is significantly higher at the 5% level, implying that happiness depends on time of day, even if students are doing the same activity. However, an F-test of the 23 hour dummies reveals that they are only significant at the 10% level, implying hour dummies have only weak additional explanatory power. Still, when we define hour dummies as a dummy for every two hours, there hours, and four hours, the F-values become significant, at the 5%, 1%, and 1% levels, respectively. Thus, we may conclude that while most of the time-variation of happiness can be attributed to time pattern of activities, there exists a time-pattern of happiness independent of activities.

Third, happiness differs depending on month: happiness in five of the months of the year is higher than that in November. Fourth, the weekday dummy is not significant, implying that the level of happiness is not different between weekdays and holidays, once activities are controlled for.

5. Difference in happiness pattern between males and females

Do the happiness patterns found thus far differ between genders? In this section, we investigate whether the activity pattern and time pattern of happiness differ between genders.[15] The sample of Kahneman et al. (2004a) is composed entirely of working females, so these authors were unable to analyze gender differences.

Our subjects are 48 males and 21 females (total 69), so that the numbers of observations for each gender are 5707 and 2727, respectively.[16] Estimation results are presented in Table 3. Point estimates of the variables *Dactivity* for both genders are depicted in Figure 7. Coefficients on drinking and smoking are not shown here, since their sample size is very small. Inspection of Table 3 reveals that the pattern of how happiness depends on activity is quite similar between males and females. Figure 7 indicates that the magnitudes of the coefficients are similar. The only differences are

[15] Though it would also be interesting to measure how these patterns depend on age, our respondents are all students and their ages are almost the same, so age analysis is impossible.
[16] Gender is not recorded for one subject, who was therefore excluded from the analysis.

that dating (activity 4) gives extremely strong happiness to males, while only moderate happiness to females, and that preparation for meals (activity 7) makes males unhappy, while it increases happiness for females. In sum, our results indicate that how happiness depends on activity does not differ much between genders.

Table 3 reveals that for males, happiness level does not change much from the level at 24:00.[17] On the other hand, for females, many of the hours after 9:00 are happier than 24:00. In Figure 8, we show point estimates of the coefficients of hour dummies for males and females, which reveals that the fluctuation of happiness is much greater for females than for males. Still the shape of the pattern is similar between males and females. Here, a problem is that F-test of all the hour dummies is not significant, implying that hour dummies do not have additional explanatory power for males and females. However, for males, when we define hour dummies as every three hours, the F-test becomes significant at the 5% level, and when we define them for every four hours, at the 1% level. On the other hand, for females such a treatment does not produce a significant result, probably due to the smaller number of females in our sample. Thus, we should be careful not to draw too strong a conclusion about the differences in the time pattern of happiness between males and females.

Table 3 also reveals that monthly variation in happiness is much larger for females

[17] The only exception is that 21:00 is happier than 24:00 at the 10% level.

than for males. Consequently, females are significantly happier than November in more months than are males.

The differences between the time pattern of happiness for males and females are summarized as follows. First, the shape of the time pattern is similar: happiness becomes highest at night after 18:00. Secondly, however, the variation of happiness is much larger for females than males. Consequently, while happiness doesn’t differ significantly after 24:00 for males, it does for females. The subjects of Kahneman et al. (2004a) are only female, and their results look like our results for females. Our study suggests that for males, happiness might not depend strongly on time.

6. Conclusions

In this paper, we investigated whether or not people’s diurnal happiness variation can be explained by the respondents’ gender and current activities. We conducted an hourly web survey, where 70 students reported their happiness every hour of one day out of every month from December 1, 2006 to February 18, 2008. Our hourly-survey methodology is a development of ESM, in that it uses a web survey, and subjects could respond by mobile phone as well as personal computer.

Analyzing the survey data, we found the following: (a) happiness significantly depends on activities, (b) subjects are relatively unhappy around 7:00 and happy from around 19:00 to 23:00, (c) the diurnal variation in happiness is still observed even when activities are controlled for, and (d) the relationship between happiness and activities does not differ between males and females. While happiness of females depends strongly on time of day, that of male does not.

It would be interesting to investigate the reason happiness depends on time even after controlling for activities. There are at least three possibilities. One is what we argued in subsection 4.1, that is, that the stress of study and release from stress make students unhappy and happy during a day. The second is that the diurnal pattern of happiness is biologically determined. The last is that our result merely indicates a lack of sufficiently detailed information on activities.

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Table 1. Frequency and happiness by activity

		number of	happiness				Csikszentm ihalyi et al.	Bassi and Fave	Kahneman et al.
Activity		Observations	average	Lower 95%	Upper 95%	Std. error	happy	happy	net affect
4	Date	97	7.371	6.939	7.803	0.218			4.74
9	drinking, pachinko	13	6.923	5.922	7.924	0.459			
8	Meals	760	6.178	6.047	6.308	0.066	0.19		3.96
5	enjoying time with friends and family	511	6.16	5.983	6.338	0.09	0.35	0.48	4.12
12	going out for things to do	245	6.033	5.788	6.278	0.124			
3	side job, club, exercise	336	5.979	5.772	6.187	0.106			
11	shopping, driving	154	5.974	5.71	6.238	0.134		0.27	3.21
ALL		8536	5.947	5.623	6.27	0.15			
7	preparation for meals	487	5.86	5.703	6.018	0.08	−0.21		3.24
1	study (alone)	1569	5.779	5.685	5.874	0.048	−0.11	−0.27	
13	Rest	475	5.773	5.593	5.952	0.091			3.91
6	TV, internet	1883	5.663	5.584	5.741	0.04	0.03	0.19	3.62
2	class, commuting	1112	5.446	5.338	5.554	0.055	−0.21	−0.36	2.65
15	Others	415	5.417	5.251	5.583	0.085			
10	smoking	6	5.333	3.9	6.767	0.558			
14	sleep (waking up)	473	5.311	5.135	5.487	0.089			

