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The role of perceived negative partner behavior in daily snacking behavior: A dynamical systems approach

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ABSTRACT

Past work suggested that psychological stress, especially in the context of relationship stress, is associated with increased consumption of energy-dense food and when maintained for long periods of time, leads to adverse health consequences. Furthermore, this association is moderated by a variety of factors, including emotional over-eating style. That being said, few work utilized a dynamical system approach to understand the intra-individual and interindividual fluctuations within this process. The current study utilized a 14-day daily diary study, collected between January–March 2020, where participants reported their partner's negative relationship behavior and their own snacking behavior. A differential equation model was applied to the daily dairy data collected. Results showed that snacking behavior followed an undamped oscillator model while negative relationship behavior followed a damped coupled oscillator model. In other words, snacking behavior fluctuated around an equilibrium but was not coupled within dyadic partners. Negative relationship behavior fluctuated around an equilibrium and was amplified over time, coupled within dyadic partners. Furthermore, we found a two-fold association between negative relationship behavior and snacking: while the association between the displacement of negative relationship behavior and snacking was negative, change in negative relationship behavior and snacking were aligned. Thus, at any given time, one's snacking depends both on the amount of negative relationship behaviors one perceives and the dynamical state a dyad is engaging in (i.e., whether the negative relationship behavior is "exacerbating" or "resolving"). This former association was moderated by emotional over-eating style and the latter association was not. The current findings highlight the importance of examining dynamics within dyadic system and offers empirical and methodological insights for research in adult relationships.

1. Introduction[1]

Psychological stress has long been associated with how one eats (Chao et al., 2017; Epel et al., 2001). Under stress, people tend to eat more energy-dense food and snacks, leading to weight-related concerns and consequences (De Vriendt et al., 2009; Maunder & Hunter, 2001; Steptoe et al., 1998). Social relationships—and romantic relationships in particular—form integral parts of everyday functioning. Social Baseline Theory (SBT; Beckes & Coan, 2011) states that humans assume proximity to social others and, when this assumption fails, require higher metabolic demands to function. In line with SBT, prior work shows that interpersonal tension is associated with higher hunger and caloric intake (Jaremka et al., 2014). Rather than examining relational or interpersonal tension, other studies focus on daily life stressors (e.g., daily hassles) as a potentiator of subsequent snacking behavior (O'Connor et al., 2008; Reichenberger et al., 2018). These studies also find that emotional eating style is an important individual difference in moderating the role of daily life stress in snacking behavior.

However, very little work has examined real-world relationship dynamics as a stressful context within which snacking behavior occurs, and whether emotional eating style exacerbates these effects. In the present study, we aimed to better characterize the association between self-reported negative partner relationship behavior and snacking behavior, as measured by a 14-day daily diary study. In parallel with the

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[1] Abbreviations: DEM = Differential Equation Modeling; SBT = Social Baseline Theory; BMI = Body Mass Index.

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above literature (O'Conner et al., 2008; Reichenberger et al., 2018), we also examined emotional eating style as a moderator between these daily dynamics. It is important to note that within the relationship context and as recent theories suggest (Butler, 2011), relationships can be better understood as dynamical systems, dependent on ongoing changes between the self and the partner. Consistent with this theoretical proposition, differential equation modeling (DEM; Boker, 2001), a dynamical system approach, is a suitable model that simplifies parameter estimation through linear combinations of the individual fluctuation and moment-to-moment dyadic coordination while examining relations between two variables of interest. Thus, in the present study, we used differential equation modeling to estimate intra-individual and inter-individual fluctuations of both negative partner relationship behavior and snacking behavior, as well as the association between these two.

1.1. Why might relationship distress matter for diet?

Psychological stressors—especially social stressors related to negative social evaluation, lack of social support, and social conflict—are well-established predictors of change in weight status and eating behavior (Chao et al., 2017; Epel et al., 2001). For example, work and home-related hassles are associated with increased consumption of energy dense food (Steptoe et al., 1998), lower consumption of main meals and vegetables (O'Connor et al., 2008), and over time, adverse obesity-related health consequences (De Vriendt et al., 2009; Maunder & Hunter, 2001). In part, the effect of psychological stressors on weight status and eating has been explained via stress-related alterations to metabolic physiology. For example, inducing a state of acute social stress can perturbate both ghrelin and leptin—metabolic hormones that regulate appetite and signal energy status (Brydon et al., 2008; Chuang & Zigman, 2010; Tomiyama et al., 2012). On the other hand, stressors may also serve as potent challenges to self-regulation, leading certain individuals to resort to suboptimal strategies to cope with stressor effects. For example, the tendency to engage in emotional eating has often been linked to broader poor self-regulation strategies (Evers et al., 2010), suggesting that some people may be more vulnerable to stress-related eating dysregulation.

