ARTICLE IN PRESS

Autonomic Neuroscience: Basic and Clinical xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Autonomic Neuroscience: Basic and Clinical

journal homepage: www.elsevier.com/locate/autneu

Short communication

Is intuitive eating related to resting state vagal activity?

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ARTICLE INFO

Keywords:
Intuitive eating
Vagal activity
Heart rate variability

ABSTRACT

Efferent and afferent fibers of the vagus nerve are involved in regulating hunger and satiety. Vagally-mediated heart rate variability (vmHRV) reflects vagal activity. Previously no study addressed a potential association between resting state vagal activity and intuitive eating. Self-reports on intuitive eating and measures of resting state vmHRV were obtained in 39 students (16 female, mean age: 19.64 ± 1.44 years). Hierarchical multiple regression models showed that, after controlling for gender, age, and body mass index, resting vagal activity was inversely related to the Unconditional Permission to Eat subscale of the Intuitive Eating scale. Individuals with higher resting vagal activity tend to be less willing to eat desired foods and are more likely to label certain foods as forbidden. Future studies should include measures of self-regulation and eating disorder symptomatology to identify potential mediators or moderators when attempting to replicate these preliminary findings in larger samples.

1. Introduction

The gastrointestinal tract is innervated by the vagus nerve (Berthoud, 2008), signifying its importance to eating behavior. Specifically, both vagal efferent (motor) and afferent (sensory) fibers are involved in regulating hunger and satiety. On the one hand, the activation of vagal efferents in the cephalic phase, when the anticipation of food entering the stomach prepares the body for digestion, leads to the release of ghrelin (Feldman and Richardson, 1986). On the other hand, the activation of vagal afferents subsequent to food ingestion initiates feedback processes that induce satiety and eventually encourage the termination of a meal (Berthoud, 2008).

The vagus nerve modulates heart rate variability (HRV). The heart is dually innervated by the parasympathetic and the sympathetic nervous system with the parasympathetic branch decelerating, and the sympathetic branch accelerating, heart rate. HRV is the resulting variation of the inter-beat-intervals. Vagally-mediated HRV (vmHRV) reflects parasympathetic modulation of the heart rate (Levy, 1997), and provides a non-invasive, widely-used, surrogate measure for vagal activity (Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology, 1996). Empirical data show that individuals with high vagal activity at rest tend to score higher on positive affect and well-being, whereas those with low vagal activity trend toward heightened anxiety and depressed mood (Chalmers et al., 2014; Geisler et al., 2010; Kemp and Quintana, 2013; Kemp et al., 2010).

Alterations in vagal activity at rest have been reported in individuals with eating disorders. Paradoxically, the majority of studies on individuals with anorexia nervosa have found vmHRV to be increased in comparison to healthy controls (for a review, see Mazurak et al., 2011). Similarly, individuals with bulimia nervosa also seem to be characterized by increased vmHRV (Peschel et al., 2016a; Peschel et al., 2016b).

While vagal activity has been examined among those with eating disorders, no study has examined associations between vagal activity and adaptive eating behavior.

Intuitive eating (IE) entails focusing on internal sensations of hunger and satiety rather than external (e.g., eating because food is readily available) or emotional (e.g., negative affect) cues when determining when, what, and how much to eat. Because those who eat intuitively are aware of their physiological hunger and satiety signals and regulate their eating behavior accordingly, they do not engage in dieting practices, including calorie restriction, avoiding certain foods, or eating only at particular times during the day (Tribole and Resch,

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https://doi.org/10.1016/j.autneu.2017.11.005
Received 31 May 2017; Received in revised form 14 September 2017; Accepted 14 November 2017
1566-0702/

1995).

In the present study, we examined a possible link between vagal activity and intuitive eating. Given that IE is negatively associated with eating disorder symptomatology (Tylka and Kroon Van Diest, 2013) and eating disorders are characterized by higher vagal activity, we hypothesized that IE would be inversely related to vagal activity indexed by vmHRV.

2. Materials and methods

2.1. Participants and procedures

Forty-five participants were recruited from a large Midwestern University's Psychology Research Experience Program, whereby students complete research tasks for partial course credit. We asked all participants not to smoke, undergo vigorous physical activity, or drink caffeine 6-h prior to the experiment. Six participants were excluded due to equipment failure, leaving a sample of 39 students for the final analysis.

After participants signed informed consent, measurements of height and weight were obtained to calculate body mass index (BMI; kg/m^2). Participants were subsequently seated in a quiet room without natural light and completed the Intuitive Eating Scale-2 (IES-2; Tylka and Kroon Van Diest, 2013). The experimenter left the room, but communication continued to be enabled through a dual microphone speaker. A non-recording camera allowed for additional supervision to ensure safety. After completing the IES-2, the experimenter entered the room and prepared the physiological recordings. Table 1 includes age and BMI data.