Table 2 Estimates of Equation (1)

	Happiness (1)	Happiness (2)	Happiness (3)
Dhour 1	0.042		0.018
	(0.25)		(0.11)
Dhour 2	0.179		0.188
	(0.95)		(1.01)
Dhour 3	0.146		0.206
	(0.67)		(0.95)
Dhour 4	-0.049		0.100
	(-0.21)		(0.43)
Dhour 5	-0.147		-0.024
	(-0.60)		(-0.10)
Dhour 6	-0.145		0.089
	(-0.74)		(0.45)
Dhour 7	-0.152		-0.047
	(-0.93)		(-0.29)
Dhour 8	-0.116		0.033
	(-0.79)		(0.23)
Dhour 9	0.006		0.105
	(0.04)		(0.77)
Dhour 10	0.024		0.139
	(0.18)		(1.06)
Dhour 11	0.078		0.168
	(0.60)		(1.31)
Dhour 12	0.147		0.160
	(1.14)		(1.25)
Dhour 13	0.113		0.109
	(0.88)		(0.86)
Dhour 14	0.094		0.142
	(0.73)		(1.12)
Dhour 15	0.144		0.185
	(1.12)		(1.46)
Dhour 16	0.013		0.054
	(0.10)		(0.42)
Dhour 17	0.059		0.113
	(0.46)		(0.89)
Dhour 18	0.147		0.169
	(1.13)		(1.31)
Dhour 19	0.363 **		0.337 **
	(2.77)		(2.59)
Dhour 20	0.292 *		0.263 *
	(2.21)		(2.01)
Dhour 21	0.296 *		0.297 *
	(2.22)		(2.24)
Dhour 22	0.324 *		0.324 *
	(2.37)		(2.39)
Dhour 23	0.315 *		0.305 *
	(2.22)		(2.17)
Dactivity 1		0.456 ***	0.407 ***
		(5.81)	(5.02)
Dactivity 2		0.381 ***	0.353 ***
		(4.44)	(4.04)
Dactivity 3		0.706 ***	0.632 ***
		(6.67)	(5.82)
Dactivity 4		1.655 ***	1.619 ***
		(9.92)	(9.61)
Dactivity 5		0.924 ***	0.857 ***
		(9.75)	(8.75)
Dactivity 6		0.565 ***	0.510 ***
		(7.41)	(6.45)

Dactivity 7			0.628	***	0.583	***
			(6.56)		(6.01)	
Dactivity 8			0.826	***	0.766	***
			(9.59)		(8.65)	
Dactivity 9			1.127	**	1.019	*
			(2.76)		(2.48)	
Dactivity 10			-0.066		-0.104	
			(-0.11)		(-0.17)	
Dactivity 11			0.849	***	0.802	***
			(6.25)		(5.82)	
Dactivity 12			0.306	**	0.265	*
			(2.65)		(2.26)	
Dactivity 13			0.531	***	0.488	***
			(5.52)		(4.96)	
Dactivity 15			0.425	***	0.383	***
			(4.28)		(3.79)	
Weekday	0.009		0.054		0.052	
	(0.22)		(1.26)		(1.21)	
Jan	0.068		0.077		0.070	
	(0.90)		(1.02)		(0.93)	
Feb	0.065		0.080		0.077	
	(0.80)		(1.00)		(0.96)	
Mar	0.382	***	0.395	***	0.388	***
	(4.38)		(4.57)		(4.49)	
Apr	0.197	*	0.202	*	0.200	*
	(2.21)		(2.29)		(2.26)	
May	0.282	**	0.276	**	0.266	**
	(3.21)		(3.17)		(3.06)	
Jun	0.120		0.149	+	0.137	
	(1.35)		(1.70)		(1.56)	
Jul	-0.167	+	-0.145	+	-0.152	+
	(-1.89)		(-1.66)		(-1.74)	
Aug	0.186	*	0.215	*	0.206	*
	(2.07)		(2.42)		(2.32)	
Sep	0.119		0.132		0.124	
	(1.34)		(1.50)		(1.41)	
Oct	0.097		0.106		0.104	
	(1.11)		(1.22)		(1.20)	
Dec	0.209	**	0.215	**	0.209	**
	(2.78)		(2.90)		(2.81)	
Constant	5.525	***	5.048	***	4.939	***
	(28.83)		(54.71)		(33.94)	
Observation	8434		8434		8434	
Adjusted R2	0.003		0.022		0.023	
F test			10.89	***	6.47	***
F(ci=c)			80.35	***	80.46	***
Chi2 Test	124.50	***				
F test (Hour=0)	60.55	***			1.41	+
F test (Active=0)			11.32	***	10.45	***
F test (Month=0)	56.44	***	5.46	***	5.42	***
Breusch-Pagan Test	82731.60	***				
Hausman Test	38.76		82.99	***	114.80	***
Estimation Model	Random		Fixed		Fixed	