While the above literature provides an important framework for understanding why stressors are sometimes related to altered eating and weight status, it is less clear how these dynamics play out in the real world. For instance, many studies focus on laboratory social stress inductions, such as the Trier Social Stress Test, to examine the appetitive effects of stress. While laboratory stressors provide standardized, robust induction of physiological and psychological stress, they do not necessarily capture the real-world dynamics of social stress in daily life contexts.

In addition to measurement context considerations, diverse *kinds* of social stressors (e.g., social evaluation) that impact eating have also remained underexamined. As we enter into adulthood, romantic relationships become a critical part of our life. Simultaneously, relationship conflicts become a prime source of stress (Kiecolt-Glaser et al., 1998). Research has linked perceived relationship conflicts with lowered immune response, greater depression, loneliness (Kiecolt-Glaser et al., 1987), and all-cause mortality (Stanton et al., 2019). Moreover, marital stress predicted poor cardiovascular prognosis in women from 30 to 65 years of age including cardiac death, acute myocardial infarction, and revascularization, above and beyond work-related stress (Orth-Gomér et al., 2000), indicating a unique and distinctive role of romantic relationship quality with implications in physical and mental health. However, few studies have focused on snacking and social stress stemming from close relationships.

Social Baseline Theory (SBT; Beckes & Coan, 2011) states that human brains have been shaped by natural selection to assume proximity to other humans—their primary ecological niche or habitat. When this assumption fails, humans perceive an increased demand on their personal resources, leading to higher metabolic costs to provide rapid responses to potential threats and challenges without assistance or support. Thus, an individual experiencing higher relationship conflicts might have increased metabolic demand and promoted gluconeogenesis and energy intake, leading to increased food craving and consumption (Pickett & Gardner, 2005).

Existing research supports this claim. Jaremka et al. (2014) found that non-obese women who experienced higher interpersonal tension had higher level of ghrelin–a metabolic hormone signaling energy depletion and hunger. These women also reported a diet that was higher in calories, fat, carbohydrates, protein, sugar, sodium, and fiber, and marginally higher in cholesterol, vegetables (but not fruits), vitamin A, and vitamin C. Another study investigating the role of perceived isolation and loneliness found that lonelier women had higher postprandial ghrelin and hunger increases, but only among those with a lower Body Mass Index (Jaremka et al., 2015). Wilkinson et al. (2013) primed individuals by asking them to visualize a relationship characterized by attachment anxiety and found that after the attachment anxiety priming, participants had significantly higher consumption of cookies. Finally, O'Connor and colleagues (2008) examined the daily hassle and eating behavior relation and found that while interpersonal hassles were associated with increased consumption of fat/sugar dense food and lower consumption of main meals, physical stress was associated with decreased snacking. As such, interpersonal stress might have differential consequences compared to other types of stress.

These data together support the idea that psychological stress—and stress related to social relationships in particular—is linked to higher metabolic needs such that interpersonal tension/hassles, loneliness, and anxiety are associated with increased levels of hunger-relevant hormones, appetite, and food consumption. However, the number of studies testing this association remains limited, with past work primarily examining a snapshot of relationship tension via self-report questionnaires. Questionnaire measures may otherwise fall prey to retrospective memory biases and summative reporting, rather than reflecting discrete day-to-day dynamics. More research is needed to examine close relationship stress through daily diary or ecological momentary assessment approaches, to capture the effects of finer-grained fluctuations in social stress on eating behavior.

