

# Does Time of Day Affect Variety-Seeking?

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Variety-seeking is a fundamental aspect of choice. But given circadian rhythms in chronobiology, might variety-seeking vary by time of day? Four studies, including an empirical analysis of millions of purchases, demonstrate diurnal variation in variety-seeking. Variety-seeking is lower in the morning than other times of day. People pick less varied flavors of yogurt, for example, when choosing in the morning. Further, the results demonstrate the underlying role of circadian changes in physiological stimulation and arousal. The effect is mediated by a physiological measure of arousal (i.e., body temperature) and moderated by factors that shape physiological arousal (i.e., sunlight and individual differences in circadian preferences). These findings shed light on drivers of variety-seeking and the biological basis of consumer behavior more generally.

**Keywords:** variety, decision-making, choice, circadian rhythms, arousal

Variety-seeking is a fundamental aspect of choice. We have Chinese food for dinner because we had Italian last night or buy different flavors of yogurt rather than multiple cartons of the same. Whether choosing something to consume now or a portfolio of options to consume at a later date (Simonson 1990), consumers seek variation (see Kahn 1995 for a review of research supporting this conclusion).

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But might how much variety people seek vary by time of day?

Consumers make choices at different times of the day. Sometimes people shop online in the middle of the day, while other times they shop in the evening. Sometimes consumers go to the supermarket in the morning, and other times they go later in the day. Might simple shifts in *when* people make their choices impact how much variety they choose? Might people be less likely to choose varied flavors of yogurt, for example, if they go shopping in the morning?

Building on research on chronobiology, we suggest that time of day impacts variety-seeking. Internal biological processes lead physiological arousal (i.e., internal levels of stimulation) to systematically fluctuate throughout the day (Kleitman 1963; Thayer 1978, 1989). Consequently, given that variety is itself stimulating, we suggest that *when* consumers choose may impact how much variety they prefer.

Four studies, including an empirical analysis of millions of supermarket purchases, demonstrate diurnal variation in variety-seeking. Through both manipulation and measurement, they demonstrate that variety-seeking is lower in the morning, and that this is driven at least in part by circadian changes in arousal.

This article makes four main contributions. First, we shed light on drivers of variety-seeking. While economic approaches (Kahneman and Snell 1990; Kreps 1979) often argue that variety-seeking is driven by uncertainty about future

preferences, diurnal variation in variety-seeking highlights the important role of more physiological factors. Further, while research on optimal stimulation level (Pessemier and Handelsman 1984) suggests that certain individuals may prefer more variety, our results suggest that desires for variety may also vary *within* individuals. Depending on time of day, the same person may choose more or less variety.

Second, we deepen understanding of the biological basis of consumer behavior. While psychologists and neuroscientists have begun to examine how physiology shapes judgment and decision-making, this area is still relatively young. Further, few articles have examined how these factors might impact consumer behavior (Durante and Arsena 2015; Kristofferson et al. 2017; Lichters et al. 2016). We contribute to the burgeoning research stream by demonstrating circadian rhythms in variety-seeking and the process behind this effect.

Third, we demonstrate an underlying process behind effects of circadian rhythms. While researchers have long been interested in diurnal variation in judgment and behavior (Freeman and Hovland 1934), little research has linked these effects to underlying physiological processes. We begin to bridge this gap by documenting the underlying role of circadian arousal.

Finally, these findings have important implications for marketing practice. Given diurnal variation in variety-seeking, managers may want to consider time of day when thinking about product offerings or what to highlight in advertising.

## VARIETY-SEEKING

Decades of research have studied variety-seeking and its impact on consumer behavior (for a review, see Kahn 1995). From mundane choices, like what to eat, to important decisions, like how to spend one's time, people often seek and are influenced by variation (Broniarczyk, Hoyer, and McAlister 1998; Kahn 1995; McAlister and Pessemier 1982; Redden and Hoch 2009). Rather than picking multiples of the same thing (e.g., two Snickers bars), for example, people often pick a variety of familiar options (e.g., one Snickers and one KitKat, Simonson 1990). Variety-seeking is so deeply ingrained that it affects what infants eat (Gerrish and Mennella 2001), and so strong that people choose varied experiences even when it means selecting less preferred items (Ariely and Levav 2000; Ratner, Kahn, and Kahneman 1999).

Prior work has mainly focused on two drivers of variety-seeking: individual differences and situational factors (e.g., choosing in public). Research on individual differences suggests that certain people tend to prefer more variety. Work on optimal stimulation level (Raju 1980), for example, suggests that some people have greater needs for stimulation, and select more variety as a way to fill that need (Pessemier and Handelsman 1984). When planning dinner

for the upcoming week, for example, people with higher optimum stimulation levels choose more dissimilar dishes (Steenkamp and Baumgartner 1992). Similarly, cross-cultural research suggests that Americans choose more variety than East Asians because Western culture values the uniqueness it expresses (Kim and Drolet 2003).

Research on situational factors examines how aspects of the surrounding environment influence variety-seeking. When choosing in a group setting, for example, people select more varied options from their peers as a way of standing out or differentiating themselves (Ariely and Levav 2000). Similarly, choosing in public, rather than private, leads people to select more variety (Ratner and Kahn 2002). Even the physical space where choice is made can influence variety-seeking (Levav and Zhu 2009).

But while individual differences or situational factors shed some light on when and why people choose variety, they have less to say about time of day. Might simply choosing in the morning, for example, rather than the afternoon, change how much variety people seek?

## THE CURRENT RESEARCH

Building on research on circadian rhythms and their impact on physiological arousal, we suggest time of day will impact variety-seeking. Circadian rhythms are any physiological process (e.g., the sleep cycle and heart rate) that systematically fluctuates over an approximately 24-hour period. Functioning as a "biological clock" (Hofstra and de Weerd 2008), circadian rhythms help organisms coordinate their physiology so that different functions occur at different times of the day (Hastings, Reddy, and Maywood 2003). Circadian rhythms help to regulate the sleep cycle, for example, by secreting the sleep hormone melatonin in the evening when the sun begins to set and by reducing melatonin levels throughout the night to aid waking in the morning (Schmidt et al. 2007). While the body can maintain consistent rhythms without external cues about time of day (Aschoff et al. 1971), circadian rhythms synchronize with external time cues (e.g., sunlight) when available (Bass 2012). Thus, most people's circadian rhythms generally oscillate at the same time every day, allowing time of day to be used as a proxy for circadian phase.

In particular, circadian rhythms shape physiological arousal, or levels of felt internal stimulation. Whether measured by skin conductance (Hot et al. 1999), heart rate (Adan et al. 2012), or body temperature (Baehr, Revelle, and Eastman 2000), physiological arousal follows a consistent circadian pattern. Arousal is lower in the morning (Kleitman 1963; Thayer 1978, 1989), increasing logarithmically in a concave manner throughout the day. The steepest change is between morning and midday (i.e., 5 a.m. to 11 a.m.; Blake 1967a; Froberg 1977) and increases at a decreasing rate after that.

Given the link between stimulation and variety, we suggest circadian rhythms may also affect variety-seeking. A great deal of research shows that variety is stimulating (for a review, see Kahn 1995). Variety, almost by definition, is associated with stimulation and change (Berlyne 1960, 1970; Raju 1980) and choosing varied things feels stimulating and exciting (Etkin and Mogilner 2016; Menon and Kahn 1995). Choosing varied activities to do with a relationship partner, for example, makes the relationship seem more stimulating and exciting (Etkin 2016). Consequently, circadian changes may shift not only how aroused people feel internally, but also how much external stimulation they want, and thus how much variety they seek.

But how might variety-seeking vary over the course of the day?

One possibility is variety-seeking is higher in the morning. Menon and Kahn (1995) suggest that people use variety as a compensatory tool to manage their optimal level of stimulation. Consequently, if people feel lower physiological arousal or internal stimulation in the morning, they might compensate by choosing more external stimulation (i.e., variety) to reach their desired or optimum level. This would suggest higher variety-seeking in the morning than the rest of the day.

This line of thinking, however, assumes that optimal stimulation level is constant throughout the day. One person may prefer more stimulation than another, but *within* a person, optimal stimulation level should stay the same. A person would want the same amount of stimulation, for instance, whether it is morning, afternoon, or evening.

Alternatively, we suggest that not only might people feel less internally stimulated in the morning, but they might *desire* less external stimulation or have a lower optimal stimulation level then as well. If this is true, people might choose less variety in the morning, either to avoid feeling stimulated or to lower felt stimulation. Further, given that the steepest change in physiological arousal occurs between the morning and afternoon (Blake 1967a), variety-seeking should show the biggest increase then as well. Variety-seeking should be lowest in the morning, increase over the day, and level off between afternoon and evening.

Four studies test our theorizing in the laboratory and in the field. We investigate both these possibilities empirically and delve into how variety-seeking may serve a compensatory or matching function in the General Discussion. Study 1 analyzes over six million supermarket shopping occasions, examining whether variety-seeking is lower in the morning than the rest of the day. Further, it investigates the role of circadian changes in arousal, testing whether factors that also affect arousal (i.e., sunlight) moderate time of day's effect. Study 2 randomly assigns participants to complete the same study at different times of day to tightly test the impact of time of day on variety-seeking. It also tests the process, measuring physiological arousal and examining whether it mediates the effect. Study 3

examines a broader set of times of day, and study 4 underscores the underlying role of circadian rhythms by testing whether the effects are moderated by individual differences in circadian preference (i.e., whether people are morning types or evening types). Together, the findings repeatedly demonstrate the link between time of day and variety-seeking and the role of circadian arousal in these effects.

