Variation among Mechanical Turk Workers Across Time of Day Presents an Opportunity and a
Challenge for Research

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Abstract

Conducting behavioral research online allows researchers to gather more data in less time than conducting studies in person. But this efficiency may sometimes have a cost. Specifically, when researchers gather data within just a few hours, their study may be subject to a time of day bias. Because participants in online platforms are generally free to complete studies whenever they want, people who take studies in the morning may be different in important ways than those who take studies at night. We explored this possibility in two studies conducted on Amazon's Mechanical Turk. In both studies, we sampled participants at different times of the day and examined whether morning and evening active people differed on a variety of psychological and behavioral characteristics known to correlate with a preference for either morningness or eveningness. We found that participants active in the morning and the evening reported different circadian typologies. Additionally, we found that participants active in the morning reported more conscientiousness and less anxiety, depression, procrastination, internet compulsion, disruptive sleep behaviors, disordered eating, and neuroticism than those sampled in the evening. Study 2 demonstrated that many signs of sub-clinical behavior were uniquely high among evening oriented people and that differences between morning and evening oriented people remained robust after controlling for local time zones and day of the week. Overall, our findings have important implications for online sampling methods and indicate that time of day differences in the composition of online samples represent both an opportunity and a challenge for research.

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Variation among Mechanical Turk Workers Across Time of Day Presents an Opportunity and a Challenge for Research

In the early 1960's, Stanley Milgram performed what are perhaps the most famous psychology experiments ever conducted (Milgram, 1963). To recruit subjects, Milgram followed a common practice at the time: he posted fliers around town and asked people interested in the study to mail him slips of paper with their contact information, demographic data, and an indication of when they might be able to participate. Once Milgram received people's replies, he called prospective participants, scheduled a time for the experiment, and ensured research staff were in the laboratory to conduct each session. As motivation for people to come to the lab and complete the study, Milgram offered participants approximately four times greater than minimum wage, plus fifty cents for car fare (Ofgang, 2018). Clearly, finding people to participate in the study was slow and expensive.

Psychologists today rarely labor as much as Milgram to find research participants. One reason is that beginning in the 1960's most universities instituted student subject pools which required students in introductory courses to participate in research. Student subject pools lowered the resources required to conduct a study because undergraduates provided a free, easily accessible, and continually replenishing source of participants. With researchers freed from figuring out where to find participants, all most needed to conduct a study was a place for people to participate (e.g., a lab), someone to guide participants through the study (e.g., research assistants), and some basic equipment (e.g., paper and pencils, a computer). And time.

Indeed, one of the biggest downsides to running studies with student samples today is that data collection is often slow. Researchers can only fit so many participants into the lab at one time. Issues like researcher error, participant no-shows, and the size of a university's subject

pool all affect how long it takes to complete a study. And, these factors say nothing about the nature of the study. Studies that employ elaborate manipulations, measure behavior in different ways, or use research confederates can take months, semesters, or even years to complete. The existence of these issues and their impact on the science of psychology has been widely commented on within the field (Anderson et al, 2019; Baumeister, Vohs, & Funder, 2007; Giner-Sorolla, 2019; Sassenberg & Ditrich, 2019). Nevertheless, an immutable hurdle of in-person data collection is that the study has to occur at a time that works for both the participant and the research team; few people are willing to show up at the lab for a study at 3:00am.

Yet, in recent years, technology has freed researchers from the need to gather data in person. Indeed, the other reason researchers today often exert little effort in finding research participants is that the internet has made it possible to quickly connect with millions of people around the world. The emergence of online data collection has profoundly changed most social science disciplines (e.g., Buhrmester, Kwang, & Gosling, 2011; Buhrmester & Talaifar, & Gosling, 2018). By fielding surveys and experiments online, researchers can further reduce the resources required to collect data with student subjects, or, more often, people outside the university. Online platforms like Amazon's Mechanical Turk (MTurk) and market research panels (Chandler, Rosenzweig, Moss, Robinson, & Litman, 2019; Coppock & McClellan, 2019) increase sample diversity and shorten data collection times while remaining relatively affordable and a source of quality data. Because online panels connect researchers with so many people and make it possible for participants to complete studies whenever it is convenient for them, studies that take months in the lab can be completed within hours or days online.

Although the speed of online data collection has primarily been celebrated as a strength, it may also be a weakness. Data that are collected within just a few hours raise the possibility of

sampling bias. Specifically, the people who participate in online studies at different times of the day or on different days of the week may differ from each other in important ways. At times, the differences between samples gathered at various times of the day may affect the psychological phenomena researchers seek to study. Despite a few previous reports commenting on the potential for time of day bias in online research (Arechar, Kraft-Todd, & Rand, 2017; Casey, Chandler, Levine, Proctor, & Strolovitch, 2017), researchers have largely failed to address how time of day differences may bias online studies. In this paper, we investigate time of day differences in the psychological and personality characteristics of people on MTurk. Our work focuses on highlighting how these differences present both an opportunity and a challenge for research.