1.2. Moderators of relationship stress-snacking behavior

One potential moderator of particular interest to the present study is emotional over-eating (O'Connor et al., 2008). Emotional over-eating, characterized as a central trait of adult eating behavior, refers to a general propensity to overeat when anxious or emotionally aroused (Conner et al., 1999). Wilkinson et al. (2013) suggested that emotional over-eating can be viewed from the perspective of affect and emotion regulation: when internal emotion regulation strategies become inaccessible to individuals under distress, some individuals resort to external sources such as food for soothing, comfort, or distraction (Maunder & Hunter, 2001). Here, stress is assumed to potentiate eating in emotional over-eaters (Kaplan & Kaplan, 1957) but to not alter eating in those with healthy emotion regulation strategies. Indeed, O'Connor and colleagues (2008) found that although potential moderators such as restrained eating, emotional eating, external eating, and disinhibition separately influenced the overall daily hassles-snacking relation, when examining them simultaneously via multilevel approaches, emotional over-eating emerged as the pre-eminent moderating variable beyond the rest.

Stress-related eating behavior manifests in several forms, but one common form is snacking. Stress has been similarly associated with increased snack intake, especially higher consumption of high fat and sweet snacks (Epel et al., 2001; O'Connor et al., 2008), possibly via glucocorticoids (Laugero, 2001; Tataranni et al., 1996) that protect cells against the hypophagic effects of leptin (Zakrzewska et al., 1997). Previous research suggests that snack intake may be more susceptible to change with stress compared to meal intake (Conner et al., 1999;

Crowther et al., 2001; O'Connor & O'Connor, 2004). As such, the present study similarly aims to examine the impact of emotional over-eating as a moderator between the relationship stress-snacking association. As a novel contribution, the present study will use a daily diary design to allow the modeling of daily within-person fluctuations and between-person coordination, together with the influence of emotional over-eating as a moderator. This combined approach provides a more ecologically valid and methodologically accurate assessment of the association between relationship stress, snacking, and its moderator.

1.3. Overview and hypotheses

For the present study, we applied coupled differential equation modeling (DEM), a dynamical system approach, to the daily diary data capturing couples' reports of their own snacking behavior and their partners' negative relationship behaviors. DEM has been applied to research in psychology to study subjects of dyadic interactions including affective processes (Steele & Ferrer, 2011), physiological synchrony (Ferrer & Helm, 2013), marriage intimacy and disclosures (Boker & Laurenceau, 2006), emotional interactions, conflicts, and prediction of break-ups (Gottman & Levenson, 2002), and affect coregulation between romantic partners (Ferrer & Steele, 2012). For transparency, we next briefly describe our analytical approach in mathematical detail.

The mathematical form of *a second order coupled DEM* can be expressed as:

$$\ddot{x} = \eta_{ix}x_{ij} + \zeta_{ix}\,\dot{x_{ij}} + \gamma_{xi}\left(\eta_{iy}y_{ij} + \zeta_{iy}\,\dot{y_{ij}}\right) + e_{ij}$$

$$\ddot{y} = \eta_{iy}y_{ij} + \zeta_{iy}\,\dot{y_{ij}} + \gamma_{yi}\,\left(\eta_{ix}x_{ij} + \zeta_{ix}\,\dot{x_{ij}}\right) + f_{ij}$$

where x and y represent the person and the partner's scores. A second order coupled DEM captures linear, nonlinear, and coupling changes within dyadic partners, in terms of three parameters: the η frequency, ζ damping, and γ coupling parameters. First, η frequency and ζ damping together represent the linear and nonlinear changes (Hu et al., 2014). When η is below zero, the system is oscillating and oscillates back to the equilibrium; when η is above zero, the system accelerates away from the equilibrium and thus no oscillation occurs. On the other hand, the damping parameter ζ describes the amplitude of the oscillation, and dependent on whether ζ is below or above zero, the oscillation is damped or amplified with increases in time. For instance, a common DEM model–damped linear oscillator (DLO) in psychological affective research utilizes a negative η frequency parameter and negative ζ parameter, representing a time series oscillating around an "individual average" (i.e., equilibrium) but damped or fading away over time (Steele & Ferrer, 2011).

Additionally, γ represents the coupling parameter, where dependent on whether γ is below or above zero, the parameters are aligned or inversely coordinated within dyadic couples. Although common methods used in dyadic data (e.g., multilevel modeling) consider the coupling parameter, traditional methods often treat each observation as independent in time and thus, do not reflect fluctuations or patterns of change. For easier interpretation, below we describe the dynamical system in terms of individual fluctuation (η frequency and ζ damping) and dyadic coordination (γ parameter). Further details of the current DEM approach can be found in Supplementary Materials.