Note: In the regression, Dactivity_14, Dhour_24, and November are excluded for normalization. t-values are in parentheses.
+ p<0.10, * p<0.05, ** p<0.01, *** p<0.001

Table 3 Estimates of Equation (1) for male and female samples

	Male		Female	
Dhour 1	0.031		0.070	
	(0.18)		(0.17)	
Dhour 2	0.056		0.670	
	(0.30)		(1.39)	
Dhour 3	0.186		0.368	
	(0.83)		(0.70)	
Dhour 4	0.003		0.513	
	(0.01)		(0.85)	
Dhour 5	-0.109		0.437	
	(-0.40)		(0.88)	
Dhour 6	0.048		0.422	
	(0.22)		(0.99)	
Dhour 7	-0.026		0.219	
	(-0.15)		(0.61)	
Dhour 8	-0.056		0.446	
	(-0.35)		(1.37)	
Dhour 9	-0.032		0.632	*
	(-0.22)		(1.99)	
Dhour 10	0.037		0.580	+
	(0.27)		(1.88)	
Dhour 11	0.045		0.718	*
	(0.33)		(2.33)	
Dhour 12	0.051		0.678	*
	(0.38)		(2.19)	
Dhour 13	-0.017		0.653	*
	(-0.13)		(2.13)	
Dhour 14	0.026		0.647	*
	(0.20)		(2.12)	
Dhour 15	0.118		0.607	*
	(0.89)		(1.98)	
Dhour 16	-0.071		0.574	+
	(-0.53)		(1.89)	
Dhour 17	0.023		0.557	+
	(0.18)		(1.79)	
Dhour 18	0.093		0.593	+
	(0.69)		(1.90)	
Dhour 19	0.150		1.057	***
	(1.12)		(3.33)	
Dhour 20	0.171		0.742	*
	(1.26)		(2.33)	
Dhour 21	0.263	+	0.646	*
	(1.90)		(2.04)	
Dhour 22	0.183		0.894	**
	(1.28)		(2.78)	
Dhour 23	0.172		0.786	*
	(1.17)		(2.36)	
Dactivity 1	0.420	***	0.307	+
	(4.69)		(1.83)	
Dactivity 2	0.272	**	0.517	**
	(2.86)		(2.72)	
Dactivity 3	0.614	***	0.557	*
	(5.11)		(2.50)	
Dactivity 4	2.182	***	0.913	**
	(10.40)		(3.11)	
Dactivity 5	0.793	***	0.922	***
	(7.32)		(4.57)	
Dactivity 6	0.484	***	0.471	**
	(5.55)		(2.87)	

Dactivity 7	0.375	**	0.820	***
	(3.25)		(4.55)	
Dactivity 8	0.703	***	0.813	***
	(7.15)		(4.50)	
Dactivity 9	0.727	+	1.822	+
	(1.70)		(1.85)	
Dactivity 10	0.448		-1.569	
	(0.67)		(-1.31)	
Dactivity 11	0.827	***	0.694	*
	(5.33)		(2.53)	
Dactivity 12	0.239	+	0.213	
	(1.79)		(0.94)	
Dactivity 13	0.379	***	0.638	***
	(3.34)		(3.37)	
Dactivity 15	0.350	**	0.392	*
	(2.97)		(2.05)	
Weekday	-0.023		0.277	**
	(-0.50)		(2.98)	
Jan	0.000		0.198	
	(0.00)		(1.33)	
Feb	-0.108		0.430	**
	(-1.21)		(2.66)	
Mar	0.168	+	0.784	***
	(1.74)		(4.52)	
Apr	0.115		0.322	+
	(1.16)		(1.83)	
May	0.011		0.814	***
	(0.11)		(4.69)	
Jun	-0.128		0.642	***
	(-1.30)		(3.67)	
Jul	-0.186	+	-0.106	
	(-1.91)		(-0.60)	
Aug	0.195	*	0.225	
	(1.97)		(1.25)	
Sep	0.149		-0.009	
	(1.54)		(-0.05)	
Oct	0.017		0.234	
	(0.17)		(1.36)	
Dec	0.125		0.306	*
	(1.50)		(2.07)	
Constant	5.121	***	4.391	***
	(33.21)		(12.89)	
Observation	5707		2727	
Adjusted R2	0.031		0.037	
F test	5.716	***	3.536	***
F(ci=c)	106.4	***	45.17	***
F test (Hour=0)	1.07		1.00	
F test (Active=0)	10.79	***	3.238	***
F test (Month=0)	4.08	***	5.948	***
Hausman Test	2666.7	***	679.2	***
Estimation Model	Fixed		Fixed	

Note: In the regression, Dactivity_14, Dhour_24, and November are excluded for normalization. t-values are in parentheses.
+ p<0.10, * p<0.05, ** p<0.01, *** p<0.001