Biology, Psychology, and Circadian Typology

When personality researchers speak about people's time of day preferences, they generally speak about two types of people. First, there is the morning-type, also referred to as a "lark." Larks go to bed early, wake up early, and achieve peak mental and physical performance earlier in the day. The second type of person is the evening-type, also known as an "owl." Owls go to bed late, wake up late, and achieve peak performance in the evening or at night (Adan et al., 2012; Cavallera & Giudici, 2008). Individual differences in preference for morning or evening are referred to as people's circadian typology, and while most research focuses on differences between morning and evening oriented people, about 60% of the population is classified as neither type (Adan et al., 2012).

The existing research on people's circadian typology shows several relationships with both biology and psychology. On the biological side, variables like age and sex are often associated with a preference for morningness over eveningness. Studies show that women tend to

be more morning-oriented than men (Adan & Natale, 2002), and older people typically report more morningness than younger people (Carrier, Monk, Buysse & Kupfer, 1997). In addition, a preference for morningness over eveningness is associated, obviously, with an earlier sleep-wake cycle, but less obviously with differences in body temperature throughout the day (Duffy et al., 1999; Horne & Östberg, 1976), hormone levels in the body like cortisol and melatonin (Bailey & Heitkemper, 1991, 2001; Griefahn & Robens, 2008; Taillard et al., 2011), genetic makeup (Archer et al., 2003), and even exposure to light during the early years of life (Natale, Adan, & Fabbri, 2009; Natale & Di Milia, 2011). To a certain extent, people's biology may predispose them toward a specific circadian typology.

Perhaps more relevant to behavioral scientists than the biological correlates of circadian typology are its psychological correlates. People who report a preference for mornings also tend to report a different personality profile than those who report a preference for evenings. For example, morning-oriented people tend to score higher on measures of conscientiousness, agreeableness, and positive affect than evening-oriented people (de Young et al., 2007; Hogben, Ellis, Archer, von Schantz, 2007; Randler, 2008; Tonetti, Fabbri, & Natale, 2009). Conversely, evening-oriented people often report more openness, extraversion, neuroticism, and impulsivity than morning-oriented people. Although the relationship between circadian typology and personality outcomes can vary depending on the measures used (Adan et al., 2012), one thing that seems clear is that people with an evening preference report a personality profile that is more subject to certain forms of psychological distress than morning oriented people.

Circadian Typology and Clinical Outcomes

Generally speaking, all circadian typologies can be part of a healthy lifestyle. Nevertheless, several behavioral and lifestyle factors common among evening-oriented people

may predispose them to higher rates of mental and behavioral health problems than morning-oriented people or those with no time of day preference. Evening-oriented people are, for example, more likely than others to encounter disturbances to their normal sleep patterns (Taillard, Phillip, & Bioulac, 2002). In addition, evening-oriented people may experience less social synchrony with others and enjoy less natural sunlight. These differences are important because they may promote biological changes in evening-oriented people that increase the risk of clinical symptomatology.

One disorder evening-oriented people are at higher risk for is mood disorder. Morning oriented people report higher levels of positive affect than evening oriented people, regardless of age (Biss & Hasher, 2012). In addition, research has consistently found that a preference for eveningness is correlated with depression. Studies conducted with both college students (Chelminski, Farraro, Petros, & Plaud, 1999) and random samples from the general population (Merikanto et al., 2013) have found that evening oriented people report more depression than morning oriented people. Some part of depression may be caused by desynchronization between the light and dark cycle and people's biological clocks (Benedetti et al., 2007), as suggested by the Seasonal Affective Disorder many people experience during winter (e.g., Rosenthal et al., 1984). Evidence also indicates that depressive thoughts surrounding perfectionism may differ between those with morningness-eveningness differences, although results from a study that tested this directly indicated differences just below the level of statistical significance (Antypa et al., 2017).

A second disorder circadian typology has been linked to is anxiety (Antypa, Vogelzangs, Meesters, Schoevers, & Penninx, 2016). Evening-oriented people often report more symptoms of anxiety, psychoticism, and psychosomatic disorders than morning-oriented people (Mecacci &

Rocchetti, 1998). Some studies suggest that factors related to people's circadian typology are also related to anxiety. For example, people's cardiovascular response to stress varies depending on the time of day when it is measured (Nebel et al., 1996), and evening-oriented male subjects show higher anxiety than morning-oriented male subjects. In addition, other research suggests that evening-oriented people may be less emotionally stable in adulthood and have more problems coping with stress than morning oriented people do (Mecacci & Rocchetti, 1998).