The present work aimed to understand the daily intra-individual and inter-individual fluctuations of perceived negative partner relationship behavior and snacking behavior. We selected perceived negative partner relationship behavior as our measure of relational stress given that past research has indicated that perceived negative partner relationship behavior is associated with poorer relationship quality and daily relationship satisfaction (Finkenauer et al., 2010; Reis et al., 2014). More importantly, we aimed to investigate how perceived negative partner behavior might predict snacking behavior on a given day. Additionally, we explored whether emotional over-eating style moderates this association. This is both theoretically and practically valuable as relationship behavior and snacking behavior are indicative of subjective well-being, with implications for public health (Maunder & Hunter, 2001). The present research was preregistered on the Open Science Framework at (https://osf.io/tvrh5/).

Hypotheses (H)[2]

H1a. Considering research on the intrinsic, homeostatic regulation of physiological cues such as hunger (Yildiz et al., 2004) and affective (Mikulincer et al., 2003) states**,** we predicted non-linear oscillation (i.e., a second order DEM model) reflected in each partner's snacking behavior from day to day (cf. Ferrer & Helm, 2013)**. H1b**. We also predicted non-linear oscillation (i.e., a second-order DEM model) in each participant's perceived negative partner behavior from day to day (cf. Butler, 2011**)**. In other words, and in both cases, we predicted significant η (i.e., frequency) and ζ (i.e., damping) parameters in both models.

H2a. Considering research demonstrating social facilitatory effect of eating (Ruddock et al., 2021), we predicted the level of snacking behavior from one partner should be coupled with the dynamics of snacking in the other partner. **H2b**. Similarly, considering research on a co-regulatory account between romantic partners (Sbarra & Hazan, 2008), we predicted that the dynamics of perceived negative partner behavior from one partner should be coupled with that of the other partner (cf. Boker & Laurenceau, 2006). In other words, and in both cases, we predicted a significant coupling parameter γ (cf. Ferrer & Helm, 2013).

H3. Then, we predicted that there would be a relation between perceived negative partner behavior and snacking behavior such that higher levels of perceived negative partner behavior would be associated with higher level of snacking behavior (cf. Beckes & Coan, 2011; Jaremka et al., 2014).

H4. Lastly, we predicted that the positive association between perceived negative partner behavior and snacking behavior would be moderated by participants' emotional over-eating style such that this association between perceived negative partner behavior and an individual's snacking behavior would be strengthened amongst people with an emotional over-eating style (cf., Debeuf et al., 2018; O'Connor et al., 2008).

2. Method

2.1. Participants

Participants were 100 couples (87 heterosexual, 9 lesbian, 1 gay, 3 other non-binary) recruited via social media, leaflet, and magazine advertising around a large city and a local university area in the UK. Participants were fluent English-speaking adults of at least 18 years of age who were involved in a romantic relationship for a minimum of three months. An *a priori* power analysis using the APIMPowerR ShinyApp (Ackerman & Kenny, 2016) suggested 100 couples would be sufficient to detect cross-sectional effects (power = 0.84, α = 0.05). Participants were between 18 and 64 years old (M_{years} = 24.15, SD_{years} = 6.61) and were mostly White (85.5%). Relationship length varied from 3 months to 35.5 years (M_{years} = 2.84, SD_{years} = 4.41), wherein participants were either casually or exclusively dating their current

[2] We note that in the pre-registration document, the second order model is described in terms of attractor and equilibrium. The hypotheses in the pre-registration and the current article remain the same but reflect differing ways of describing the model. The frequency and damping parameters describe the shape of the attractor that revolves around the equilibrium. There has been a change in the wording of how the model is described since pre-registration for the purpose of clarity. Hypotheses however remained unchanged.

partner (85.5%) or were common-law, engaged, in a civil partnership, or married (14.5%). When testing Hypotheses 1-4, one couple was excluded due to low response rate (3.57%) on the negative relationship and snacking behavior measures. One additional couple was excluded when testing Hypothesis 4 due to failure completing the Adult Eating Behavior Questionnaire. Participants provided written consent and the study was conducted in compliance with the PPLS Research Ethics Committee (protocol reference: #15–1920/3) at the University of Edinburgh.