## STUDY 1: SHOPPING BEHAVIOR OF ONE MILLION HOUSEHOLDS

Study 1 analyzes the supermarket shopping behavior of more than one million households over 25 months to test whether variety-seeking varies by time of day—that is, whether someone buying two yogurts, for example, buys two of the same flavor if they shop in the morning, but two different flavors if they shop in the afternoon.

We also test the underlying process by examining whether the effects are moderated by a factor that affects physiological arousal (i.e., sunlight). Circadian rhythms are endogenous (Aschoff et al. 1971), meaning they can operate even in the absence of outside stimuli, but they are often adjusted, or synchronized, by external cues such as light (Bass 2012). If the effect of time of day on variety-seeking is driven by circadian changes in physiological arousal, as we suggest, it should be moderated by sunlight. We test this possibility.

### Method

*Data Description.* We use scanner panel data from a single California location of a major grocery chain. Each purchase includes the time of day and a unique household identifier for consumers using the grocery rewards card. This allows us to track the same household over time and isolate the time-of-day effect using within-household variation. The data includes purchases from 1,115,133 households across a 25-month time period.

*Analysis Method.* Our analysis focuses on the variety purchased within a category for a given shopping trip. Following prior work (Levav and Zhu 2009),<sup>1</sup> variety is defined as the number of unique UPCs purchased in a category, relative to the number of total items purchased in that category. For example, someone buying two yogurts might purchase two of the same flavor (i.e., less variety) or two different flavors (i.e., more variety).<sup>2</sup>

1 We prefer to not use the log-odds transformation used in that article, which changes the range from 0 to 1 into a range unbounded below but still bounded above by 6.91 (a number determined by the authors' decision to treat measures of 1 as 0.99 to prevent dividing by zero). That said, our results are robust to the transformation.

2 Because unique products are defined based on UPC, any difference (flavor, size, form, etc.) will lead to products being classified as distinct.

The variety measure is defined as follows:

$$\text{Var}_{iCt} = \frac{\sum_{j \in C} 1\{j \in B_{it}\}}{\sum_{j \in C} q_j \in B_{it}}$$

This measure is calculated by product category for each shopping basket and is defined as the number of unique products  $j$  in shopping basket  $B_{it}$  in category  $C$  divided by the total number of products purchased in that category. If a consumer purchased four yogurts, for example, two each of two different types (e.g., flavor or brand), the variety in that category would be .5. The variable takes a maximum value of 1 when all products purchased in the category are unique. We use this measure rather than a simple count of unique products because we do not want to conflate variety with number of items purchased in the category (though, as we show below, all results hold for simple counts as well). Our analyses focus on occasions where at least two products are purchased in the category, but results are robust to including one-item cases (in which case the variety measure is equal to 1) and when we restrict the sample to more products purchased within the category (e.g., at least three or four).<sup>3</sup> We use all observations and categories in which multiple items were purchased in a category, and [web appendix table A1](#) gives a sense of which categories appeared most frequently (e.g., yogurts and frozen dinners) and what percentage of observations came from each category.

To determine the effect of time of day on variety purchased, controlling for other factors such as shopping basket size, number of purchases in the category, store traffic, and day of week, we use the following model:

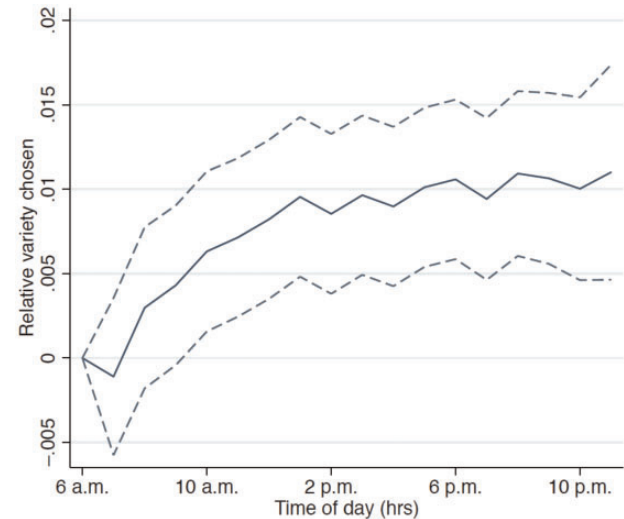
$$\text{Var}_{icdt} = \eta_h + \delta^1 I_{dt} + \delta^2 I_{dt}^2 + \xi_m + \zeta_{dom} + \omega_{dow} + \gamma_{icdt}^{NC} + \gamma_{idt}^N + \theta_{ic} + \epsilon_{icdt}, \quad (1)$$

in which  $i$  designates the household,  $c$  indicates the category, and  $d$  and  $t$  indicate the day and time of the transaction, respectively. The subscripts  $i$ ,  $d$ , and  $t$  together define a unique transaction. The  $\eta_h$  is the hour-of-day dummy variable of interest, and  $I_{dt}$  is the number of transactions that hour (in our sample) to control for store traffic.  $\xi_m$  is the month-of-year dummy,  $\zeta_{dom}$  is the day-of-month dummy,  $\omega_{dow}$  is the day-of-week dummy,  $\gamma_{icdt}^{NC}$  is the dummy for the number of purchased items in the category

3 While one could argue that purchasing just one item in a category indicates that a consumer is not interested in variety, it could just as easily be argued that this person needs only one item or that the person is maximizing variety. When someone purchases at least two items, quantity desired and variety-seeking can be disentangled. A consumer can purchase two items with or without seeking variety. Thus, consistent with prior work (Hoch, Bradlow, and Wansink 1999), our primary results focus on transactions in which multiple items are purchased in a category.

FIGURE 1

VARIETY-SEEKING VARIES BY TIME OF DAY



NOTE.—These are the estimated  $\eta_h$  in equation (1). Points are plotted relative to average variety purchased at 6 a.m. dotted lines indicate 95% CIs.

in transaction  $t$ ,  $\gamma_{idt}^N$  is the dummy for the number of items purchased in the shopping basket, and  $\theta_{ic}$  refers to household-category fixed effects. By including fixed effects for all household-category combinations, we identify the time-of-day effects exclusively from within household-category variation. This allows us to compare the same household, purchasing in the same category, but at different times of day. The dummies for the number of items in the category and number of items in the shopping basket allow us to make inferences by comparing category (and basket) purchases of the same size.

## Results

Figure 1 plots the estimates of the hour-in-day fixed effects with their 95th percent confidence intervals. Consistent with prior findings regarding physiological arousal over the day (i.e., increasing sharply up to 11 a.m. and then less sharply after that, Blake 1967a), the function is clearly increasing at a declining rate over the course of the day, with an hourly increase of .0013 for the 6–10 a.m. hours (up to but not including 11 a.m.) and only .0003 afterward.

This implies that a log functional form would fit the data well. Thus, we replace the hour fixed effects with log hours since 5 a.m. and estimate the revised model shown below:



TABLE 1:  
REGRESSION RESULTS

Variable	Coef.	Any purchases in category	Exactly 2 purchases in category	At least 2 purchases in category	At least 3 purchases in category	At least 4 purchases in category
Log Time (Hr Since 5 a.m.)	$\alpha$	0.00222*** (0.00016)	0.00496*** (0.00052)	0.00509*** (0.00052)	0.00404*** (0.00069)	0.00420*** (0.00083)
# Txns in Store-Hr	$\delta^1, \delta^2$	Y	Y	Y	Y	Y
Month-of-Year FE	$\zeta_m$	Y	Y	Y	Y	Y
Day-of-Month FE	$\zeta_{dom}$	Y	Y	Y	Y	Y
Day-of-Week FE	$\omega_{dow}$	Y	Y	Y	Y	Y
# Items in Cat. FE	$\gamma_{icdt}^{NC}$	Y	Y	Y	Y	Y
# Items in Basket FE	$\gamma_{idt}^N$	Y	Y	Y	Y	Y
HH x Cat. FE	$\theta_{iC}$	Y	Y	Y	Y	Y
R-squared		0.7506	0.5801	0.6407	0.7251	0.7267
N		10,379,180	1,793,382	2,854,447	863,968	481,337

Note: "Txn" indicates transaction, and "Cat" indicates category. Standard errors are clustered at the household level. Significance levels: \*\*\* 1%, \*\* 5%, \* 10%

$$\begin{aligned} \text{Var}_{iCdt} = & \alpha \log(t_{it} - 5AM) + \delta^1 I_{dt} + \delta^2 I_{dt}^2 + \zeta_m + \zeta_{dom} \\ & + \omega_{dow} + \gamma_{icdt}^{NC} + \gamma_{idt}^N + \theta_{iC} + \epsilon_{iCdt} \end{aligned} \quad (2)$$

As predicted, people choose less variety in the morning. This result held when we examined at least two items purchased in the category ( $\alpha = .00509$ ,  $p < .001$ , table 1, column 3) and is robust to either more or fewer items (table 1, other columns).