Figure 1. Number of observations by hour

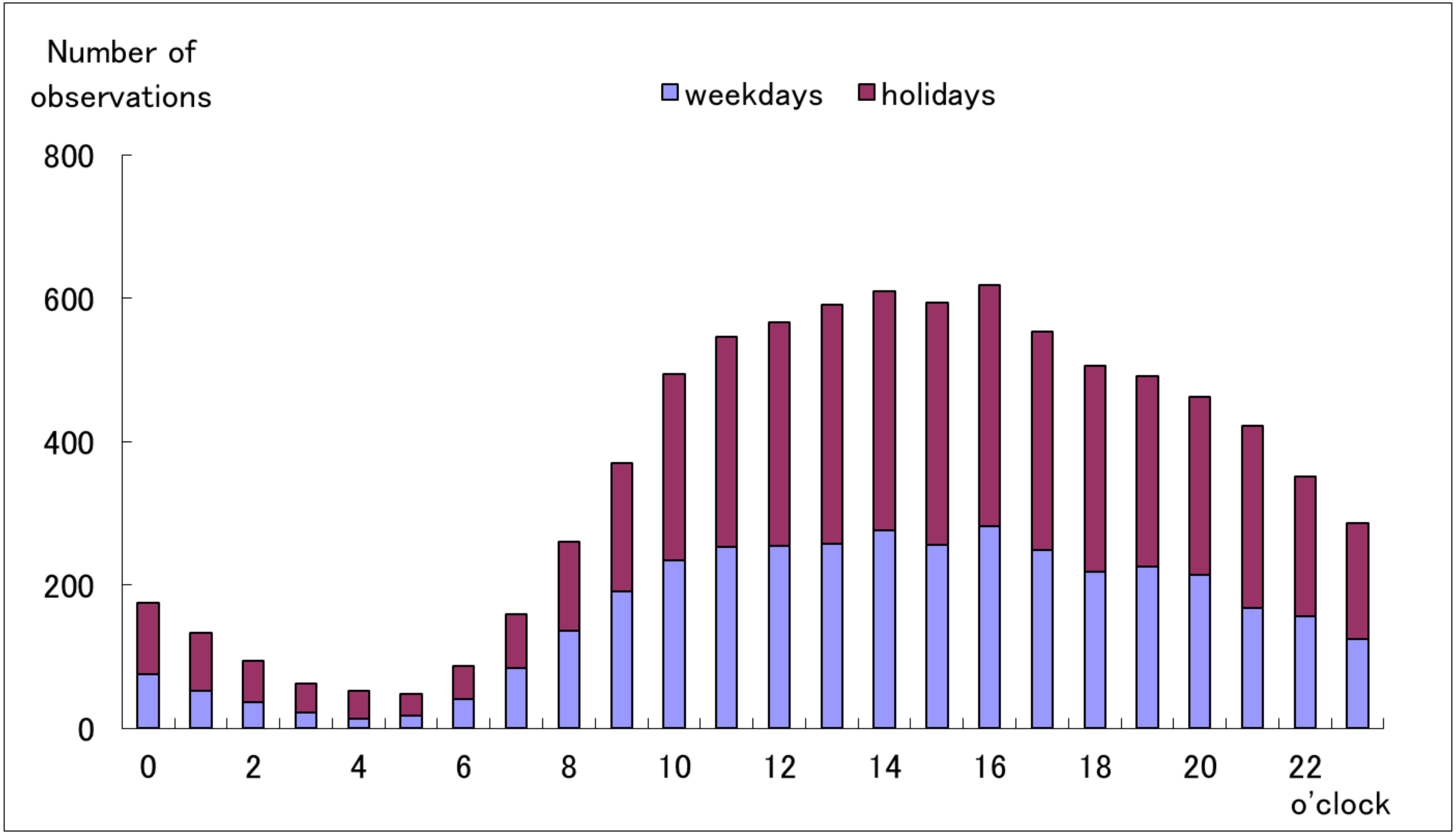

Figure 2. Happiness during the day

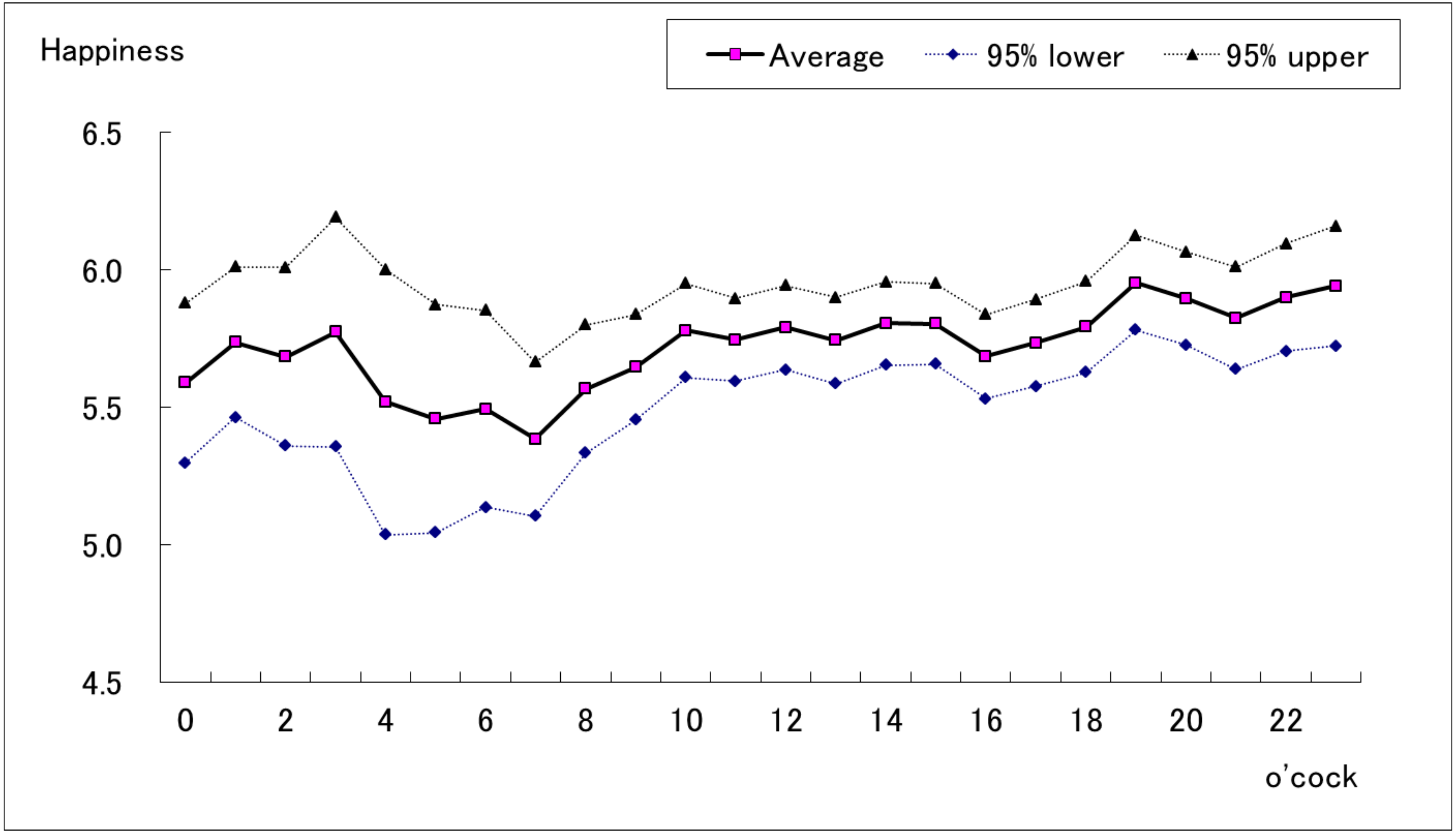

