USING THE APPLE WATCH TO TEACH AND LEARN ABOUT HEART RATE VARIABILITY WHILE VACATIONING

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Abstract Vacations are known to contribute to well-being. Wearable sensing technologies associated with 'the quantified self' hold promise for designing experiences such as vacations based on evidence to optimize their well-being outcomes. Tourism organizations may also ask to collect data from customers to help with experience management. The present project shows the potential of heart rate variability data, measured using an Apple Watch, during vacation to produce such insights, and to do so in cooperation with students for the purpose of inspiring them to state-of-the-art research ideas in the context of tourism. Findings show that heart rate variability during vacation appears to follow a conversation-of-resources pattern, whereby days with low life satisfaction on vacation feature significant increases in heart rate variability. While students gained insights from providing these data and becoming familiar with the Apple Watch, future iterations of this project may feature students learning to work with their data themselves.

Keywords: tourism, emotions, experience, quantified self, heart rate variability.

1 Introduction

The term *the quantified self* has been used to refer to the use of personal technologies to digitize and analyze the workings of one's own body and mind (Lupton, 2016; Swan, 2013). The original impetus for exploring the quantified self was development of biosensing technologies such as smartwatches with photoplethysmogram sensors to measure heart rate and sensors which recorded temperature, location, and movement. There was hope that such data would positively inform individuals wishing to improve their own health and well-being. A part of life important to well-being is vacationing (Mitas & Kroesen, 2019). The present contribution applies this logic the use of the Apple Watch to measure six students' autumn vacation experiences, with two aims: 1) to assess the role of heart rate variability in vacation well-being outcomes, and 2) to reflect on this project as a way of teaching students about the quantified self.

Vacations, defined here as travel away from one's usual place of residence for leisure purposes of between one night and one year in duration, have demonstrable positive effects for well-being. We use a *subjective well-being* conceptualization in this paper, which means that we define well-being as a judgment an individual makes about *their own* life, and that this judgment comprises an affective dimension, operationalized as positive and negative emotions and moods, as well as a cognitive dimension, operationalized as life satisfaction (Diener & Oishi, 2005). In the short term, vacations produce boosts in positive emotions (de Bloom et al., 2010; Mitas et al., 2012); over a period of several years, vacation frequency is associated with higher life satisfaction as well (Mitas & Kroesen, 2019).

The theoretical foundation we use to examine this association comprises the broaden-and-build theory, which holds that brief experiences of positive emotion (which often occur on vacation) accumulate to personal resources, eventually contributing to well-being as a whole (Fredrickson, 2001); and conservation of resources, which alleges that workaday life drains individuals' personal resources in a way that only a respite from work—often a vacation—can allow to naturally regenerate (Hobfoll, 2011). Both theories would suggest that vacations contribute to well-being via increased positive emotions and/or decreased negative emotions. However, while broaden-and-build theory suggests this process would be running across all emotional experiences, conservation of resources theory suggests that vacation experiences would be at their most powerful when personal resources had been diminished.

Vacation experiences have occasionally been studied using the kind of mobile sensing technology that brings to mind the quantified self. For example, wristbands which measure skin conductance have been used to measure peaks of emotional arousal during city walks (Kim & Fesenmaier, 2015; Shoval et al., 2018) and theme park visits (Strijbosch et al., 2021). These measurements can demonstrate, for example, which emotional content of a tour improves an experience, and which degrades it (Mitas, Mitasova, et al., 2020). Skin conductance is an indicator of emotional arousal independent of valence, however, so it cannot indicate whether an experienced emotion peak is positive or negative (Braithwaite et al., 2015). For this purpose, heart rate variability is a more promising metric, though it is not well understood (Levenson, 2014; Ragot et al., 2017). Unlike skin conductance, which indicates sympathetic arousal in response to emotional stimuli, heart rate variability is associated with the parasympathetic down-regulation of this response. In other words, heart rate variability increases when the mind judges an emotional situation to be non-threatening and begins to return physiological responses to emotion back to baseline levels. Therefore, heart rate variability is associated with well-being over a course of days to weeks (Kok & Fredrickson, 2010).