**Robustness Checks.** One might wonder whether the effect holds when the number of unique items is used as the variety measure. We believe our variety measure is more appropriate because it controls for the number of items purchased in the category. Households that purchase more items, for example, likely purchase more unique items, but this may be driven by basket size more than by variety-seeking. That said, using this alternate measure of variety (i.e., counts of unique items in category) shows the same effect ( $\alpha = .01884$ ,  $p = .001$ , web appendix table A2, column 1). Results are also robust to different category definitions. Categories can be defined broadly (e.g., fruit) or narrowly (e.g., berries), so we perform the analyses using different approaches. Moving from more to less general, the firm used a category tree structure including group, category, class, subclass, and subclass. In many cases, the category, class, and so on are all the same. Refrigerated yogurts, for example, are a category, subclass, and everything in between. Blackberries, on the other hand, are in the berries category and class, but

distinguish between domestic and imported at the subclass and subclass level. The main analyses focus on "category," but results are the same when we use different category definitions (see web appendix table A2, columns 2–4). People purchase less variety in the morning than the rest of the day

We also find the same results using the number of categories in the transaction as the dependent variable (or number of classes, subclasses, and subclasses; see web appendix table A3). In all cases, variety (i.e., number of categories purchased) increases over the course of the day.

Results are also robust to measuring variety-seeking when we focus on each UPC purchased. Simonson and Winer (1992), for example, measure variety as the extent to which that UPC is typically purchased, and Kahn and Raju (1991) define variety-seeking as choice behavior in which the purchase probability of a brand just after a consumer purchases it is lower than under a zero-order process. We believe our measure is more appropriate because it explicitly captures variety-seeking in the moment (e.g., a particular transaction) rather than over longer time horizons, but using both of these articles' definitions, we estimate UPC-level regressions, again showing that variety increases with time of day (see web appendix table A4).

**Alternative Explanations.** One might wonder whether the results are driven by *between-household variation* (e.g., different households having different variety preferences and shopping at different times of day). If households that prefer less variety shop more in the morning, for example,

maybe that could drive the pattern of results. Similarly, maybe larger households purchase later in the day and also buy more variety. But this is not the case. Including household  $\times$  category fixed effects controls for the fact that some households prefer more or less variety and that certain households may buy more variety in some categories than others. The fixed effects also mean that we are comparing the amount of variety purchased within each specific category by the same household when it shops at different times of the day (i.e., the effect cannot be explained by different types of households purchasing at different times of day).

Alternatively, one might wonder whether the results could be driven by *shopping basket composition* (i.e., people buying different categories at different times of day). If people buy low-variety categories in the morning, for example, and high-variety categories in the afternoon, maybe that could account for the observed pattern. But this is not the case. To test this possibility, we examine the effects within a single category. We focus on the category where people buy multiple items most often: yogurts (though the effects are consistent in other categories). Results are the same, albeit slightly stronger (see [web appendix table A2](#), column 5). People buy less variety in the morning than the rest of the day.

*Shopping basket size* also cannot explain the results. If morning shoppers are just buying a few things but evening shoppers engage in larger trips, maybe that could account for the results. In contrast with this suggestion, the largest baskets are in the mid-morning (see [web appendix figure A1](#)). Further, and more importantly, results are the same when we control for basket size in a variety of ways. In our main results, we include dummy variables for each number of purchased items in both the category and transaction, but the results also hold when we do conditional regressions at every single basket size (see [web appendix figure A2](#)). Regardless of how many items people bought, people who bought that many items and shopped in the morning bought less variety than people who bought that many items but shopped later in the day.

Differences in the *timing of shopping trips* on weekdays versus weekends also cannot explain the behavior. [Web appendix figure A3](#) shows similar distributions of shopping times on weekdays and weekends. In addition, the day-of-week dummy variables rule out any common weekend effects for households. We also rerun our specifications with the inclusion of household-specific weekend dummies and the results are largely unaffected, increasing the coefficient on log time with at least two purchases in the category from .00459 to .00546 (we report the analogous results for [table 1](#) with household-specific weekend dummies in [web appendix table A5](#)).

*Preliminary Process Test—Moderation by Light.* We further test the underlying role of circadian rhythms and,

more specifically, circadian changes in physiological arousal by examining whether time of day's effect is moderated by sunlight. In addition to cueing the biological clock to increase physiological arousal in the morning, light itself can also be stimulating and boost arousal ([Badia et al. 1991](#); [Cajochen 2007](#)). Thus, if circadian stimulation plays a role, as we suggest, then variety-seeking, and its relationship with time of day, should vary with seasonal changes in day length. Variety-seeking should be higher in months with more sun exposure, and should be higher in the mornings when the sun rises earlier. To test this possibility, we collected sunrise time for the 761 days in the dataset.

First, we simply examine seasonal variation in variety-seeking. Plotting the month-of-year dummy variable estimates from our regression in [equation \(1\)](#) shows that variety-seeking is higher in months where there is more sunlight (e.g., summer; see [web appendix figure A4](#)). The difference between the lowest and the highest sunlight months (i.e., December vs. June), for example, is .0045 ( $p < .001$ ).

Second, to examine whether the relationship between time of day and variety-seeking is moderated by sunlight, we estimate an alternative regression where we replace the month dummies with time since sunrise (which is negative prior to sunrise) and its interaction with log time since 5 a.m. (since most of the variation in sunrise time is due to changes over the course of a year due to the earth's rotation, we cannot include both sunrise and month). The main effect allows for variety to increase directly with more sunlight, and the interaction allows for different curvature in the time-of-day effect, depending on the amount of daylight thus far:

$$\begin{aligned} \text{Var}_{i\text{Cdt}} = & \alpha \log(t_{it} - 5AM) \\ & + \beta^1 (t_{it} - s_d) + \beta^2 \log(t_{it} - 5AM)(t_{it} - s_d) \\ & + \xi_m + \zeta_{\text{dom}} + \omega_{\text{dow}} + \gamma_{i\text{Cdt}}^{\text{NC}} + \gamma_{i\text{dt}}^{\text{N}} + \theta_{i\text{C}} + \epsilon_{i\text{Cdt}} \end{aligned} \quad (3)$$

Results show that diurnal variation in variety-seeking is moderated by sunlight ( $\beta^1 = .00276$ ,  $p = .003$  and  $\beta^2 = -.00082$ ,  $p = .001$ , [table 2](#), column 1). Morning variety-seeking is higher on days when the sun comes up earlier. [Figure 2](#) shows the combined effects of the log time of day, time since sunrise, and their interaction. Variety starts higher and increases earlier in the day on earlier sunrise days.

We also examine daylight saving time. In an alternative specification, we replace the time since sunrise with month-of-year dummies and a dummy for daylight saving time (and its interaction with log time). When the clock "falls back" an hour, leading to more sunlight at a given hour in the morning, as expected, variety-seeking increases ( $\gamma = .00565$ ,  $p = .008$ , [table 2](#), column 2). This helps rule

**TABLE 2:**  
MODERATION BY SUNLIGHT

Variable	Coef.	(1)	(2)
Log Time (Hr Since 5 a.m.)	$\alpha$	0.00378** (0.00177)	0.00437*** (0.00061)
Time Since Sunrise	$\beta^1$	0.00276*** (0.00093)	
Log Time (Hr Since 5 a.m.) X Time Since Sunrise	$\beta^2$	-0.00082** (0.00025)	
Daylight Savings	Not shown		-0.00565* (0.00288)
Log Time (Hr Since 5 a.m.) X Daylight Savings	Not shown		0.00164 (0.00106)
Month-of-Year FE	$\zeta_m$	N	Y
Day-of-Month FE	$\zeta_{dom}$	Y	Y
Day-of-Week FE	$\omega_{dow}$	Y	Y
# Items in Cat. FE	$\gamma_{icdt}^{NC}$	Y	Y
# Items in Basket FE	$\gamma_{icdt}^N$	Y	Y
HH x Cat. FE	$\theta_{ic}$	Y	Y
R-squared		0.6406	0.6406
N		2,854,452	2,854,452

Note: "Cat" indicates category. Standard errors are clustered at the household level. Significance levels: \*\*\* 1%, \*\* 5%, \* 10%

out alternative explanations for the sunlight finding since it is identified from the exogenous daylight saving time changes.

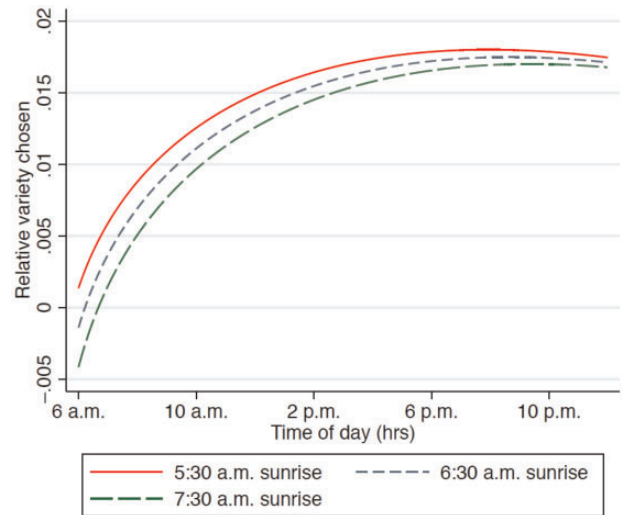
**Discussion**

Study 1 provides preliminary evidence that variety-seeking varies by time of day. Looking across over one million households, grocery shoppers bought less variety if they shopped in the morning. This effect is similar in size to other work examining effects on variety-seeking in the field (Levav and Zhu 2009). Compared to buying five yogurts of three types at 7 a.m., for example, people shopping at 7 p.m. are 6.5% more likely to instead purchase four types (increasing the dependent variable from .6 to .8).