2.2. Procedure

We conducted secondary analysis of an existing larger parent dataset, Diverse Romantic Relationships and Well-Being I (DRRAW I; https://osf.io/ekv6x/), which investigated the experiences of romantic couples in a 2-h lab session (Phase 1), a 14-day diary period (Phase 2), and a follow-up questionnaire two months later (Phase 3). Data from Phases 1 and 2 were collected between January–March 2020 with data from Phase 3 collected between April–May 2020.

The present project focused on data collected from Phase 1 and Phase 2 to address our research questions of interest. In Phase 1, romantic partners participated in a 2-h laboratory session in which they reported gender, age, height and weight in their preferred metrics, and completed the Adult Eating Behavior Questionnaire. Body Mass Index (BMI) was calculated using one of two formulae depending on the metrics of choice: weight (lb)/[height (in)]^2 × 703 or weight (kg)/[height(m)]^2. In Phase 2, romantic partners completed a 15-min questionnaire online each day for 14 consecutive days that included questions about their partner's relationship behavior and their own snacking behavior. Each survey was sent at 4:00 PM each day and participants had until 11:59 PM that day to complete. Each survey included a timestamped link that expired on the day to ensure same-day survey completion. Partners were directed to complete tasks separately from one another. Participants were compensated up to GBP £50.00 each depending on how many segments of the study they completed. The overall completion rate was 93.1% for the snacking behavior measure and 92.6% for the negative relationship behavior measure.

2.3. Measures

Negative Relationship Behavior (Perceptions of Partner): Participants reported their perceptions of their partners' daily negative relationship behavior using 12 items adapted from prior studies (Finkenauer et al., 2010; Gable et al., 2003; Reis et al., 2014; e.g., "in the past 24 h, my partner said or did something that irritated me"). Participants were asked to rate the strength of each on a 5-point scale ranging from "not at all" to "very much." The composite score was indexed as perceived negative partner behavior for the individual on a given day ($M = 2.60$, $SD = 4.39$). We used a multilevel confirmatory factor analysis (MCFA) to estimate the reliability of this scale, and results revealed good reliability for both within-level ($\omega = 0.83$) and between-level ($\omega = 0.76$).

Snacking Behavior: This daily diary questionnaire asked participants to indicate if they had any of the following food or drink as a snack in between meals in the past 24 h. A snack included sweets, salty or savory snacks, fast food, sugary drinks, fruit or vegetables, nuts or seeds, non-sweet dairy, and cereal or granola. Notably, the original parent study focused on the number of snacks consumed and did not collect information regarding specific snacks consumed (e.g., pretzels vs. crisps). As such, we were not able to identify snack ingredients and their macronutrients, thus limiting the possibility of assessing the role of snack type. Instead, we opted to sum the amount of snack (regardless of types) consumed to reflect daily snack consumption. Specifically, the number of snacks consumed each day was summed ($M = 1.60$, $SD = 1.22$).

Adult Eating Behavior Questionnaire: The AEBQ (Hunot et al., 2016) consists of 35 items measured using a 5-point Likert scale (1 = "strongly disagree"; 5 = "strongly agree"). The AEBQ contains eight subscales. The subscale of interest, *Emotional Over-Eating*, consists of five items (e.g., "I eat more when I'm anxious"; $\alpha = 0.87$). To create an emotional eating style score, we took the average across all five items of this subscale, with higher scores reflecting higher emotional over-eating style ($M = 2.64$, $SD = 0.97$).

2.4. Analysis plan

Data were analyzed using R, version 4.0.2 (R Core Team, 2021) and the package OpenMx (Neale et al., 2016). We tested individual fluctuation and dyadic coordinating effects of perceived negative partner behavior and snacking behavior using DEM. We estimated differential equations in a structural equation modeling framework, that is, latent differential equation (Boker & Laurenceau, 2006). First, to account for individual differences in equilibrium values, we fit a slope and intercept model to each person's time series and save the residuals from the predicted slope and intercept as input to the differential equation analysis. Then, time-delay embedding was used to allow the estimation of coefficients of differential equation models by creating a dataset with multiple occasions of measurement on any one individual. We tried a range of values and found the when the time-delay embedding equals 5, the estimated η is stable and the model is optimal (i.e., the parameter is not too small that high frequency noise reduces the reliability of the signal, and it is not too large that the signals are smoothed over). Next, two coupled DEM models were fit respectively to estimate the individual fluctuation and dyadic coordinating process of the snacking behavior and perceived negative partner behavior.