Figure 3.　Happiness during the average weekday

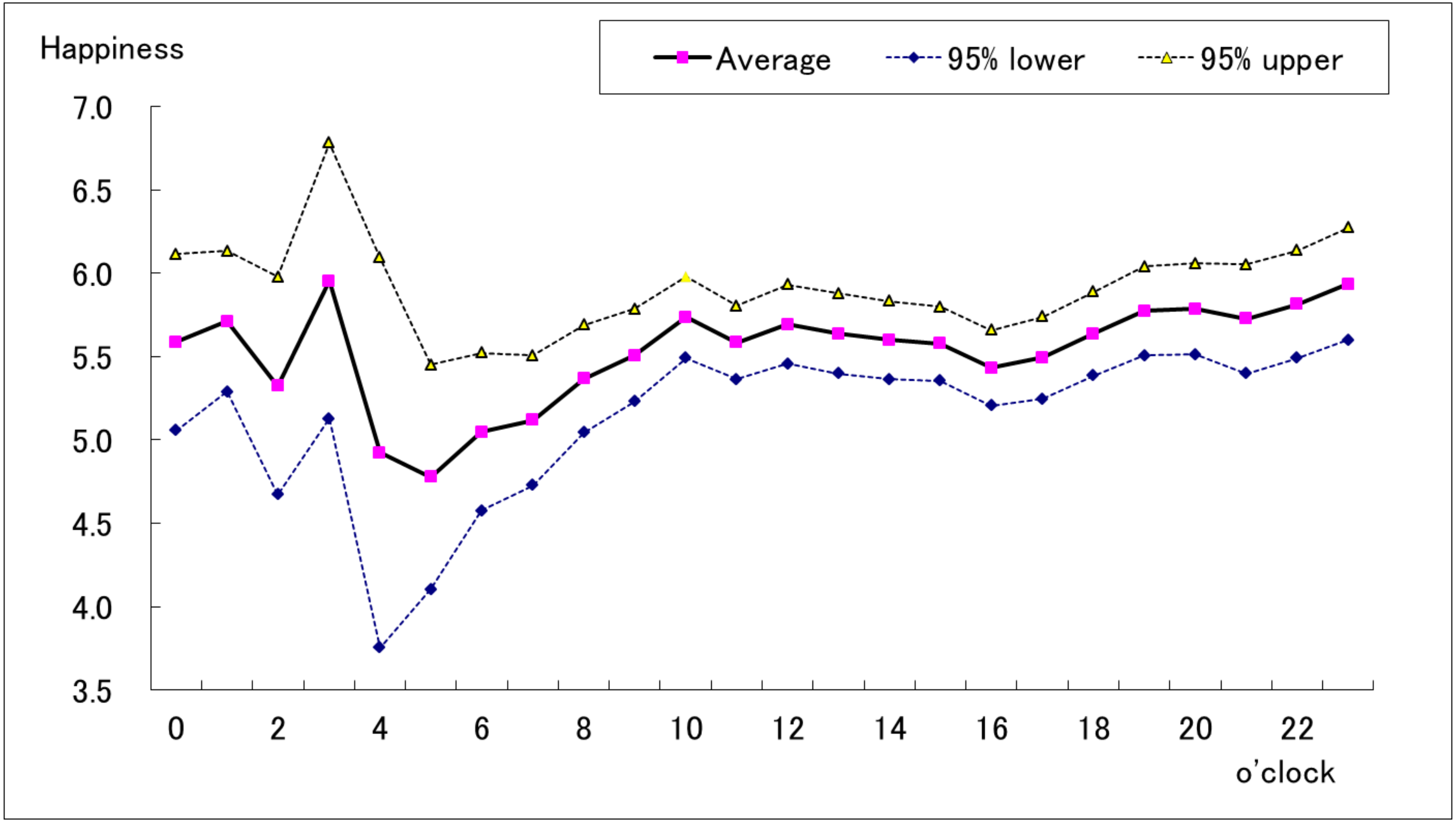

Figure 4. Happiness during the average holiday day