Further, the results support the hypothesized underlying role of arousal. First, consistent with observed circadian changes in physiological arousal (Blake 1967a), there was a steep increase in variety-seeking between morning and midday, with a leveling off afterward. Second, sunlight shapes arousal, and the effects are moderated by sunlight and daylight saving time. In months where there is more sunlight, and thus people should be more stimulated, they purchased more variety. On days where people should be more stimulated in the morning (i.e., the sun rose earlier), the decreased preference for variety in the morning was attenuated. And when the hour of day changed independently of the sun (i.e., on

**FIGURE 2**

SUNLIGHT MODERATES TIME OF DAY'S EFFECT ON VARIETY-SEEKING



NOTE.—This figure includes the main terms in table 2, column 1. To improve readability, confidence intervals are not included but household-clustered standard errors are reported in table 2.

daylight saving time), variety-seeking also shifted. The moderation by sunlight effect is about a third of the size of the effect of time of day.

The results cast doubt on numerous alternative explanations. As noted above, explanations based on between-household variation, shopping basket, composition, shopping basket size, or timing of shopping trips all have difficulty explaining the effects. In addition, the pattern of results also cast doubt on a number of alternative individual-level processes.

First, the pattern of results casts doubt on an alternative explanation based on diurnal changes in cognitive performance. Variety-seeking is often used as simplifying heuristic (Simonson 1990), but circadian changes in cognitive performance would predict the opposite pattern of results. Cognitive performance generally increases throughout the day (Althoff et al. 2017), with people less likely to use heuristics as the day goes on (e.g., most people are less likely to stereotype later in the day, Bodenhausen 1990). To the degree that people seek variety to simplify, a cognitive performance account would suggest that variety-seeking would decrease throughout the day, being highest in the morning. Further, given that cognitive performance also exhibits a post-lunch dip in the mid-afternoon (Blake 1967b; for a review, see Carrier and Monk 2000), it would also predict a post-lunch shift in variety-seeking. But the fact that variety-seeking increases throughout the day, and

that there is no post-lunch shift, casts doubt on an alternative explanation based on cognitive performance.

Second, one could argue that people are *hungrier* in the morning, and so are less picky, choosing multiples of the same item rather than different items in a category. The fact that there is no similar dip in variety-seeking right before lunch and dinner, however, casts doubt on this possibility. Further, hunger can't explain why daylight exposure (or individual difference in circadian preferences, as shown in study 4) moderates the effect.

Third, *confinement* cannot explain the results. Feeling confined increases variety-seeking (Levav and Zhu 2009), so if the store environment was busier later in the day, this could lead to increased variety. However, we control for confinement using the number of transactions per hour (a measure of store density) and its quadratic and our results still hold.

Fourth, the results are inconsistent with an explanation based on *positive mood*. Positive mood boosts variety-seeking (Kahn and Isen 1993), but while the diurnal pattern of mood might predict variety-seeking would be lower in the morning, it would not predict a leveling off after midday. Mood has been shown to follow an inverted-U pattern, with lows in both the morning and the evening (Clark, Watson, and Leeka 1989; Murray, Allen, and Trinder 2002; Watson et al. 1999). It rises sharply in the morning, peaks around midday (between 11 a.m. and 4 p.m.), and declines thereafter, such that mood at 6 p.m. is similar to that at 9 a.m. Consequently, a positive mood account would predict that variety-seeking would also follow an inverted-U pattern, peaking in the midday and equally low in morning and evening. But, as shown in figure 1, that is not the case. Rather than decreasing after midday, variety-seeking simply levels off, casting doubt on a mood explanation.

That said, as is often the case with field data, it is difficult to rule out all alternative explanations. Rather than variation in variety-seeking, for example, one could argue that the results are driven by different shopping purposes at different times. While unlikely, maybe people shop for the entire household in the afternoon, and thus choose variety to accommodate multiple preferences, but buy less variety in the morning because they are just shopping for themselves. Alternatively, though also unlikely, maybe individuals within each household who dislike variety are systematically more likely to shop in the morning. While the daylight saving results (which exogenously shifts the amount of sunlight at a given hour) suggest these alternatives do not play a role, the next studies use experiments to clearly demonstrate effects on individual choice.

## STUDY 2: MANIPULATING TIME OF DAY AND TESTING AROUSAL

Study 2 has four main goals. First, to rule out alternative explanations, we look at individual-level choice. Second,

to avoid concerns about selection of different types of people into different times of day, we manipulate what time of day people make choices. We recruit people for a lab session, assign them to time of day, and measure their choices. If our theorizing about circadian rhythms and variety-seeking is correct, people should choose less variety in the morning. Third, we directly test the underlying role of physiological arousal. Body temperature is a standard measure of physiological arousal (Froberg 1977; Monk et al. 1983), and we test whether it mediates our effect. Finally, we further test alternative explanations (e.g., mood and tiredness).

## Method

*Participants and Design.* Eighty-three English proficient undergraduates completed a two-part study for monetary compensation. To ensure that participants' circadian rhythms were in sync with time of day, we a priori excluded participants who indicated they were on a nocturnal schedule (i.e., regularly asleep during the day and awake at night,  $n = 9$ ) or were up all night before the study ( $n = 1$ ). We also a priori excluded participants who had a temperature outside the normal healthy range (less than or equal to 95.1 degrees Fahrenheit,<sup>4</sup>  $n = 3$ ), leaving a final sample of 70 participants ( $N = 70$ ,  $M_{\text{age}} = 20.87$ ,  $SD = 2.02$ , 90% female). Results are the same when we use the entire sample. Exclusions did not vary by assigned time of day (all  $p$ s > .05).

*Materials and Procedures.* First, we randomly assigned participants to certain times of day to complete the study. Participants completed an online questionnaire through the university's subject pool website, where they completed basic demographics and then were randomly assigned to a time to come to the lab to complete the second part of the study (7:30 a.m., 12:30 p.m., or 5:30 p.m.).

When participants arrived at the lab, they were seated at a computer and completed a variety-seeking measure adapted from prior work (Levav and Zhu 2009). They imagined shopping for six highlighter pens at an office supply store and indicated how many of each of six colors (purple, orange, blue, pink, green, yellow) they would choose. They could pick any combination of colors (i.e., six of one, one of each, etc.) as long as they picked six total. As in prior work (Levav and Zhu 2009; Simonson 1990), variety-seeking was measured as the number of unique highlighter pens selected.<sup>5</sup>

4 <https://www.webmd.com/first-aid/normal-body-temperature#2>

5 Note that number of unique items selected is a more appropriate DV here than in study 1 because here the number of items selected by all participant is the same (i.e., six). In study 1, that number varied, and thus the number of unique items chosen could be driven simply by a larger basket size.



After participants completed the dependent measure, we measured a number of alternative explanations. To measure tiredness, we had participants complete a three-item measure (adapted from Froberg 1977) indicating the extent to which they currently felt tired, sluggish, and sleepy (1 = not at all, 10 = very much,  $\alpha = .89$ ). To measure mood, they completed the Positive Affect Negative Affect Scale (PANAS,  $\alpha = .89$ , Watson, Clark, and Tellegen 1988). To ensure participants' circadian rhythms were synched with the cycle of the sun and time of day, we asked participants what time they woke up, how long they had been awake, and whether they are usually on a nocturnal schedule (i.e., awake during the night and asleep during the day).

Finally, we measured physiological arousal. A research assistant, blind to the hypothesis, took participants' body temperature using an instant ear thermometer (Braun Digital Ear Thermometer ThermoScan5 IRT6500).

## Results

*Variety-Seeking.* As predicted, a contrast of the predicted logarithmic pattern (contrast weights:  $-2, .5, 1.5$ ) revealed that time of day influenced variety-seeking in a logarithmic pattern throughout the day ( $F(1,67) = 9.85$ ,  $p = .003$ ,  $\eta^2 = .13$ ), see figure 3. Consistent with our theorizing, people chose less variety if they completed the survey in the morning ( $M = 3.62$ ) than other times of day ( $F(1,67) = 7.70$ ,  $p = .007$ ,  $\eta^2 = .10$ ). In particular, they choose less variety in the morning than in the afternoon ( $M = 4.36$ ,  $p = .106$ ) or evening ( $M = 5.04$ ,  $p = .002$ ).<sup>6</sup>

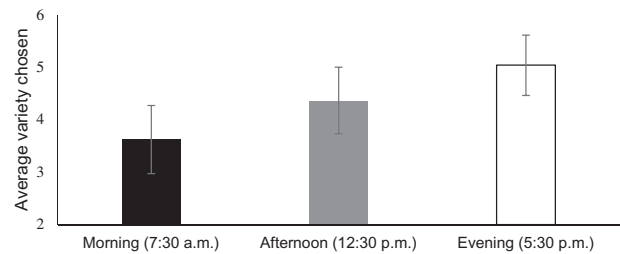
*Physiological Arousal.* As expected, and consistent with prior work (Baehr et al. 2000; Froberg 1977), a similar analysis shows that time of day also influenced internal arousal in a logarithmic manner ( $F(1,67) = 10.62$ ,  $p = .002$ ,  $\eta^2 = .14$ ). Using a physiological measure (i.e., body temperature) indicates that people were less aroused in the morning ( $M = 97.48$ ) than the afternoon ( $M = 97.88$ ,  $p = .097$ ) or evening ( $M = 98.24$ ,  $p = .001$ ).

*Mediation by Physiological Arousal.* Further, as predicted, arousal mediated the effect of time of day on variety-seeking. A bias-corrected bootstrapping mediation analysis with 10,000 samples (PROCESS model 4, Hayes 2013) reveals a significant indirect effect of physiological arousal (morning vs. afternoon:  $ab = -.24$ , 95% CI =  $[-.687, -.008]$ ; morning vs. evening:  $ab = -.47$ , 95% CI =  $[-.974, -.154]$ ; afternoon vs. evening:  $ab = -.22$ , 95% CI =  $[-.583, -.009]$ ).