Very few examples of heart rate variability measurement in the context of vacationing exist. Heart rate variability, alongside heart rate and skin conductance, was assessed in a sample of museum visitors in the Netherlands (Mitas, Cuenen, et al., 2020) as well as in a Spanish city walk (i Agustí et al., 2019). The assumption of these studies is that heart rate variability is associated minute-to-minute with emotional valence or, at least, negatively associated with unpleasant emotional stress. While that assumption remains untested, the validity of heart rate variability as a metric of favorable well-being on a scale of days or weeks is somewhat more widely accepted. It is unknown whether it is associated with the subjective well-being changes that occur during vacationing.

Therefore, in the present study, we used daily measurements of heart rate variability and self-reported subjective well-being before, during, and after six students' vacations during the autumn of 2022 to determine if 1) subjective well-being self-reports changed during vacation; 2) heart rate variability changed during vacation, and 3) these changes interacted.

The choice to work with students as participants was made not only based on convenience, but also served an important educational goal. After providing their data, students were debriefed on study variables and hypotheses, and challenged to generate research proposals based on wearable sensing technologies such as the Apple Watch as tools answer applied research questions in tourism experience management. Thus, by reflecting on being research participants, students were triggered to design new project ideas with practical implications based on technology that had just been used to measure their experiences.

2 Methods

In the present study, we invited six students to borrow an Apple Watch paired with an iPhone using the Apple Health application to monitor heart rate variability at three to five random, recurring 60 second daily intervals. This approach is native within the Apple Health software environment. We asked participants to use the device over a period of three weeks. The second of these weeks was the annual 'October break' during which students are free from classes and exams, and many take vacations, including camping or visiting family. Besides recording their heart rate variability, we asked the student-participants to respond to daily questionnaires measuring their positive and negative emotions, life satisfaction, and whether or not they were on vacation. To record emotions using the SPANE instrument (Diener et al., 2010), we asked participants to indicate how strongly they felt each of 8 different emotions (*happy, joyful, content, positive, positively surprised, negative, sad, angry, and afraid*) on a 5-point scale from *Not at all* to *Extremely*. This emotion list represents a slight adjustment from the original SPANE, in that general and redundant items are omitted, and positive surprise, which is important to tourism experiences, was added. Positive emotion items were averaged together into a positive emotion index, while negative emotion items were averaged together into a negative emotion index. We measured life satisfaction using the almost universal Satisfaction With Life Scale (SWLS; Diener et al., 1985), which comprises five statements such as *I am most satisfied with my life* and a 7-point Likert-type scale from *Strongly disagree* to *Strongly agree*. Instead of using the raw heart rate variability data, we asked the students to report the daily average generated by Apple Health, in order to keep the data structured at a daily level.

In line with our three research questions, we conducted three analyses in a within-persons random intercept framework. It was necessary to use random intercept models as much variation in longitudinal well-being data can be explained by within-participant autocorrelation. Thus, each data point had to be analyzed with respect to the baseline of the participant it came from. With this in mind, we first created a boxcar regressor which was coded 1 for days on vacation and otherwise 0. This was used to predict subjective well-being and heart rate variability measures. Then, we entered subjective well-being variables as predictors to the model of heart rate variability as a function of vacation. Finally, we allowed the boxcar regressor for vacationing to interact with subjective well-being variables.

3 Findings

Participants reported being slightly happy on average during the data collection period. Means of positive emotions (3.24) and life satisfaction (4.69) were just over the scale midpoints of each respective variable, while negative emotions were just below (2.26). Average daily heart rate was 71.12 beats per minute, while inter-beat intervals varied by a daily average of 59.53 miliseconds, which is how the Apple Watch measures heart rate variability (Table 1).