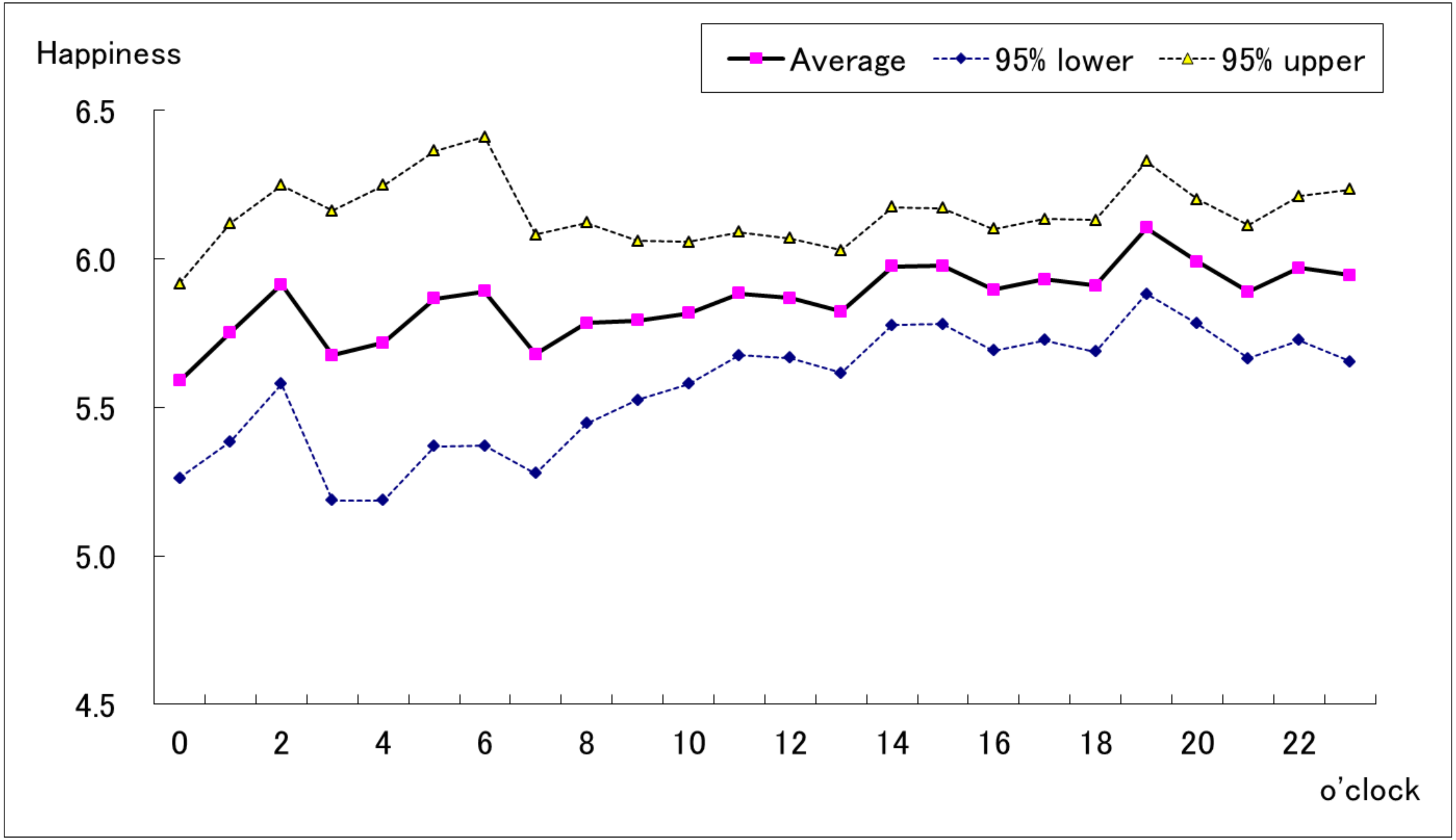

Figure 5. Point estimates of the coefficients of *Dactivity* when Hour is controlled for (Table 2 (3)) and not controlled for (Table 2 (2))