<sup>6</sup> Note that, while the predicted log-shaped contrast is significant and the means trend in the predicted direction, the nonlinear effect of time of day on variety-seeking is not as pronounced here as it is in study 1 or in subsequent studies. This may simply be a power issue stemming from the limited number of participants that could be recruited for such a complex study.

FIGURE 3

### VARIETY BY TIME OF DAY



NOTE.—Error bars are 95% confidence intervals. See web appendix table A6, for standard deviations for studies 2 and 3.

Results are the same when we treat hour as continuous (linear: 07:30, 12:30, 17:30;  $ab = .05$ , 95% CI =  $[-.017, .098]$ ) and using the log-shaped weights for hour ( $-2, .5, 1.5$ ) as the dependent variable ( $ab = .13$ , 95% CI =  $[-.044, .270]$ ).

*Alternative Explanations.* Ancillary analyses cast doubt on a number of alternative explanations. One might wonder, for example, whether tiredness, which occurs independently of physiological arousal (Schmidt et al. 2007), could explain the effects. People sometimes use variety as a simplifying heuristic (Simonson 1990), so if they are more tired as the day goes on (e.g., from classes or work), maybe these factors could explain the results. This is not the case. First, if anything participants report the opposite—being more tired in the morning ( $M = 5.98$ ) than evening ( $M = 4.84$ ,  $p = .09$ ). Second, a bias-corrected bootstrapping mediation analysis with 10,000 samples shows that tiredness does not mediate the effect. Third, the observed effects of arousal all hold when we control for tiredness (all  $ps < .05$ ). Thus, tiredness has difficulty explaining the results.

Alternatively, similar to study 1, one might wonder whether positive mood could explain the results. While possible, a couple pieces of evidence cast some doubt on this possibility. First, a bias-corrected bootstrapping mediation analysis with 10,000 samples shows that mood does not mediate the effect. Second, the observed effects of arousal all hold when we control for mood (all  $ps < .05$ ). Thus, positive mood cannot explain the results.

## Discussion

Study 2 underscores how time of day affects variety-seeking and the underlying role of circadian changes in physiological arousal. First, consistent with study 1, people chose less variety in the morning than later in the day. Experimentally manipulating time of day provides direct causal evidence of its impact. Second, the results support the hypothesized process. Consistent with our theorizing,

circadian changes in physiological arousal mediated the effects. Measuring arousal through body temperature, rather than self-report, provides strong evidence of its role. Third, ancillary analyses cast further doubt on alternative explanations based on tiredness and positive mood. Further, random assignment to time of day casts doubt on other explanations that also coincide with time of day, such as closeness to any daily work or school deadlines or schedule constraints. Thus, although circadian variation in variety-seeking may be multiply determined (see General Discussion), these results demonstrate that physiological arousal plays a key role.

### STUDY 3: MORE TIMES OF DAY

Study 3 further tests our theorizing by examining individual choice at more time points. In addition, we use an alternate variety measure (i.e., activity choices) to examine the generalizability of the effect. We predict that participants who completed the study in the morning would seek less variety.

#### Method

*Participants and Design.* Eight hundred thirty-three participants recruited through Amazon Mechanical Turk (MTurk; age and gender not collected to make the study as short as possible) completed a short survey for monetary compensation. We opened slots for up to 80 people to complete the survey each hour from 5 a.m. to 11 p.m. Sixty-one participants failed to follow directions (i.e., selected an incorrect number of options) and 23 reported being awake from the night before, meaning their circadian rhythms might not be synched with time of day. We removed these individuals prior to analyzing the data, leaving 749 participants ( $N = 749$ ).

To examine whether variety-seeking varies over the course of the day, we had participants complete the study at different times. We measured time of day as hours since 5 a.m. (i.e., the starting point of the study).

*Materials and Procedure.* We used a variety measure adapted from prior work (Etkin 2016; Simonson 1990). Participants were shown a list of six activities (watch a movie, take a walk, cook dinner, exercise, go out to dinner, and go shopping) and asked to pick six they would like to do over the coming week. As in prior work (Etkin 2016; Simonson 1990), variety preference was measured as the number of unique activities selected. Participants indicated their time zone so their data could be matched with their current time of day.

#### Results

As predicted, variety-seeking was positively correlated with logged time of day ( $\beta = .12$ ,  $t(746) = 2.85$ ,  $p = .005$ ,

$R^2 = .0094$ ,  $\eta^2 = .01$ ); people chose less variety in the morning than they did later in the day. Compared to people choosing in the evening (i.e., 5 p.m. to 8 p.m.;  $M = 3.76$ ) or midday (i.e., 11 a.m. to 2 p.m.;  $M = 3.74$ ), for example, people who choose in the morning (i.e., 5 a.m. to 8 a.m.) picked less variety ( $M = 3.59$ ). Variety-seeking was also positively linearly correlated with linear time of day ( $r = .06$ ,  $p = .075$ ), but, consistent with the patterns observed in studies 1 and 2 and prior findings regarding the logarithmic change in physiological arousal throughout the day, a non-linear relationship fit better.

*Alternative Explanations.* Rather than time of day impacting variety-seeking, one might wonder whether the results are driven by people in the morning simply exerting less effort when completing the variety task. If people are tired in the morning, for example, maybe they are more likely to pick just one type of activity (as that requires less effort than thinking through the task), which makes it look like people are picking less variety in the morning.

But this was not the case. We conducted a chi-square difference test of the percentage of participants who chose only one type of activity across the early morning (5 a.m. to 8 a.m.), late morning (8 a.m. to 11 a.m.), midday (11 a.m. to 2 p.m.), late afternoon (2 p.m. to 5 p.m.), evening (5 p.m. to 8 p.m.), and night (8 p.m. to 11 p.m.). The percentage of people choosing just one type of activity did not differ by time of day ( $\chi^2(4, N = 749) = 3.87$ ,  $p > .250$ ), indicating that simply exerting less effort in the morning does not explain the effect. Further, if selecting multiple alternatives takes more effort than grabbing several of the same, fatigue would lead to less variety-seeking late in the day, the opposite of what we find.

Alternatively, one could argue the people are more depleted (Baumeister and Heatherton 1996) later in the day and that this leads them to minimize effort by spreading out and picking all six activity options. But this was not the case. We conducted a similar chi-square test of the percentage of participants who chose all six activities across the day. The percentage of people choosing all six activity options did not differ by time of day ( $\chi^2(4, N = 749) = 2.53$ ,  $p > .250$ ), indicating that the effect is not driven by people simply making cognitively easier selections later in the day, and casting doubt on a depletion-based alternative explanation.

Analyses also cast doubt on a default-based explanation. People sometimes pick default options to simplify decision-making or reduce effort (Johnson and Goldstein 2003). In our context, one could argue that people may be tired or focused on getting to work or school in the morning, and so stick with default options to save energy and time. In this study, the two effort-reducing “default” type choices would be to pick one of every activity, or all of one activity. As noted above, however, these choice

patterns did not differ by time of day. Thus, a default-based explanation also cannot account for the pattern of results.

Finally, one could wonder whether rather than changing variety-seeking, time of day simply shifted which of the six activities people preferred, making it seem like variety preferences changed. Maybe people who completed the study in the morning avoided activities that involved effort, for example, and gravitated to low-effort alternatives. But this was not the case. Time of day had no effect on the number of times people chose the lowest-effort activity (i.e., watching a movie;  $\chi^2(24, N = 749) = 21.50, p = .61$ ) or picked higher-effort activities (i.e., exercising or taking a walk;  $\chi^2(24, N = 749) = 22.07, p = .58$ ). Similarly, comparing high- and low-effort versions of the same activity (cooking vs. going out for dinner), showed no difference by time of day ( $t(742) = -.49, p = .63$ ). Further, there was no bias toward picking evening-related activities (e.g., cooking dinner, going out to dinner, or watching a movie) later in the day. In fact, there is no effect of time of day on whether or not any of the six activity options were chosen (binary; all  $ps > .05$ ). Thus, it is unlikely that preferences for the exact activities listed varying by time of day drove the effect.

## Discussion

Study 3 provides further evidence that variety-seeking varies by time of day and demonstrates the generalizability of the effect. Ancillary analyses cast doubt on a range of alternative explanations (e.g., effort, depletion, defaults, or specific activity preferences).

## STUDY 4: MODERATION BY CHRONOTYPE

Our final study uses moderation to further test the underlying role of circadian changes in arousal. People vary in sleep/wake and alertness patterns (i.e., chronotype). Morning types, or larks, go to bed and wake up earlier, and feel more alert and energized in the morning (Natale and Cicogna 1996; Wilson 1990). Particularly important to our context, morning types have higher levels of physiological arousal in the morning (Baehr et al. 2000; Froberg 1977). If less variety-seeking in the morning is driven by arousal, as we suggest, then morning-types (who are already more physiologically aroused in the morning) should seek greater variety in the morning compared to other individuals. Further, because the difference in arousal levels between morning types and evening types is less pronounced later in the day than it is in the morning (Froberg 1977), morning types should not seek more or less variety later in the day relative to other individuals.

To test this possibility, study 4 examined whether time of day's effect on variety-seeking varies by chronotype, or individual differences in circadian rhythms.

## Method

*Participants and Design.* Eight hundred five participants recruited from MTurk ( $N = 805$ ; age and gender not collected to make the study as short as possible) completed a short survey for monetary compensation.