In addition to depression and anxiety, there are other clinically relevant traits that are associated with variation in morningness-eveningness. Evening oriented people seem to struggle with impulsivity more than morning oriented people and may be at a higher risk for certain addictive behaviors (Kandeger, Selvi, & Tanyer, 2019). Evening oriented people show more signs of internet addiction, eating disorders (Kasof, 2001; Natale et al., 2008; Schmidt & Randler, 2010), and disordered sleep behavior than morning oriented people do. Additionally, research suggests that evening oriented people tend to focus more on the present, to procrastinate, and to be more hedonistic than morning oriented people (Drezno, Stolarski, & Matthews, 2019; Przepiórka, Błachnio, & Siu, 2019).

Time of Day Effects Among MTurk Workers

Amazon's Mechanical Turk is part of the gig economy, allowing workers to complete online tasks (known as Human Intelligence Tasks, or HITs for short) for small compensation whenever they want. Workers on MTurk set their own schedule and work as many or as few hours as they wish. Since 2011, MTurk has been a common source of research participants within the behavioral and social sciences. Mechanical Turk gives researchers access to a more diverse group of participants than found in university subject pools and can even be used to study clinical populations (Shapiro, Chandler, & Mueller, 2013). In addition, because of the way

MTurk is structured, researchers can collect data at all times of the day and participants can complete studies when it is most convenient for them. Due to MTurk's popularity for social science research and the ability of workers to complete HITs whenever they want, MTurk seems like an ideal place for individual differences in circadian typology to emerge as a determining factor of when people choose to work. Morning-oriented people should be more likely to work in the morning and throughout the early part of the day. Evening-oriented people, meanwhile, should be more likely to work in the evening and throughout the night.

While the tendency for MTurk workers to drift toward working at a time that fits with their circadian typology may have little effect on some tasks, it may have a big effect on behavioral science research. Much of the previous research conducted on MTurk has not addressed the potential for a time of day sampling bias. Although some researchers have designed MTurk studies to limit the time a HIT is available (Crump, McDonnell & Gureckis, 2013) they did so without evidence that time of day affects sample composition or the data collected. More recently published research has looked at variations in demographics among samples drawn from MTurk at varying times of day (Arechar et al., 2017; Casey et al., 2017). However, these studies were either unable to find time of day differences in behavior (Arechar et al., 2017) or limited to small demographic differences (Casey et al., 2017) that are unrelated to clinical or behavioral differences between samples of MTurk workers. As a result, in this study, we sought to examine whether participants who are active on MTurk in the morning are more morning oriented than those who are active at night. In addition, we investigated whether people active on MTurk in the morning and evening differ on several psychological and behavioral factors known to correlate with people's time of day preference.

Research Overview

In two studies, we examined whether time of day differences in clinically relevant personality traits and behaviors exist among workers on Mechanical Turk. In Study 1, we collected data in the morning and the evening and looked for sample differences that should emerge if morning and evening-oriented people do indeed work at different times of the day. In Study 2, we added an afternoon condition and made extensive efforts to control for differences in time zones across the US as well as day of the week. In both studies, we measured people's preference for morningness versus eveningness and assessed several personality characteristics morning and evening oriented people are known to differ on (e.g., conscientiousness, perfectionism, neuroticism, procrastination, hedonism). In addition, we measured the presence of several clinical symptoms that morning and evening oriented people are known to show differences on (e.g., depression, anxiety, internet compulsion, disordered eating, disordered sleeping). Across studies, we hypothesized that people who took our study in the morning would be more likely to have morning-type personalities than people who took the study in the evening. We also hypothesized that people who took the study in the evening would show more signs of clinical symptomatology than people who took our study in the morning. Considering the cluster of variables known to consistently correlate with eveningness, we predicted that evening-oriented people would report less conscientiousness and more neuroticism, anxiety, depression, procrastination, disordered eating, compulsive internet use, erratic night time behavior, and hedonism than morning-oriented people.

Study 1

Method

Participants and Procedure

Two hundred and twelve US adults from MTurk—115 men, 97 women—participated in the study in exchange for \$1.00. On average, it took people 14.65 minutes ($SD = 6.83$) to complete the study. People ranged in age from 20 to 63 years ($M = 34.82$ years, $SD = 9.86$). Complete demographic information for all participants in Study 1 is reported in Appendix A, Table 1.

We launched two identical HITs at different times of the day using the TurkPrime platform (Litman, Robinson, Abberbock, 2017) to examine whether MTurk workers active in the morning and evening differed on the constellation of variables we were interested in. The first HIT (morning condition, $n = 102$) was launched at 6:00am; the second HIT (evening condition, $n = 108$) was launched at 8:30pm. After giving consent, people answered demographic questions and completed a measure assessing preference for morningness or eveningness. Then, they completed six additional measures that were presented in random order. Two participants' data was discarded because of an error during their survey.