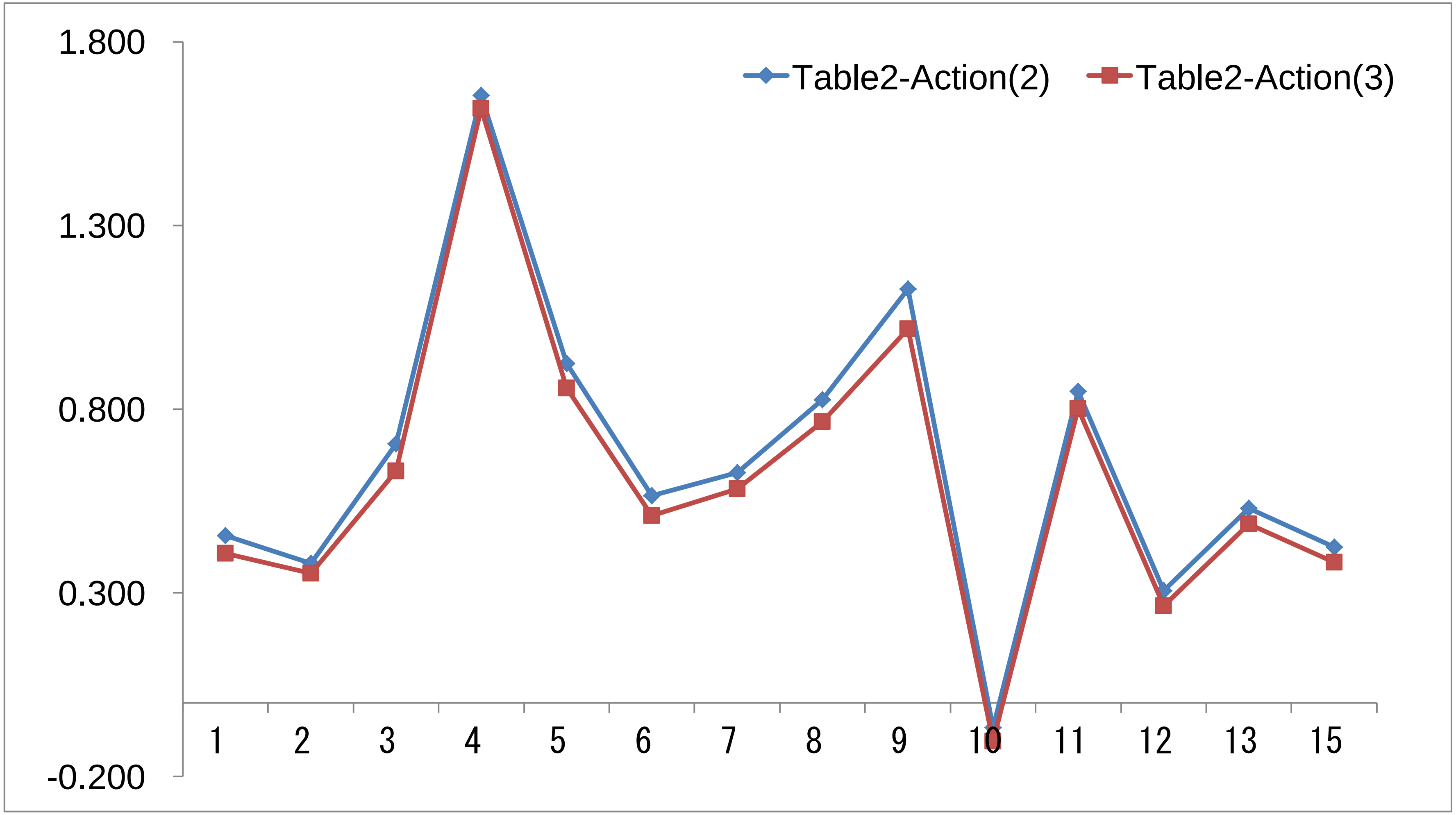

Figure 6. Point estimates of the coefficients of *Dhour* when Activity is controlled for (Table 2 (3)) and not controlled for (Table 2 (1))