2.2. Measures

2.2.1. Resting state vagal activity

Once electrodes were in place, participants completed a 5-minute baseline-resting period, while they sat in a comfortable chair placed in a room without natural light, and viewed a blank, gray screen, and were instructed not to move or fall asleep while spontaneously breathing. Heart rate was continuously recorded with a 3-lead electrocardiogram attached to a 16-channel bioamplifier (NeXus 16). BioTrace+ software was used to collect and store physiological data. Inter-beat-intervals were exported to Kubios software (Tarvainen et al., 2014) for artifact correction and HRV analyses. The first and last minute of recordings were excluded to rule out potential effects of adaption. We calculated the root mean square of successive differences (RMSSD) as an index of resting vagal activity. As such, we report vmHRV results using RMSSD. RMSSD values were natural log transformed (ln) to fit assumptions of linear analyses (Ellis et al., 2008). Mean (3.83) and standard deviation (0.46) values for lnRMSSD in the current study are comparable to average values and standard deviations reported elsewhere (Nunan et al., 2010).

Table 1
Sample characteristics.

N (female)	39 (16)
Age, mean years (*SD*)	19.64 (1.44)
BMI[a], mean kg/m^2 (*SD*)	25.16 (5.08)
IES-2, mean (SD)	
Total	3.52 (0.44)
UPE	3.39 (0.75)
EPR	3.62 (0.74)
RHSC	3.54 (0.66)
B-FCC	3.44 (0.95)
RMSSD, mean ms log (*SD*)	3.83 (0.46)

RVT = resting state vagal activity; RMSSD = root mean square of successive differences as a proxy for resting state vagal activity (log transformed); IES-2: Intuitive Eating Scale–2; EPR: Eating for Physical Rather Than Emotional Reasons; UPE: Unconditional Permission to Eat; RHSC: Reliance on Hunger and Satiety Cues; B-FCC: Body–Food Choice Congruence.

[a] Recordings from four individuals on BMI were missing.

2.2.2. Intuitive Eating Scale

The 23-item self-report IES-2 (Tylka and Kroon Van Diest, 2013) contains four subscales: Unconditional Permission to Eat (UPE; six items, e.g., "If I am craving a certain food, I allow myself to have it"), Eating for Physical Rather Than Emotional Reasons (EPR; eight items, e.g., "When I am lonely, I do NOT turn to food for comfort"), Reliance on Hunger and Satiety Cues (RHSC; six items, e.g., "I trust my body to tell me how much to eat"), and Body-Food Choice Congruence (B-FCC; three items, e.g., "I mostly eat foods that give my body energy and stamina"). Items are rated on a 5-point scale (1 = *strongly disagree*; 5 = *strongly agree*) and averaged to generate total IES-2-score and subscale scores, with higher values indicating greater intuitive eating.

2.3. Data analysis

All statistical tests were conducted using SPSS v. 22. Hierarchical multiple regression analyses examined the relationships between lnRMSSD (resting vmHRV) as a continuous variable and IES-2 total and subscale scores controlling for age, gender, and BMI. All tests were two-tailed and analyzed using $p < 0.05$.

3. Results

Hierarchical multiple regression models showed that, after controlling for gender, age, and BMI, resting vagal activity (lnRMSSD) was inversely associated with UPE (see Table 2). No associations between resting vagal activity and IES-2 total or other subscale scores were significant. However, the positive association between resting vagal activity and the B-FCC-subscale approached statistical significance (see Table 2).

Table 2
Hierarchical regression analyses for resting state vagal activity predicting IES-2 scores controlling for age, gender, and BMI[a].

Criterion	Step	Predictor	β	*t*	R^2	ΔR^2	ΔF
IES-2: Total	1	Gender	− 0.069	− 0.397	0.005	0.005	0.157
	2	Age	− 0.084	− 0.466	0.011	0.007	0.218
	3	BMI	− 0.033	− 0.172	0.012	0.001	0.030
	4	RMSSD	− 0.240	− 1.067	0.049	0.036	1.140
IES-2: UPE	1	Gender	− 0.018	− 0.105	0.000	0.000	0.011
	2	Age	0.016	0.086	0.001	0.000	0.007
	3	BMI	− 0.147	− 0.760	0.019	0.018	0.578
	4	RMSSD	− 0.451	− 2.125	0.147	0.128	4.515*
IES-2: EPR	1	Gender	− 0.134	− 0.779	0.018	0.018	0.607
	2	Age	− 0.140	− 0.789	0.037	0.019	0.622
	3	BMI	− 0.123	− 0.647	0.050	0.013	0.418
	4	RMSSD	− 0.075	− 0.334	0.053	0.004	0.111
IES-2: RHSC	1	Gender	0.087	0.503	0.008	0.008	0.253
	2	Age	− 0.115	− 0.647	0.020	0.013	0.419
	3	BMI	0.179	0.941	0.048	0.027	0.886
	4	RMSSD	− 0.235	− 1.068	0.082	0.035	1.140
IES-2: B-FCC	1	Gender	− 0.060	− 0.346	0.004	0.004	0.120
	2	Age	0.123	0.687	0.018	0.014	0.472
	3	BMI	0.127	0.663	0.032	0.014	0.439
	4	RMSSD	0.347	1.597	0.108	0.076	2.550

Note. RMSSD = root mean square of successive differences (log transformed) as a proxy for resting state vagal activity; IES-2: Intuitive Eating Scale-2; EPR: Eating for Physical Rather Than Emotional Reasons; UPE: Unconditional Permission to Eat; RHSC: Reliance on Hunger and Satiety Cues; B-FCC: Body–Food Choice Congruence; BMI = body mass index.