Measures

Morningness-Eveningness Questionnaire. We measured people's preference for morningness vs. eveningness with the Morningness-Eveningness Questionnaire (MEQ) (Horne & Östberg, 1976). The MEQ has 19 items, measured on either a 4 or 5-point Likert-type scale. The sum of all items gives a score ranging from 16 to 86. Scores of 41 and below indicate a preference for eveningness while scores of 59 and above indicate a preference for morningness;

scores between 42-58 indicate an intermediate preference. The MEQ had strong reliability ($\alpha = .88$).

Anxiety. We measured anxiety with the Beck Anxiety Inventory (Beck, Epstein, Brown, & Steer, 1988). This measure consists of 21 common symptoms of anxiety, like “heart racing,” “unable to relax,” and “fear of losing control.” Participants indicated how much they have been bothered by each symptom during the past month using a scale that ranged from 1 (*not at all*) to 4 (*severely – it bothered me a lot*). The reliability of the measure was very good ($\alpha = .95$).

Procrastination. Procrastination was measured with the General Procrastination Scale (Lay, 1986). This scale consists of 20 items that measure people’s tendency to complete tasks immediately (e.g., “I generally return phone calls promptly”) or to procrastinate (e.g., “Even with jobs that require little else except sitting down and doing them, I find they seldom get done for days”). People indicated how well each item described them using a scale that ranged from 1 (*Extremely Uncharacteristic*) to 5 (*Extremely Characteristic*). The reliability of the measure was good ($\alpha = .90$).

Perfectionism. We measured perfectionism with eight items from Mazzetti, Schaufeli, & Guglielmi, (2014). People responded to all items on a scale that ranged from 1 (*strongly disagree*) to 5 (*strongly agree*). The reliability of the measure was acceptable ($\alpha = .71$).

Hedonism. We measured hedonism, or people’s present-oriented time perspective, with five items adapted from Bozkurt, Bayram, Furnham, & Dawes, (2010). Example items include: “People should not sacrifice the pleasure of the present for the possibility of something better in the future” and “People should always pursue pleasure in their lives.” People answered each item on a 5-point scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). The reliability of the measure was acceptable ($\alpha = .73$).

Internet compulsion. We measured compulsive internet use with the Compulsive Internet Use Scale (Meerkerk et al., 2009). This scale consists of 14 items that people answer on a 5-point scale that ranges from 0 (*never*) to 4 (*very often*). Questions on this scale include: “How often do you continue to use the Internet despite your intention to stop?” and “How often are you short of sleep because of the Internet?” The reliability of this scale was very good ($\alpha = .93$).

Sleep behavior. Finally, we used the 12-item Sleep Behavior Scale (Suh et al., 2014) to measure how often in the previous month people engaged in behaviors known to interfere with sleep (e.g., “smoking before bedtime,” “staying in bed when unable to stay asleep,” and “having irregular sleep and wake times”). People answered each item on a scale that ranged from 1 (*never*) to 5 (*every day*). The measure had acceptable reliability ($\alpha = .75$).

Results

We examined whether people sampled in the morning and evening differed on the constructs of interest with independent samples *t*-tests. Correlations among all Study 1 variables are presented in Table 1 and condition means, inferential statistics, and measures of effect size are presented in Table 2.

For the measure of morningness-eveningness, higher scores indicate a preference for morningness. As expected, people sampled at 6:00am were more morning-oriented than those sampled at 8:30pm. Further, and as predicted, people sampled in the morning reported less anxiety, procrastination, hedonism, internet compulsion, and behaviors that interfere with sleep than people sampled in the evening (see Table 2). The one variable that did not show a group difference was the measure of perfectionism.

Collapsing across condition, correlations indicated that people who reported a preference for eveningness were more likely to report higher levels of procrastination, internet compulsion,

and disruptive sleep behaviors (see Table 1). Finally, disruptive sleep behaviors, which were higher in the evening than the morning group, were strongly correlated with greater anxiety and internet compulsion. Altogether, these results suggest that people active on Mechanical Turk at night are more likely to differentially present on a large cluster of clinical and personality related outcomes than people active early in the morning.

Table 1. *Overall means, standard deviations, and correlations in Study 1.*

Variable	<i>M</i>	<i>SD</i>	1	2	3	4	5	6	7
1. Morningness	49.89	11.78	--						
2. Anxiety	29.50	11.36	-.12 [†]	--					
3. Procrastination	52.77	14.84	-.47**	.27**	--				
4. Perfectionism	3.62	0.62	.15*	.15*	-.30**	--			
5. Hedonism	3.44	0.74	-.03	.10	.09	.20**	--		
6. Internet compulsion	2.34	0.82	-.39**	.44**	.53**	.04	.18*	--	
7. Sleep behavior	23.09	7.17	-.32**	.50**	.35**	.04	.10	.56**	--

[†] $p = .08$, * $p < .05$, ** $p < .01$

Table 2. *Group means, standard deviations, and inferential statistics for Study 1.*