Participants were recruited either in the morning (5 a.m. to 8 a.m.), midday (11 a.m. to 2 p.m.), or evening (5 a.m. to 8 p.m.).<sup>7</sup> Twenty-five participants were up from the night before and 37 reported a time zone that didn't match the recorded data, so their circadian rhythms would not be in sync with the recorded time of day. We removed them prior to analyzing the data.

*Materials and Procedure.* First, participants completed a scale that tapped individual differences in circadian preferences (i.e., chronotype). They filled out the 13-item Composite Scale of Morningness (CSM, Smith, Reilly, and Midkiff 1989), which includes measures like, "Assuming normal circumstances, how easy do you find getting up in the morning?" and "Please indicate to what extent you are a morning or evening active individual" ( $\alpha = .93$ ). As in prior work (Smith et al. 1989), anyone scoring more than a 43 is treated as a morning type, anyone scoring less than a 23 is treated as an evening type, and anyone scoring in between is treated as an intermediate type. We plot our results using the midpoints of each of these groupings (treating CSM score as continuous).

Second, we measured variety-seeking. Participants completed the same activity choice task as in study 3, where the number of unique options chosen served as the measure of variety.

7 To ensure a range of chronotypes completed the survey at different times of day, we took additional steps to recruit certain individuals at certain times of day. Not surprisingly, consistent with their chronotype, it is harder to find evening types naturally interested in completing a survey early in the morning and morning types naturally interested in completing a survey in the evening. Consequently, simply allowing the survey to fill naturally would lead to morning types being underrepresented in the evening and evening types being underrepresented in the morning. To avoid this, in addition to the main data collection, we used the Composite Scale of Morningness (Smith et al. 1989) to prescreen for morning and evening types. First, we screened out any intermediate types and allowed only morning and evening types to complete the survey to ensure a sufficient number of morning types and evening types in our sample. A total of 10.1% ( $n = 81$ ) of participants were screened into the survey. We further supplemented this screening by recruiting morning and evening types the day before and then randomly assigning participants to an hour within their non-optimal time slot to complete the variety-seeking measure (e.g., an evening type would be randomly assigned to complete the choice task at either 5 a.m., 6 a.m., or 7 a.m. the next day). A total of 8.2% ( $n = 66$ ) of participants completed the first part of study 4 the day before. Our screening efforts were successful: the proportion of morning types and evening types does not differ by condition ( $p > .05$ ).



## Results

A series of regressions of variety-seeking by Composite Scale of Morningness (continuous,  $M = 34.52$ ,  $SD = 9.96$ ,  $Min = 13$ ,  $Max = 55$ ), time of day (dummy-coded), and their interactions shows the predicted pattern of results (adjusted  $R^2 = .0071$ ).

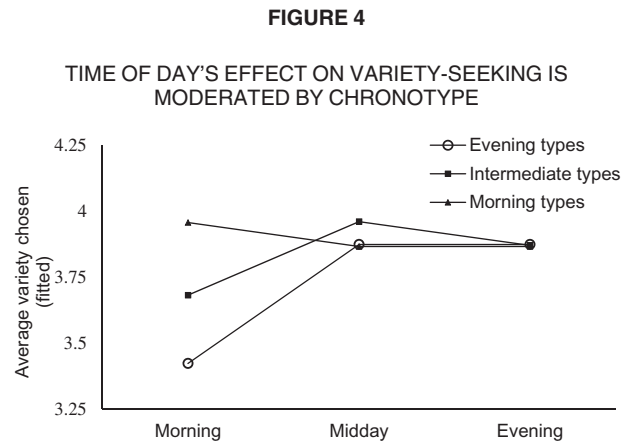
Consistent with the hypothesized underlying role of stimulation, individual differences in chronotype moderated the time-of-day effect (see figure 4). While both evening types (morning vs. midday:  $\beta = -.68$ ,  $t(799) = -3.17$ ,  $p = .002$ ,  $\eta^2 = .004$ ; morning vs. evening:  $\beta = -.46$ ,  $t(799) = 2.26$ ,  $p = .024$ ,  $\eta^2 = .004$ ) and intermediate types (morning vs. midday:  $\beta = -.28$ ,  $t(799) = -2.57$ ,  $p = .01$ ,  $\eta^2 = .004$ ; morning vs. evening:  $\beta = -.19$ ,  $t(799) = -1.86$ ,  $p = .063$ ,  $\eta^2 = .004$ ) preferred less variety in the morning than other times of day, this pattern was reduced among morning types (morning vs. midday:  $\beta = .14$ ,  $t < 1$ ,  $\eta^2 = .004$ ; morning vs. evening:  $\beta = .09$ ,  $t < 1$ ,  $\eta^2 = .004$ ). Morning types did not prefer any less variety in the morning than at other times of day ( $\beta = -.07$ ,  $t < 1$ ,  $\eta^2 = .004$ ).

Looked at another way, while there was no difference in variety-seeking due to chronotype in the middle of the day ( $\beta = -.008$ ,  $t(799) = -1.17$ ,  $p = .243$ ,  $\eta^2 = .0004$ ) or evening ( $\beta = -.0003$ ,  $t < 1$ ,  $\eta^2 = .0004$ ), consistent with the hypothesized role of arousal, morning types (who are more physiologically aroused in the morning) choose more variety in the morning as well ( $\beta = .016$ ,  $t(799) = 2.22$ ,  $p = .027$ ,  $\eta^2 = .0004$ ).

*Alternative Explanations.* Similar to study 3, one might wonder whether the effect is driven by morning types being more willing to select different types of activities, such as high-effort activities like exercising, in the morning than other types are. However, time of day did not impact the specific activities people chose (all  $ps > .05$ ), casting doubt on the possibility that the nature of the specific activities in the measure can explain the effect.

Cognitive performance also does not explain the results. Unlike physiological arousal, cognitive performance matches chronotype: morning types have better cognitive performance in the morning (their "optimal" time) than in the evening (their "nonoptimal" time), and evening types have better cognitive performance in the evening than in the morning (May 1999). Thus, a cognitive performance account would predict a crossover interaction with variety-seeking and chronotype, such that morning types would choose less variety in the morning than they do in the evening and evening types would choose the opposite. But this is not the case. Consistent with the differences in physiological arousal between chronotypes at different times of the day, chronotype moderates variety-seeking only in the morning.

Further, as in study 3, choosing the default option (either picking all of one activity or one of each activity) does not



vary by time of day (all  $ps > .05$ ). Thus, cognitive effort as expressed by picking defaults does not explain the results.

## Discussion

Study 4 underscores time of day's effect on variety-seeking and provides further evidence for the underlying role of circadian rhythms. People chose less variety in the morning, but this was moderated by individual differences in circadian rhythms (i.e., chronotype). Consistent with the pattern of circadian arousal, while evening and intermediate types preferred less variety in the morning, this effect was reduced among morning types who are more physiologically aroused in the morning to begin with.

It is worth noting that while we overrecruited morning types to test the underlying process, such individuals make up only a small portion of the overall population (i.e., ~20%; Posey and Ford 1981). Thus, while we do not see an effect of time of day on variety-seeking among morning types, we do see it among the majority of the population. As shown in studies 1–3, the effect persists when we aggregate across all chronotypes in the general population.

## GENERAL DISCUSSION

Variety-seeking is an important driver of consumer choice. But while it is clear that individual differences and situational factors shape variety-seeking, less is known about whether the mere time of day someone happens to choose might affect the amount of variety that person selects.

Four studies, including empirical analysis of supermarket shopping behavior of more than one million households over 25 months and controlled experiments, demonstrate consistent diurnal variation in variety-seeking. Variety-seeking is lower in the morning than the rest of the day. Further, we test the hypothesized process through both



mediation and moderation. As predicted, time of day's impact on variety-seeking was mediated by physiological arousal (study 2). Consistent with circadian changes in physiological arousal, the effects were moderated by light and individual differences in circadian preferences. In times when people are more physiologically stimulated (i.e., when they've been exposed to more sunlight, study 1), they prefer more variety, and people who should feel more physiologically stimulated in the morning (i.e., morning-types, study 4), preferred more variety than as well.

The studies cast doubt on a number of alternative explanations including positive mood, cognitive performance, depletion, defaults, and tiredness. While one could wonder whether the results were driven by different kinds of people completing the studies at different times of day, studies 1 and 2 rule this out, demonstrating that even looking within the same household or manipulating the time of day of individual's choices, choosing at different times of day shaped the variety chosen. Further, the positive correlation between variety and physiological stimulation (study 2) goes against the notion that people would choose more variety in the morning because they feel less stimulated.

The fact that we find a consistent effect across different methods highlights its generalizability. Whether examining millions of supermarket purchases (study 1), highlighter pens (study 2), or activity choices (studies 3 and 4), we find similar results. Combining controlled experiments with field data enables us to rigorously test causality while also demonstrating external validity.

### Contributions and Future Research

These findings make several contributions. First, the results shed light on drivers of variety-seeking. While prior work has identified several motivators for variety-seeking (e.g., hedging against changing future preferences, Simonson 1990; and social influences, Ariely and Levav 2000; Etkin 2016; Ratner and Kahn 2002), aggregating across people and contexts, these findings demonstrate the important role of time of day. Further, while work on optimal stimulation or culture suggests that different people may prefer more or less variety, our findings suggest that even within a person, variety-seeking varies over the course of the day.

Second, the results further understanding of the biological basis of behavior. While the circadian rhythms literature has documented behaviors that vary by time of day, there is little empirical evidence demonstrating the underlying physiological processes. Our findings suggest that physiological arousal plays an important role in changing behavior throughout the day.