Table 1: Descriptive statistics

	Response scale	Mean	Proportion	Standard deviation
Positive emotions	1 - 5	3.24		0.71
Negative emotions	1 - 5	2.26		0.58
Life satisfaction	1 - 7	4.69		1.13
Heart rate		71.12		35.41
Heart rate variability		59.53		36.48
Days on vacation	0 – 100%		20%	

As expected, being on vacation improved participants' positive emotions (difference = 0.32 (0.19); p = 0.099) at a marginally significant level, while life satisfaction remained unchanged (difference = 0.04 (0.15); p = 0.781). Their negative emotions were also marginally higher (difference = 0.28 (0.16); p = 0.0743). Heart rate variability was higher on vacation, but the difference was not significant (difference = 6.025 (5.026); p = 0.2344). Day-to-day variation in heart rate variability was also unrelated to all subjective well-being variables (all p's > 0.3).

Table 2: Random intercept model coefficients

Outcome variable	Predictor(s)	Coefficient (Standard error)	Model AIC; BIC
Positive emotions	Being on vacation	**3.19 (0.19) ***	170.5; 180.1
Negative emotions	Being on vacation	**0.28 (0.16) ***	138.9; 148.4
Life satisfaction	Being on vacation	0.042 (0.153)	139.1; 148.5
Heart rate variability	Being on vacation	6.025 (5.026)	707.3; 716.8
Heart rate variability	Positive emotions	-2.687 (2.939)	707.8; 717.4
Heart rate variability	Negative emotions	2.638 (3.595)	708.1; 717.7
Heart rate variability	Life satisfaction	-3.375 (3.933)	692.8; 702.2
Heart rate variability	Positive emotions	-2.587 (3.031)	709.2; 723.5
	Being on vacation	38.806 (35.176)	
	Positive emotions X Being on vacation	-9.180 (10.031)	
Heart rate variability	Negative emotions	3.378 (3.696)	709.0; 723.3
	Being on vacation	44.243 (28.029)	
	Negative emotions X Being on vacation	-13.634 (9.723)	
Heart rate variability	Life satisfaction	-2.299 (3.842)	691.4; 705.5
	Being on vacation	**51.506 (22.686)****	
	Life satisfaction X Being on vacation	**-8.915 (4.335)****	

Note: * = p < 0.1; ** p < 0.05

Heart rate variability was also unrelated to positive and negative emotions when these were allowed to interact with the boxcar regressor representing vacation days (all p's > 0.1). However, the interaction between being on vacation and life satisfaction significantly predicted heart rate variability (coefficient = -8.915 (4.335); p = 0.0433), over and above a significant positive effect of vacation (difference = 51.505 (22.686); p = 0.0262). In other words, heart rate variability was significantly higher on vacation on days with low life satisfaction. As life satisfaction increased, the positive effect of vacation on heart rate variability decreased, and above a life satisfaction of 5.78—approximately a point higher than the mean in our sample—the sign of the vacation effect on heart rate variability is modeled to become negative (Figure 1).

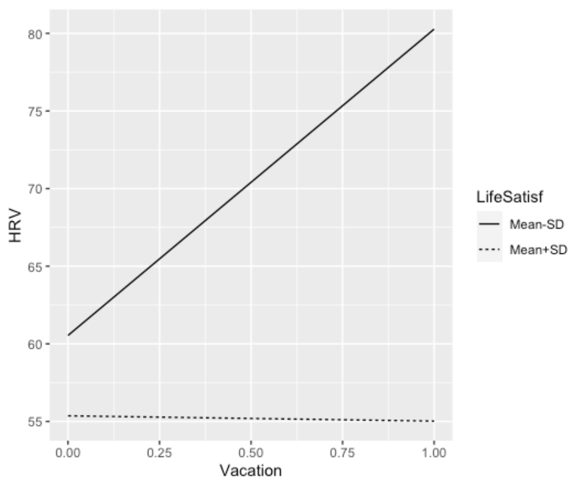

Figure 1. Simple slopes plot of relationship of vacationing (1 = vacation; 0 = at home), life satisfaction, and heart rate variability