Variable	Group		<i>t</i>	<i>p</i>	<i>d</i>	95% CI
	Morning	Evening				
	<i>M (SD)</i>	<i>M (SD)</i>				
Morningness	55.47 (10.71)	44.75 (10.41)	7.36	< .001	1.02	[0.73, 1.30]
Anxiety	27.52 (8.41)	31.24 (13.37)	-2.40	.02	-0.33	[-0.58, -0.60]
Procrastination	48.52 (13.77)	56.46 (14.78)	-4.02	< .001	-0.56	[-0.28, 0.83]
Perfectionism	3.67 (0.58)	3.58 (0.65)	-1.10	.28	0.15	[-0.12, 0.42]
Hedonism	3.32 (0.77)	3.57 (0.68)	-2.55	.01	-0.35	[-0.07, -0.62]
Internet compulsion	2.14 (0.72)	2.60 (0.84)	-4.25	< .001	-0.59	[-0.31, -0.86]
Sleep behavior	21.88 (6.97)	24.18 (7.27)	-2.33	.02	-0.32	[-0.05, -0.59]

Discussion

The results of Study 1 suggest that people active on MTurk in the morning differ from those active in the evening on a large number of clinical and personality variables. People sampled in the morning reported a greater preference for morningness and less evidence of dispositional (e.g., anxiety, procrastination, hedonism) and behavioral (e.g., disruptive sleep behaviors, internet compulsion) characteristics associated with clinically relevant outcomes than those sampled in the evening. Although we observed moderate to large effect sizes on all the variables we examined except one, Study 1 was limited in design. Specifically, we used standard Mechanical Turk sampling methods, meaning we did not control for the time zone participants were in when they completed the study or the day of the week they participated on. In Study 2, we attempted to control for these variables while also examining a few additional measures we expected morning and evening people to differ on.

Study 2

Study 2 aimed to replicate and extend the results of Study 1. To do so, we added a mid-day condition, controlled for the time zone in which participants took the study, ran the study across all the days of the week, and examined additional measures of personality and clinical symptomatology. The mid-day condition was added to demonstrate that the differences we observed on personality and clinical measures examined in Study 1 were unique to evening oriented people. We expected people sampled in the morning and afternoon to look essentially the same. Next, we added two personality measures (conscientiousness and neuroticism) and two clinically relevant measures of depression and disordered eating to Study 2. Finally, when conducting the study, we made extensive efforts to control for differences in local time zone and day of the week.

Method

Participants and Procedure

Three hundred and fifteen US adults from MTurk—183 men and 132 women—completed the study for \$1.50. On average, it took participants 19.14 minutes ($SD = 8.76$) to complete the study. Participants ranged in age from 19 to 74 years ($M = 34.80$, $SD = 10.55$). Complete demographic information for participants in Study 2 is reported in Appendix A, Table 1.

To examine whether people active on MTurk at different times of day differed on the variables of interest, we opened identical HITs at three different times. The first HIT ($N = 74$) was launched at 5:00am, the second ($N = 126$) at 1:30pm, and the third ($N = 98$) at 12:30am. Unlike Study 1, in Study 2 we imposed greater control over the time each study was open to participants working in different time zones. For each time of day condition, we launched a separate study within four different US time zones. Additionally, so as not to bias the study by any specific day of the week, each study was open for two hours each day. Thus, starting on Monday and for each day of the week thereafter, we launched four studies in different time zones at different times throughout the day. Repeating this process for seven consecutive days resulted in ninety-four separate studies across the week. Data collection for each HIT was open for two hours, at which point it was paused and activated again at the same time the following day. Time zone targeting was managed by TurkPrime software (Litman et al, 2017) which enables each study to only be visible to participants in selected time zones, and for researchers to pause and re-launch studies.

Similar to Study 1, after participants gave consent they completed demographic questions and a measure assessing preference for morningness or eveningness ($\alpha = .86$). Then, they

completed nine scales in random order. Five scales—anxiety ($\alpha = .95$), procrastination¹ ($\alpha = .94$), hedonism ($\alpha = .71$), internet compulsion ($\alpha = .92$), and sleep behavior ($\alpha = .66$)—were identical to Study 1. Four additional scales, described below, were unique to Study 2 and added because they helped capture differences that previous research has identified between morning and evening oriented people.

Measures

Depression. We measured depression with the revised Beck Depression Inventory (Beck & Steer, 1987). This scale consists of 21 self-report questions in which each item has four statements indicating a different level of severity for a particular symptom people have experienced over the past week. Scores for all 21 items are summed to yield a single depression score. The reliability of this measure was very good ($\alpha = .96$).

Attitudes toward disordered eating. We measured disordered eating with the Eating Attitudes Test - Short Version (EAT-8; Richter et al., 2016). This measure consists of eight items such as “I feel extremely guilty after eating,” “I am terrified about being overweight,” and “I am preoccupied with the thought of having fat on my body.” People responded to each item on a dichotomous scale (1 = *I agree somewhat*, 0 = *I disagree somewhat*). The scale had good reliability ($\alpha = .82$).