The derivatives were treated as latent variables, through which the relationship between the variable and derivatives (η and ζ), and the coupling parameter γ were estimated (see Fig. 1). Additionally, we entered snacking behavior as ordinal outcomes of the coupled DEM model fitted to the perceived negative partner behavior to test the association between the displacement (*X* and *Y*) and the snacking behavior, as well as the association between the changes in displacement ($\dot{x}$ and $\dot{y}$) and the snacking behavior (see Fig. 2). These models adjusted for gender (coded as 1 = men, 0 = women), age, and self-reported body mass index (BMI), all reported at Phase 1, due to their established effects on metabolic hormones related to eating behavior in past literature (Jaremka et al., 2015; see review in MacCormack & Muscatell, 2019). Finally, emotional over-eating style was tested in a separate model as a moderator between the association of negative partner behavior and snacking behavior. Missing values were handled using full information maximum likelihood estimation (6.85% missing data in Daily Snacking Behavior; 7.36% missing data in Negative Relationship Behavior).

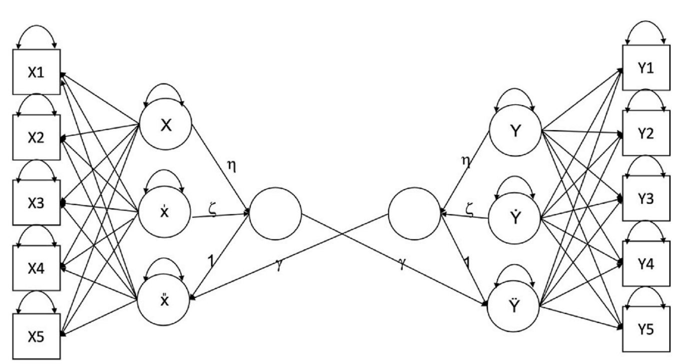

Fig. 1. Coupled differential equation models (coupled DEM) where x and y represent the person and the partner's scores of negative partner behavior and snacking. η, ζ, and γ were estimated as the regression coefficient of the displacement on second derivative, the regression coefficient of the first derivative on second derivative, and the coupling parameter. The graph models a proportionally coupled DEM where η, ζ, and γ were symmetrical within pair.

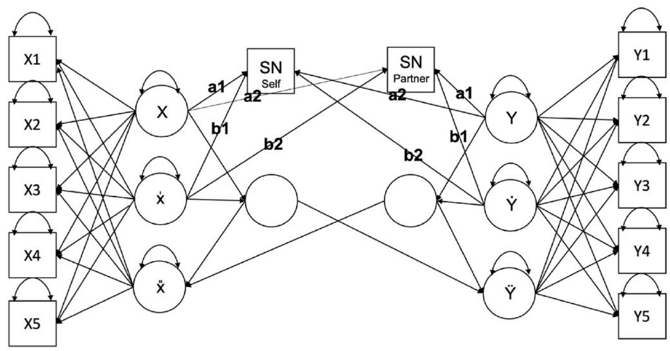

Fig. 2. To estimate the relationship between negative partner behavior and snacking behavior, snacking behavior of the person (SN Self) and the partner (SN Partner) were entered as ordinal outcomes of a coupled differential equation where x and y represent the person and the partner's scores of negative partner behavior. a1 and a2 were estimated as the regression coefficients of the displacement of negative partner behavior perceived by the self on snacking of the self and the partner. b1 and b2 were estimated as the regression coefficients of the first derivative of negative partner behavior perceived by the self on snacking of the self and the partner. The parameter estimates were again symmetrical within pair.

3. Results

3.1. Hypothesis 1 and 2: Is there intra-individual and inter-individual dynamics in perceived negative partner behavior and snacking behavior?

First, we fitted models where values of parameter estimates η, ζ, and γ were set to be free between partners in a pair. Then, we fitted models where values of the parameter estimates were set to be identical across pairs. As the two models fitted similarly (snacking behavior: $\Delta\chi\ (3)^2 = 2.460$, $p = 0.483$; negative partner behavior: $\Delta\chi\ (3)^2 = 0.072$, $p = 0.995$) and we have no hypothesis regarding differentiating processes within pair, for easier interpretation purposes, we used the models where the parameter estimates η and ζ, and the coupling parameter γ from one participant were set to be the same as their partners'.