4 Discussion

We used Apple Watches to measure six students' heart rate variability before, during, and after the autumn holiday week. We aimed to examine the effects of vacationing on heart rate variability and subjective well-being. Within-individual, between-day analyses showed that vacationing during the holiday week featured slightly improved emotions and, for days with low life satisfaction, improved heart rate variability as well. These findings have theoretical implications for understanding the effects of vacationing on well-being, as well as for teaching about the quantified self in the context of tourism.

4.1 Theoretical implications

It has been posited that vacations contribute to well-being by creating positive emotions (Mitas et al., 2012), thus building up life satisfaction over time by 'broadening and building' resources (Fredrickson, 2001; Mitas & Kroesen, 2019). The present data do not represent a time span which can demonstrate effects of positive emotion on life satisfaction, as that normally takes a number of years, but did show improvement in positive emotions. Thus, our findings are not confirmatory but consistent with this account. Other scholars have demonstrated that vacations improve occupational well-being outcomes by restoring or conserving attentional and physical resources (Fritz & Sonnentag, 2006). Our finding that life satisfaction negatively moderates the effect of vacationing on heart rate variability are accordingly consistent with conservation of resources theory (Hobfoll, 2011). On days with high life satisfaction, participants did not experience elevated heart rate variability if they were on vacation. Vacationing did raise their heart rate variability on days with low life satisfaction, however. In sum, it is possible that days with low life satisfaction were marked by physical, attentional, or emotional exhaustion. To be on vacation those days, without the demands of school, facilitated a restoration of those resources reflected by elevated heart rate variability.

4.2 Reflections on teaching

Students collected data in six groups of four students. We instructed them to consider various ways to record experiences using quantified self approaches which tourism companies can, in turn, ask their customers to share as a source of feedback and quality monitoring. Thus, within each group, only one student had the Apple Watch and reported their heart rate variability. Others recorded their location or considered their photos or social media posts as a source of potential data. As a result of working in groups, with a breadth of data sources in each group, students had a more diverse view on possibilities than if they merely heard about these research methods secondhand. While they were nominally studying tourism, wherein they considered possible implications for »marketing and advertising efforts,« »offsites or workations for employees,« or »determine how travel packages perform,« students were also able to consider applications to universities to »give better insights of work/study lifestyle« or »insights in person's life satisfaction…for people that have a lot of pressure at work.«

Nevertheless, from a teaching point of view, the present methods could be improved, namely in three ways. First, the sample size could be larger if more devices were available. This would obviously improve the sensitivity of the analyses, but would also give the students the choice to use multiple data streams, for example combining their physiological data together with their photos. Second, some of the students found the process rather unappealing, having to keep devices charged, and wearing during potentially dangerous or appearance-sensitive activities. For example, they asked if we had any other watch bands available so the watches would look better. Also, students emphasized that security of the data, and decoupling location tracking from the physioloigcal and self-response data collection, would be important for the confidentiality of the data. Third, rather than proposing research based on the data they had collected, students could be taught to inspect and visualize their own data, which would empower them to not only propose but also conduct research based on such devices once working in the travel industry.

It is widely appreciated that excellent vacation experiences contribute to well-being (Mitas et al., 2017) and that wearable sensing technologies hold promise for designing such experiences based on evidence (Bastiaansen et al., 2019). We acknowledge that the sample size of six students x 21 days is too small for a robust analysis of the examined phenomena of vacation experiences and well-being. This study should be seen as a test of data collection and modeling methodology on the way to a larger and more diverse sample which would address these questions more substantially. Despite the small sample size, the present project shows the potential of heart rate variability measurement during vacation to produce such evidence, and to do so in cooperation with students for the purpose of inspiring them to state-of-the-art research ideas in the context of tourism.

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