Conscientiousness. We measured conscientiousness with items from the Big Five Inventory (BFI) (John, Naumann, & Soto, 2008). The conscientiousness subscale consists of nine items that people respond to on a scale that ranges from 1 (*disagree strongly*) to 5 (*agree strongly*). The scale had good reliability ($\alpha = .88$).

¹ Due to a programming error, we had to drop two items from the procrastination measure.

Neuroticism. Similar to conscientiousness, we measured neuroticism with eight items from the BFI. People responded to each item on a 1 (*disagree strongly*) to 5 (*agree strongly*) Likert-type scale. Overall, the measure had good reliability ($\alpha = .91$).

Results

Analysis Plan

To examine whether people sampled in the morning, afternoon, and evening differed on the constructs of interest, we conducted a Multivariate Analysis of Variance (MANOVA) and followed significant ANOVAs with two types of tests to examine differences between the groups. First, we conducted one-tailed *t*-tests to compare the morning and evening groups. We did this because we had specific hypotheses—based on theory and the results of Study 1—in which we predicted that the morning group would score lower across measures than the evening group. Second, we conducted Scheffe-corrected post-hoc tests to examine differences between the morning and afternoon and afternoon and evening groups. Overall means, standard deviations, and correlations among variables in Study 2 are presented in Table 3.

The MANOVA was significant, Wilks' $\Lambda = .88$, $F(7, 117) = 2.27$, $p = .03$, $\eta^2 = .12$. In addition, there were significant univariate effects on all variables, $F_s > 3.87$, $p_s < .02$, $\eta^2_s > .03$, except for depression, $F(2, 295) = 0.04$, $p = .96$, and neuroticism, $F(2, 295) = 2.06$, $p = .13$.

Group means for all dependent variables are displayed in Table 4.

Table 3. Overall means, standard deviations, and correlations among variables in Study 2.

Variable	<i>M (SD)</i>	1	2	3	4	5	6	7	8	9	10
1. Morningness	48.32 (9.81)	-									
2. Anxiety	28.78 (10.78)	-.12*	-								
3. Procrastination	41.60 (13.78)	-.25**	.33**	-							
4. Hedonism	3.54 (0.72)	-.02	.01	.00	-						
5. Internet compulsion	2.33 (0.76)	-.23**	.44**	.48**	.10 [†]	-					
6. Sleep behavior	22.13 (6.04)	-.18*	.49**	.29**	.08	.47**	-				
7. Depression	8.69 (11.06)	-.20**	.65**	.38**	-.07	.43**	.47**	-			
8. Eating attitudes	0.36 (0.31)	.00	.40**	.14*	.08	.29**	.23**	.29**	-		
9. Conscientiousness	3.83 (0.79)	.14*	-.40**	-.75*	.03	-.46**	-.27**	-.45**	-.19**	-	
10. Neuroticism	2.60 (1.03)	-.24**	.60**	.43**	-.14*	.43**	.26**	.61**	.34**	-.55**	-

[†] $p = .08$, * $p < .05$, ** $p < .01$

Table 4. *Group means, standard deviations, and inferential statistics for Study 2.*

Variable	Group		
	Morning	Afternoon	Evening
	<i>M (SD)</i>	<i>M (SD)</i>	<i>M (SD)</i>
Morningness	52.31 (9.49)	48.29 (9.13)	45.26 (9.94)
Anxiety	26.66 (8.69)	27.21 (9.97)	32.69 (12.37)
Procrastination	39.85 (13.77)	40.59 (13.50)	44.95 (13.67)
Hedonism	3.70 (0.71)	3.40 (0.67)	3.55 (0.77)
Internet compulsion	2.27 (0.78)	2.19 (0.75)	2.59 (0.68)
Sleep behavior	21.91 (5.90)	20.73 (5.44)	24.44 (6.33)
Depression	6.12 (8.74)	7.95 (10.69)	11.90 (12.67)
Eating attitudes	0.36 (0.32)	0.36 (0.32)	0.37 (0.32)
Conscientiousness	3.91 (0.79)	3.91 (0.78)	3.64 (0.79)
Neuroticism	2.46 (0.90)	2.56 (1.06)	2.76 (1.04)

Comparisons Between the Morning and Evening Groups

Consistent with Study 1, people sampled in the morning were more morning-oriented than those sampled in the evening, $t(170) = 4.70, p < .001, d = 0.73$. In addition, people sampled in the morning reported more conscientiousness, $t(170) = 2.22, p < .01, d = 0.34$, and less anxiety ($d = -0.56$), depression ($d = -0.53$), procrastination ($d = -0.37$), internet compulsion ($d = -0.44$), disruptive sleep behaviors ($d = -0.41$), and neuroticism ($d = -0.31$) than those sampled in the evening, $ts(170) > -2.00, ps < .02$. There was no difference between the morning and evening groups in hedonism, $t(170) = 1.31, p = .10$, or eating attitudes, $t(170) = -0.20, p = .42$.