[a] Recordings from four individuals on BMI were missing. $p < 0.05$.

4. Discussion

After controlling for gender, age, and BMI, a significant negative association was found between resting vagal activity and one component of intuitive eating: UPE. Thus, individuals with higher resting vagal activity tend to be less willing to eat desired foods and more likely to label certain foods as forbidden. Given the conceptual overlap between low UPE and high dietary restraint (Tylka and Wilcox, 2006), those with higher vagal activity seem to be more restraining regarding their eating behavior, meaning they aim to limit their intake of calories and unhealthy food more strongly than individuals with lower resting vagal activity. Yet, high rigid dietary restraint has been associated with *poorer* physical and psychological outcomes, such as *lower* life satisfaction, interoceptive awareness, and body appreciation and *higher* negative affect, binge eating, eating disorders, depression, food preoccupation, and adiposity/BMI (Goldfield et al., 2010; Stice et al., 2010; Tylka et al., 2015).

The finding of the present study might appear surprising because higher resting vagal activity has been found to be largely associated with adaptive processes, such as self- and emotion-regulation (Segerstrom and Nes, 2007; Thayer et al., 2009; Williams et al., 2015). However, the negative association between UPE and resting vagal activity is not necessarily paradoxical, considering that restriction of food intake, reflected by lower UPE, is also a highly self-regulatory (although unhealthy) process. Accordingly, higher resting vagal activity in individuals with lower UPE may reflect increased efforts to restrict intake of certain foods and the amount of calories. Including measures of self- and emotion-regulation in future research would allow for the examination of potential mediating or moderating effects of the link between lower UPE and higher resting vagal activity.

Unquestionably, inferences to the potential presence of eating pathologies exclusively based on the IES-2 scores cannot be drawn, since eating disorder symptoms or diagnoses were not evaluated in the present study. Notably, however, of the IES-2 subscales, UPE has the largest inverse association with eating disorder symptomatology (Tylka and Wilcox, 2006). This is of particular interest, since vagal activity is increased in individuals with eating disorders (Mazurak et al., 2011; Peschel et al., 2016b).

Nevertheless, even with the small sample size, the beta of the B-FCC subscale approached statistical significance, a trend suggesting that higher resting vagal activity may be linked to higher B-FCC, and thus should be most relevant to be tested in a larger group of participants.

Although our results should be considered preliminary, some strengths of the present study can be pointed out. First, the study applied a well-validated questionnaire to measure IE. The psychometric properties of the IES-2 have been upheld in college students (Tylka and Kroon Van Diest, 2013). Specifically, its 4-factor structure was confirmed, and its total and subscale scores were internally consistent, stable over a 3-week period and yielded evidence of construct (convergent, discriminant, and incremental) validity. Second, we investigated RMSSD which, measured in milliseconds, is considered to be a stable (Li et al., 2009) and valid (Thayer and Sternberg, 2010) time-domain measure of vmHRV. Whereas some have suggested that under certain circumstances RMSSD may reflect sympathetic influences (Berntson et al., 2005), RMSSD correlated strongly with high frequency power ($r = 0.932$, $p < 0.001$), suggesting that RMSSD is primarily vagally-mediated.

As a surrogate indicator for the activity of the vagus nerve, which plays an important role in regulating hunger and satiety (Berthoud, 2008; see Section 1), vmHRV has been previously subject to investigation in the context of eating regulation. For example, significant associations between increased vmHRV and eating restraint (Geisler et al., 2016; Young et al., 2017) as well as decreased vmHRV and disinhibited eating (Young and Watkins, 2016) have been reported. Accordingly, it can be inferred that vmHRV is a valid and suitable measure for the purposes of examining eating behavior and regulation.

The present study has several limitations. First, participants were recruited from a college population, which clearly limits the generalizability of the results. Moreover, the study did not measure eating disorder symptomatology, nor were participants asked or evaluated for a current or past eating disorder diagnosis. Including these assessments in future research could reveal whether the negative association between vagal activity and UPE holds true in populations in which individuals with eating disorders have been excluded or if our finding may be exclusively attributable to the conceptual overlap between UPE and eating disorder symptomatology.

Lastly, taking height and weight measurements, as well as asking about dietary habits, may have acted as a potential stressor for those participants who are sensitive about their body and eating behaviors. This might have affected the subsequently recorded resting vmHRV. To rule out such an effect, it may be beneficial to change the order of the study procedure in future investigations.

4.1. Conclusion

The present study's findings provide tentative evidence for higher vagal activity indexed by vmHRV as a potential marker for unfavorable eating behaviors (i.e., low UPE). Future studies should include measures of self-regulation and eating disorder symptomatology to identify potential mediators or moderators.

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