Future work might examine other effects of time of day. Circadian rhythms have a host of downstream effects that might be of interest to consumer researchers. If we focus

just on stimulation, for example, time of day might impact novelty seeking, impulsivity, willingness to select defaults, or status quo biases. Consumers might be less willing to try new products in the morning, for example, and voters might be more prone to vote for incumbents if they vote in the morning rather than later in the day.

It would also be worthwhile to examine whether circadian changes in stimulation affect variety choices made for others. Do daily fluctuations in physiology affect only choices made for our own consumption? Or do we allow our internal states to influence judgments and consumption decisions made for others? Further research could use circadian rhythms to examine how our own internal states influence choices made even beyond ourselves.

Future work might also examine whether other factors also contribute to time of day's impact on variety-seeking. While the studies demonstrate that physiological arousal plays an important role, circadian rhythms' influence may be multiply determined. Dopamine, for example, has been linked to novelty-seeking traits and behaviors (Dellu et al. 1996). While there is some evidence that it oscillates with time of day in rats (Castaneda et al. 2004), we are not aware of any work documenting a circadian rhythm of dopamine in humans. Other hormones like melatonin have clearer circadian rhythms, but don't vary in a way that could easily explain our effects (i.e., melatonin stays at the same low level throughout the day; Hofstra and de Weerd 2008). Even outside of circadian rhythms, other factors such as mood may also play a role. Feeling more positive moods at certain times of day (e.g., a lunch break) could lead people to seek more variety. How various factors combine to determine variation in variety-seeking over the course of the day merits further attention.

### Matching and Compensatory Process in Variety-Seeking

More generally, these results raise interesting questions about the role of compensatory and matching processes in variety-seeking. A good deal of research suggests that variety-seeking can be used as a tool to achieve a satisfactory level of stimulation (Berlyne 1960; Driver and Streufert 1964; Fiske and Maddi 1961; Levav and Zhu 2009). Menon and Kahn (1995), for example, find that having variety in one domain (i.e., drink options) made consumers less likely to choose variety in a second domain (i.e., snack options), suggesting that people sought less variety in the second domain to compensate for increased stimulation in the first. Other work suggests that a similar compensating mechanism could impact how time of day affects variety-seeking (Roehm and Roehm 2004).

In contrast, one could argue that the current findings (and theorizing) seem more consistent with a matching account. Circadian rhythms lead people to feel lower physiological arousal or internal stimulation in the morning and

they choose less variety than as well, picking a level of variety that seems to match their current level of stimulation rather than compensating for it.

A couple points are worth note, though. First, our findings could still be interpreted through a compensatory lens. Consumers may desire less stimulation in the morning (than later in the day), but if they feel more stimulated than they want in the morning (e.g., by having to wake up and deal with the day), they may still choose less variety to reduce felt stimulation. Similarly, consumers may desire more stimulation later in the day, but if they feel less stimulated than they want, they may choose more variety to increase felt stimulation. This highlights the importance of separating felt (or current) and optimal stimulation level, and empirically testing how both vary over the day.

Second, although consumers sometimes use variety-seeking in a compensatory manner, this may not always be the case. Variety-seeking studies often show that participants in a target condition choose more or less variety than those in a control condition, but within the control, there is also variation (e.g., some people choose more variety and others choose less). While this variation can be attributed to individual differences in optimal stimulation level (OSL), how OSL shapes choice could just as easily be driven by matching as by compensation. A compensatory story might suggest that all participants felt the same level of stimulation initially, so those with a higher optimal stimulation level chose more variety to increase felt stimulation (and vice versa for those with a lower OSL). But it's just as possible that participants with a higher optimal stimulation level felt more stimulated coming into the study, so chose more variety to match their current state. Rather than using variety to change where they are (i.e., compensation), participants are already at their desired stimulation level and pick variety consistent with that (i.e., matching). An important step for future work is to separate current or felt stimulation from optimal stimulation level and empirically test how both contribute to variety-seeking behavior.

### Managerial Implications

These findings also have potential managerial implications. First, the effectiveness of variety appeals likely vary over the course of the day. Ads that appeal to variety-seeking, for example, should be more effective in the afternoon or evening than in the morning. Consequently, products that are naturally high (or low) in variety may want to focus their advertising at certain times of day rather than others. Yogurts or lip balms, which naturally evoke variety, for example, may be better served by advertising outside of the morning. Similarly, what features to highlight in marketing communications may also differ. When advertising in the afternoon, a cruise company might want to focus on the variety of activities consumers can do, but when

advertising in the morning, they might want to pick a different aspect to highlight.

Second, the findings suggest tailoring product offerings by time of day. Restaurants, for example, might want to downplay variety on their breakfast menus but highlight variety in their lunch and dinner menus. Radio stations might want to play less varied music in the morning and more varied music in the evenings.

Finally, the results have implications for new product introductions. If time of day also affects novelty seeking, companies may want to be particularly careful about introducing novel, or new-seeming, offerings in the morning. Taco Bell often introduces novel food items, for example, but when thinking about what to offer at breakfast, the company may not want to introduce options that are too different from what consumers are used to seeing at other fast food establishments.

In conclusion, this research demonstrates that time of day impacts variety-seeking. While variety may be the proverbial spice of life, how much spice consumers desire may depend on when that choice is made.

### DATA COLLECTION INFORMATION

The last author received access to and analyzed the data for study 1 from the SIEPR-Grannini Data Center in 2016. The data is from a single California location of a major grocery store chain over a 25-month period (05/01/2005–05/31/2007). The first author conducted and analyzed studies 2–4 under the guidance of the second and third authors. Data for study 2 (spring 2018) was collected using participants from a Duke University subject pool. Data for studies 3 (spring 2016) and 4 (summer 2016) were collected using Amazon Mechanical Turk.

### REFERENCES

- Adan, Ana, Simon N. Archer, Maria Paz Hidalgo, Lee Di Milia, Vincenzo Natale, and Christoph Randler (2012), "Circadian Typology: A Comprehensive Review," *Chronobiology International*, 29 (9), 1153–75.
- Althoff, Tim, Eric Horvitz, Ryan W. White, and Jamie Zeitzer (2017), "Harnessing the Web for Population-Scale Physiological Sensing: A Case Study of Sleep and Performance," paper presented at the 26th International Conference on World Wide Web, Perth, Australia.
- Ariely, Dan and Jonathan Levav (2000), "Sequential Choice in Group Settings: Taking the Road Less Traveled and Less Enjoyed," *Journal of Consumer Research*, 27 (3), 279–90.
- Aschoff, Jürgen, M. Fatranska, H. Giedke, P. Doerr, D. Stamm, and Hermann Wisser (1971), "Human Circadian Rhythms in Continuous Darkness: Entrainment by Social Cues," *Science*, 171 (3967), 213–5.
- Badia, Pietro, Brent Myers, Maren Boecker, Janice Culpepper, and J. R. Harsh (1991), "Bright Light Effects on Body Temperature, Alertness, EEG and Behavior," *Physiology and Behavior*, 50 (3), 583–8.