Other Comparisons

People sampled in the morning were more morning-oriented than those sampled in the afternoon, $t(198) = 2.96, p = .02$. In addition, those sampled in the afternoon were more morning-oriented than those sampled at night, $t(222) = 2.38, p = .06$. For all other measures, our analyses were exploratory, but we expected the evening group to show more signs of clinical symptoms than the other two groups.

Comparisons between the morning and afternoon groups. People in the morning and afternoon groups were similar in many respects. They reported similarly low levels of anxiety, procrastination, internet compulsion, disruptive sleep behavior, depression, eating attitudes, and neuroticism, $ts(198) < 1.43, ps > .39$, while also reporting nearly identical levels of conscientiousness. The only variable the two groups did vary on was hedonism, $t(198) = 2.93, p = .02$. Unexpectedly, people in the morning group reported more hedonism than people in the afternoon group.

Comparisons between the afternoon and evening groups. People in the afternoon group reported less anxiety, internet compulsion, disruptive sleep behavior, and depression than

those in the evening group, $ts(222) > 2.53$, $ps < .03$. In addition, people sampled in the afternoon reported marginally less procrastination, $t(222) = -2.39$, $p = .06$, and significantly more conscientiousness, $t(222) = -2.57$, $p = .04$, than people in the evening group. Afternoon and evening people did not differ in hedonism, eating attitudes, or neuroticism, $ts(222) < -1.50$, $ps > .32$.

General Discussion

A strength of online data collection is the freedom for participants to complete studies whenever it is convenient for them. Perhaps unsurprisingly, the research reported here suggests that people who have this freedom gravitate toward taking studies during hours aligned with their circadian typology. In two studies, we found that people active on MTurk in the morning were more morning oriented than those active on MTurk in the evening. In addition to differences in time of day preference, we found several relationships among variables that theory predicts should correlate with people's preference for morningness or eveningness. For example, in both studies people who were morning oriented reported more conscientiousness and less procrastination, anxiety, depression, internet compulsion, disruptive sleep behaviors, and neuroticism than those sampled in the evening. In Study 2, we found further evidence that many clinical and personality outcomes were higher in evening oriented people; people active in the morning and the afternoon reported similarly low levels of anxiety, procrastination, internet compulsion, disruptive sleep behavior, depression, disordered eating attitudes, and neuroticism. In the discussion that follows, we focus on the implications of this work for researchers conducting online studies and for people's work preferences in the gig economy.

Implications for Online Sampling

Nearly half of all studies reported in experimental psychology's top journals today are conducted online for a reason: online sampling is faster than in person (Zhou & Fischbach, 2016). Lab-based studies that take weeks or months with undergraduates and community samples can be completed within hours on MTurk. Although this efficiency is often viewed as a positive, it may also be a confound for psychological phenomena that vary throughout the day. For example, consider the morning morality effect. As originally reported by Kouchaki and Smith (2014), the morning morality effect explains a general tendency for people to act more ethically early in the day and less ethically later in the day as resources for self-control are taxed. Although the original research reported a general effect of time of day, subsequent research suggested that accounting for people's circadian typology in addition to time of day might do a better job of predicting moral behavior than time of day alone (Gunia, Barnes, & Sah, 2014). Thus, studies that investigate phenomena that vary across time of day and fail to account for variation in peoples' circadian typology may yield incomplete or inaccurate findings.

We believe the results of our studies have two important implications for sampling practices on Mechanical Turk. First, by highlighting the potential for time of day sampling bias, our work reveals a challenge for researchers who use MTurk and a possible flaw in current sampling practices. Currently, most researchers run their studies by choosing a time to launch the study and gathering the data as quickly as possible. However, our results suggest there are instances in which researchers may want to slow down data collection in order to control the time of day, day of the week, or local time zone in which participants complete the study. Similar to the way in which changing worker qualifications can help researchers avoid biasing their sample toward the most experienced workers on MTurk (Robinson, Rosenzweig, Moss, &

Litman, 2019), changing sampling practices around the time when a study is launched may help researchers avoid biasing their study by participant age, conscientiousness, anxiety, level of depression and other characteristics known to vary with morningness-eveningness. At a minimum, researchers could control time of day bias by dividing their study into smaller batches and launching different HITs throughout the day. When researchers want to take more extensive steps to control bias, they can spread data collection across all the days of the week or combine their efforts to control time of day and day of the week with targeting workers in specific time zones as we did in Study 2.