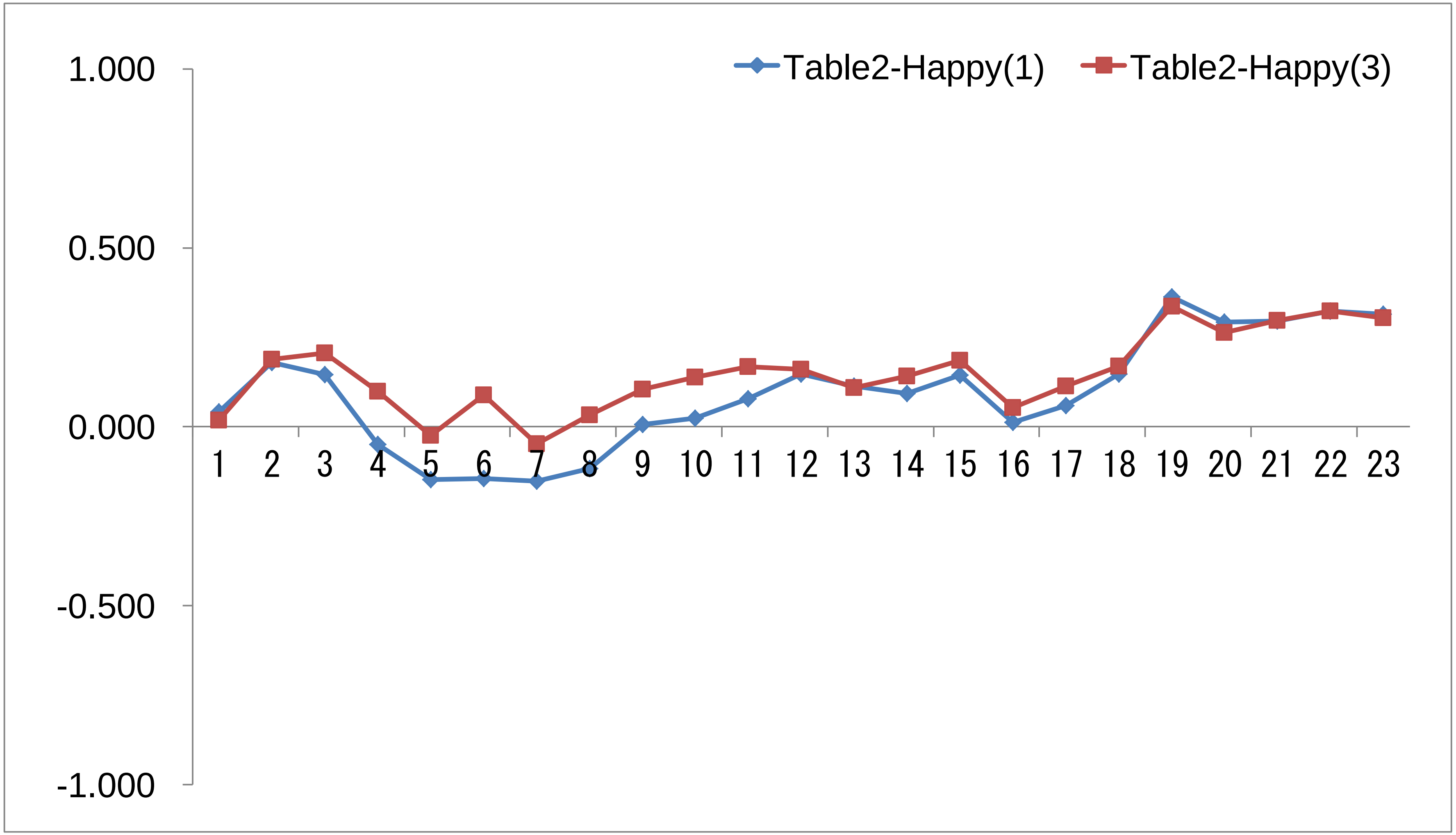

Figure 7. Point estimates of *Dactivity* for males and females

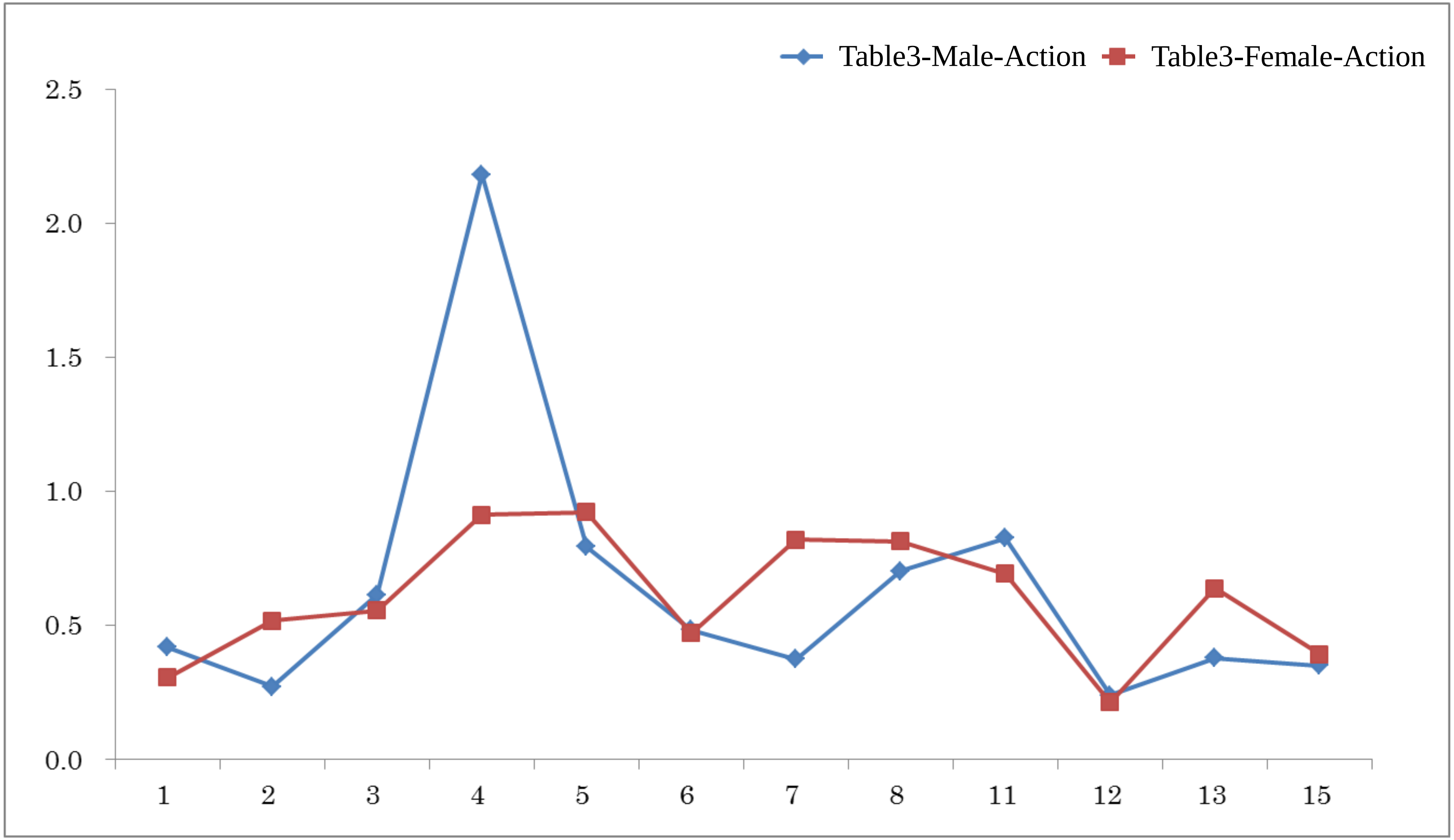

Figure 8. Point estimates of *Dhour* for males and females