- Baehr, Erin K., William Revelle, and Charmane I. Eastman (2000), "Individual Differences in the Phase and Amplitude of the Human Circadian Temperature Rhythm: With an Emphasis on Morningness–Eveningness," *Journal of Sleep Research*, 9 (2), 117–27.
- Bass, Joseph (2012), "Circadian Topology of Metabolism," *Nature*, 491 (7424), 348–56.
- Baumeister, Roy F. and Todd F. Heatherton (1996), "Self-Regulation Failure: An Overview," *Psychological Inquiry*, 7 (1), 1–15.
- Berlyne, Daniel Ellis (1960), *Conflict, Arousal, and Curiosity*, New York: McGraw-Hill.
- (1970), "Novelty, Complexity, and Hedonic Value," *Attention, Perception, & Psychophysics*, 8 (5), 279–86.
- Blake, M. J. F. (1967a), "Relationship between Circadian Rhythm of Body Temperature and Introversion-Extraversion," *Nature*, 215 (5103), 896–7.
- (1967b), "Time of Day Effects on Performance in a Range of Tasks," *Psychonomic Science*, 9 (6), 349–50.
- Bodenhausen, Galen V. (1990), "Stereotypes as Judgmental Heuristics: Evidence of Circadian Variations in Discrimination," *Psychological Science*, 1 (5), 319–22.
- Broniarczyk, Susan M., Wayne D. Hoyer, and Leigh McAlister (1998), "Consumers' Perceptions of the Assortment Offered in a Grocery Category: The Impact of Item Reduction," *Journal of Marketing Research*, 35 (2), 166–76.
- Cajochen, Christian (2007), "Alerting Effects of Light," *Sleep Medicine Reviews*, 11 (6), 453–64.
- Carrier, Julie and Timothy H. Monk (2000), "Circadian Rhythms of Performance: New Trends," *Chronobiology International*, 17 (6), 719–32.
- Castaneda, Tamara R., Blanca Marquez de Prado, David Prieto, and Francisco Mora (2004), "Circadian Rhythms of Dopamine, Glutamate and GABA in the Striatum and Nucleus Accumbens of the Awake Rat: Modulation by Light," *Journal of Pineal Research*, 36 (3), 177–85.
- Clark, Lee Anna, David Watson, and Jay Leeka (1989), "Diurnal Variation in the Positive Affects," *Motivation and Emotion*, 13 (3), 205–34.
- Dellu, F., P. V. Piazza, W. Mayo, M. Le Moal, and H. Simon (1996), "Novelty-Seeking in Rats—Biobehavioral Characteristics and Possible Relationship with the Sensation-Seeking Trait in Man," *Neuropsychobiology*, 34 (3), 136–45.
- Driver, Michael J. and Siegfried Streufert (1964), "The 'General Incongruity Adaptation Level' (GIAL) Hypothesis: An Analysis and Integration of Cognitive Approaches to Motivation," Paper No. 114, Institute for Research in the Behavioral, Economic and Management Sciences, Krannert Graduate School of Management, Purdue University, West Lafayette, IN.
- Durante, Kristina M. and Ashley Rae Arsena (2015), "Playing the Field: The Effect of Fertility on Women's Desire for Variety," *Journal of Consumer Research*, 41 (6), 1372–91.
- Etkin, Jordan (2016), "Choosing Variety for Joint Consumption," *Journal of Marketing Research*, 53 (6), 1019–33.
- Etkin, Jordan and Cassie Mogilner (2016), "Does Variety among Activities Increase Happiness?" *Journal of Consumer Research*, 43 (2), 210–29.
- Fiske, D. W. and Salvatore Maddi, eds. (1961), *Functions of Varied Experience*, Homewood, IL: Dorsey Press.
- Freeman, G. L. and C. I. Hovland (1934), "Diurnal Variations in Performance and Related Physiological Processes," *Psychological Bulletin*, 31 (10), 777–99.
- Fröberg, Jan E. (1977), "Twenty-Four-Hour Patterns in Human Performance, Subjective and Physiological Variables, and Differences between Morning and Evening Active Subjects," *Biological Psychology*, 5 (2), 119–34.
- Gerrish, Carolyn J. and Julie A. Mennella (2001), "Flavor Variety Enhances Food Acceptance in Formula-Fed Infants," *American Journal of Clinical Nutrition*, 73 (6), 1080–6.
- Hastings, Michael H., Akhilesh B. Reddy, and Elizabeth S. Maywood (2003), "A Clockwork Web: Circadian Timing in Brain and Periphery, in Health and Disease," *Nature Reviews Neuroscience*, 4 (8), 649–61.
- Hayes, Andrew F. (2013), *Introduction to Mediation, Moderation, and Conditional Process Analysis: A Regression-Based Approach*, New York: Guilford.
- Hoch, Stephen J., Eric T. Bradlow, and Brian Wansink (1999), "The Variety of an Assortment," *Marketing Science*, 18 (4), 527–46.
- Hofstra, Wytse A. and Al W. de Weerd (2008), "How to Assess Circadian Rhythm in Humans: A Review of Literature," *Epilepsy & Behavior: E&B*, 13 (3), 438–44.
- Hot, Pascal, Janick Naveteur, Pierre Leconte, and Henrike Sequeira (1999), "Diurnal Variations of Tonic Electrodermal Activity," *International Journal of Psychophysiology*, 33 (3), 223–30.
- Johnson, Eric J. and Daniel Goldstein (2003), "Do Defaults Save Lives?" *Science*, 302 (5649), 1338–9.
- Kahn, Barbara E. (1995), "Consumer Variety-Seeking among Goods and Services: An Integrative Review," *Journal of Retailing and Consumer Services*, 2 (3), 139–48.
- Kahn, Barbara E. and Alice M. Isen (1993), "The Influence of Positive Affect on Variety Seeking among Safe, Enjoyable Products," *Journal of Consumer Research*, 20 (2), 257–70.
- Kahn, Barbara E. and Jagmohan S. Raju (1991), "Effects of Price Promotions on Variety-Seeking and Reinforcement Behavior," *Marketing Science*, 10 (4), 316–37.
- Kahneman, Daniel and Jackie Snell (1990), "Predicting Utility," in *Insights in Decision Making: A Tribute to Hillel J. Einhorn*, ed. Hillel J. Einhorn and Robin M. Hogarth, Chicago: University of Chicago Press, 295–310.
- Kim, Heejung S. and Aimee Drolet (2003), "Choice and Self-Expression: A Cultural Analysis of Variety-Seeking," *Journal of Personality and Social Psychology*, 85 (2), 373–82.
- Kleitman, Nathaniel (1963), *Sleep and Wakefulness*, Chicago: University of Chicago Press.
- Kreps, David M. (1979), "A Representation Theorem for 'Preference for Flexibility,'" *Econometrica*, 47 (3), 565–77.
- Kristofferson, Kirk, Brent McFerran, Andrea C. Morales, and Darren W. Dahl (2017), "The Dark Side of Scarcity Promotions: How Exposure to Limited-Quantity Promotions Can Induce Aggression," *Journal of Consumer Research*, 43 (5), 683–706.
- Levav, Jonathan and Rui Zhu (2009), "Seeking Freedom through Variety," *Journal of Consumer Research*, 36 (4), 600–10.
- Lichters, Marcel, Claudia Brunnlieb, Gideon Nave, Marko Sarstedt, and Bodo Vogt (2016), "The Influence of Serotonin Deficiency on Choice Deferral and the Compromise Effect," *Journal of Marketing Research*, 53 (2), 183–98.
- May, Cynthia P. (1999), "Synchrony Effects in Cognition: The Costs and a Benefit," *Psychonomic Bulletin & Review*, 6 (1), 142–7.



- McAlister, Leigh and Edgar Pessemier (1982), "Variety-Seeking Behavior: An Interdisciplinary Review," *Journal of Consumer Research*, 9 (3), 311–22.
- Menon, Satya and Barbara E. Kahn (1995), "The Impact of Context on Variety Seeking in Product Choices," *Journal of Consumer Research*, 22 (3), 285–95.
- Monk, Timothy H., Victoria C. Leng, Simon Folkard, and Elliot D. Weitzman (1983), "Circadian Rhythms in Subjective Alertness and Core Body Temperature," *Chronobiologia*, 10 (1), 49–55.
- Murray, Greg, Nicholas B. Allen, and John Trinder (2002), "Mood and the Circadian System: Investigation of a Circadian Component in Positive Affect," *Chronobiology International*, 19 (6), 1151–69.
- Natale, Vincenzo and Piercarla Cicogna (1996), "Circadian Regulation of Subjective Alertness in Morning and Evening Types," *Personality and Individual Differences*, 20 (4), 491–7.
- Pessemier, Edgar and Moshe Handelsman (1984), "Temporal Variety in Consumer Behavior," *Journal of Marketing Research*, 21 (4), 435–44.
- Posey, T. B. and J. A. Ford (1981), "The Morningness-Eveningness Preference of College Students as Measured by the Horne and Ostberg Questionnaire," *International Journal of Chronobiology*, 7 (3), 141–4.
- Raju, Puthankurissi S. (1980), "Optimum Stimulation Level: Its Relationship to Personality, Demographics, and Exploratory Behavior," *Journal of Consumer Research*, 7 (3), 272–82.
- Ratner, Rebecca K. and Barbara E. Kahn (2002), "The Impact of Private versus Public Consumption on Variety-Seeking Behavior," *Journal of Consumer Research*, 29 (2), 246–57.
- Ratner, Rebecca K., Barbara E. Kahn, and Daniel Kahneman (1999), "Choosing Less-Preferred Experiences for the Sake of Variety," *Journal of Consumer Research*, 26 (1), 1–15.
- Redden, Joseph P. and Stephen J. Hoch (2009), "The Presence of Variety Reduces Perceived Quantity," *Journal of Consumer Research*, 36 (3), 406–17.
- Roehm, Harper A. and Michelle L. Roehm (2004), "Variety-Seeking and Time of Day: Why Leader Brands Hope Young Adults Shop in the Afternoon, but Follower Brands Hope for Morning," *Marketing Letters*, 15 (4), 213–21.
- Schmidt, Christina, Fabienne Collette, Christian Cajochen, and Philippe Peigneux (2007), "A Time to Think: Circadian Rhythms in Human Cognition," *Cognitive Neuropsychology*, 24 (7), 755–89.
- Simonson, Itamar (1990), "The Effect of Purchase Quantity and Timing on Variety-Seeking Behavior," *Journal of Marketing Research*, 27 (2), 150–62.
- Simonson, Itamar and Russell S. Winer (1992), "The Influence of Purchase Quantity and Display Format on Consumer Preference for Variety," *Journal of Consumer Research*, 19 (1), 133–8.
- Smith, Carlla S., Christopher Reilly, and Karen Midkiff (1989), "Evaluation of Three Circadian Rhythm Questionnaires with Suggestions for an Improved Measure of Morningness," *Journal of Applied Psychology*, 74 (5), 728–38.
- Steenkamp, Jan-Benedict E. M. and Hans Baumgartner (1992), "The Role of Optimum Stimulation Level in Exploratory Consumer Behavior," *Journal of Consumer Research*, 19 (3), 434–48.
- Thayer, Robert E. (1978), "Toward a Psychological Theory of Multidimensional Activation (Arousal)," *Motivation and Emotion*, 2 (1), 1–34.
- (1989), *The Biopsychology of Mood and Arousal*, New York: Oxford University Press.
- Watson, David, Lee Anna Clark, and Auke Tellegen (1988), "Development and Validation of Brief Measures of Positive and Negative Affect: The PANAS Scales," *Journal of Personality and Social Psychology*, 54 (6), 1063–70.
- Watson, David, David Wiese, Jatin Vaidya, and Auke Tellegen (1999), "The Two General Activation Systems of Affect: Structural Findings, Evolutionary Considerations, and Psychobiological Evidence," *Journal of Personality and Social Science*, 76 (5), 820–38.
- Wilson, Glenn D. (1990), "Personality, Time of Day, and Arousal," *Personality and Individual Differences*, 11 (2), 153–68.