The second implication of our work for sampling on MTurk is that there will be instances in which time of day differences among participants present an opportunity for researchers to sample participants who meet certain demographic criteria. For example, older adults are difficult to sample on Mechanical Turk. Research on time of day preferences has shown that older adults are more morning oriented than younger adults. Hence, sampling in the morning may be a way to recruit more older adults into a study. Similarly, the results of our studies align with previous research that suggests people active on MTurk later in the day are less conscientious and higher in neuroticism than those active in the morning (Arechar et al., 2017; Casey et al., 2017). Our work also extends previous research by showing that several other variables vary across time of day including people's anxiety, tendency to procrastinate, likeliness to compulsively use the internet, and ability to get routine sleep. Researchers interested in studying people who vary in these characteristics or in using MTurk for clinical research (e.g., Chandler & Shaprio, 2016), may tailor their data collection toward the evening and overnight hours in order to maximize the odds of sampling people who possess characteristics the

researchers want to study. In this way, time of day differences on MTurk may represent an opportunity for researchers to sample specific subsets of the worker pool.

Implications for the Gig-Economy

Knowing that people on MTurk choose to work during hours that align with their circadian typology has implications for the gig economy. One implication is that autonomy may be usefully studied as a predictor of job satisfaction within gig economy platforms. To date there have been relatively few empirical investigations of what predicts worker satisfaction on MTurk (e.g., Brawley & Pury, 2016). Theoretically, however, the freedom to choose one's own working hours, working environment, and the absence of traditional costs associated with commuting to and from work should all increase job satisfaction. Mechanical Turk also presents some unique challenges (e.g., dealing with requesters, maintaining a high approval rating, poor communication from requesters) that should be studied in concert with job satisfaction, but at least on the surface the flexibility of work hours should contribute to job satisfaction.

A second implication of our research for the gig economy is that some gig economy work might be usefully tailored to the psychological and personality characteristics of people who prefer to work at different times of the day. That is, for some types of work, gig economy platforms might be able to tailor tasks with workers' strengths and preferences. For example, people active in the morning are likely to be more conscientious than those active at night. As a result, a platform like Mechanical Turk might be able to reserve tasks requiring a high level of conscientiousness for the morning hours. Doing so could allow workers to complete tasks suited to their strengths, potentially increasing their earnings.

Finally, an alternative way some gig economy platforms might be able to structure work is to nudge workers toward personal goals or healthy behaviors. For example, Uber notoriously

experimented with framing and psychological nudges intended to get drivers to spend more time on the road (Scheiber, 2017). Rather than exploiting people, however, a platform like MTurk could create nudges that move workers toward personal goals like ending work by a certain time of day or promoting routine behaviors at night in order to limit time on the internet and help workers wind down before sleep. If these initiatives are created with worker input and if workers are free to choose whether or not to use them, such small changes may have the ability to increase worker satisfaction with some types of gig economy work.

Conclusion

On Mechanical Turk, researchers can quickly gather lots of data. This speed has been viewed primarily as an asset, but as our research here has shown it may also present a problem for some types of research. When researchers study phenomena that change throughout the course of the day or that are correlated with people's circadian typology, gathering the data all at once may introduce a confound into the study. Our research suggests the composition of workers changes throughout the day and researchers can take advantage of this fact by adjusting their sampling practices. When necessary, researchers can slow down or stagger their data collection to avoid time of day confounds. At other times, researchers can take advantage of time of day differences and sample people higher or lower in specific characteristics by making studies live during the hours when these workers are most active. In the end, time of day differences in online platforms represent both an opportunity and a challenge for research.

Open Practices Statement

Data and materials are available from the study authors upon request. None of the studies were preregistered.

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Appendix A

Table 1. *Demographic characteristics of participants in Studies 1 and 2.*

Variable	Study 1	Study 2
	%	%
Gender		
Male	54.2	58.1
Female	45.8	41.9
Education		
High school or less	16.0	15.9
Some college	27.8	25.1
Associate's degree	10.4	14.6
Bachelor's degree	37.7	35.6
Graduate degree	8.1	8.9
Race		
White	72.2	73.9
Black	11.3	8.6
Asian	7.1	6.7
Hispanic/Latino	6.1	6.4
Other	3.3	4.5
Marital Status		
Single	58.5	60.3
Married	33.0	33.0
Separated	1.4	1.0
Divorced	6.6	5.7
Widowed	0.5	0
Children		

None	63.7	67.9
1-2	25.9	24.8
3+	10.4	7.3
Household Income		
<20k	18.8	14.3
20k – 39k	27.4	36.5
40k – 59k	24.1	21.0
60k – 79k	12.3	13.0
80k – 99k	8.5	8.0
>100k	8.9	7.3
Employment		
Paid employee	63.2	65.1
Self-employed	18.4	17.5
Temporary layoff	1.9	0.6
Looking for work	8.5	6.3
Retired	0.9	1.6
Disabled	0.9	1.9
Not working (other)	5.2	5.4
Prefer not to answer	0.9	1.6