Fitting a coupled DEM model to predict the snacking behavior, we found significant oscillation of individual snacking behavior ($\eta = -0.896$, $SE = 0.061$, $\Delta\chi\ (1)^2 = 37.473$, $p < 0.001$): individual snacking revolved around an equilibrium ("individual average")–the further away the individual's snack consumption deviates from the equilibrium (i.e., "individual average"), the faster their snacking behavior returned to the equilibrium and vice versa. The damping parameter ζ was not significant ($\zeta = 0.130$, $SE = 0.073$, $\Delta\chi\ (1)^2 = 3.215$, $p = 0.073$) and, thus, we conclude that within the current sample, there was an oscillating process of individual snacking behavior such that their snacking ebbed and flowed around an individual "average" over time, perhaps consistent with an energy regulation model of appetite. Examining the coupling effect between partners, the coupling parameter estimate $\gamma = 0.084$ ($SE = 0.051$, $\Delta\chi\ (1)^2 = 2.859$, $p = 0.091$) was not significant, suggesting that within the current sample, the snacking behavior of one participant did not affect that of their partner. After adjusting for age, gender, and BMI, the effects remained ($\eta = -0.906$, $SE = 0.061$, $\Delta\chi\ (1)^2 = 38.130$, $p < 0.001$; $\zeta = 0.123$, $SE = 0.071$, $\Delta\chi\ (1)^2 = 3.037$, $p = 0.081$; $\gamma = 0.083$, $SE = 0.050$, $\Delta\chi\ (1)^2 = 2.854$, $p = 0.091$; Fig. 3A).

Fitting a coupled second-order DEM model to predict the negative partner behavior, we found significant oscillation of individual negative relationship behavior ($\eta = -0.578$, $SE = 0.024$, $\Delta\chi\ (1)^2 = 146.471$, $p < 0.001$): the perceived negative relationship behavior revolved around the equilibrium (i.e., "individual average")–the further away the negative relationship behavior deviates from the equilibrium, the faster they returned back to the equilibrium and vice versa. The damping parameter ζ was positive and significant ($\zeta = 0.179$, $SE = 0.038$, $\Delta\chi\ (1)^2 = 23.553$, $p < 0.001$) and thus, we conclude that within the current sample, there was an amplified oscillating effect of negative relationship behavior such that the amount of negative relationship behavior perceived by individuals within romantic dyadic couples ebbed and flowed around an "individual average" and over time, we also observed a general amplification of the negative relationship behavior within romantic dyads. When examining the coupling effect between the participant and partner, the coupling parameter estimate $\gamma = -0.372$ ($SE = 0.058$, $\Delta\chi\ (1)^2 = 64.535$, $p < 0.001$) was significant. The negative γ indicated that negative partner relationship behavior within a pair were negatively coupled with each other such that higher level of negative relationship behavior from one individual was associated with lower negative relationship behavior from their partner. After adjusting for age, gender, and BMI, the effects remained ($\eta = -0.638$, $SE = 0.029$, $\Delta\chi\ (1)^2 = 91.869$, $p < 0.001$; $\zeta = 0.201$, $SE = 0.038$, $\Delta\chi\ (1)^2 = 28.792$, $p < 0.001$; $\gamma = -0.270$, $SE = 0.056$, $\Delta\chi\ (1)^2 = 29.819$, $p < 0.001$; Fig. 3B).

3.2. Hypothesis 3: Does higher (i.e., displacement and changes in displacement of) negative partner behavior associate with more snacking behavior?

Snacking behavior was entered as time-varying covariates, aligned with time-embedded negative partner behavior and as ordinal outcomes of the coupled DEM fitting the negative partner behavior. First, we examined the total number of snacks consumed as the ordinal outcome. Because of the wide range of values in the current sample (ranging from 0 to 8), when we converted the snacking behavior from numeric to ordinal outcomes, we examined the distribution of total consumption of snacks per day per individual. Individuals consuming no snacks (16.79%), one snack (37.55%), two snacks (25.60%), or three snacks (13.75%) took up the majority (93.70%) of the sample. Thus,

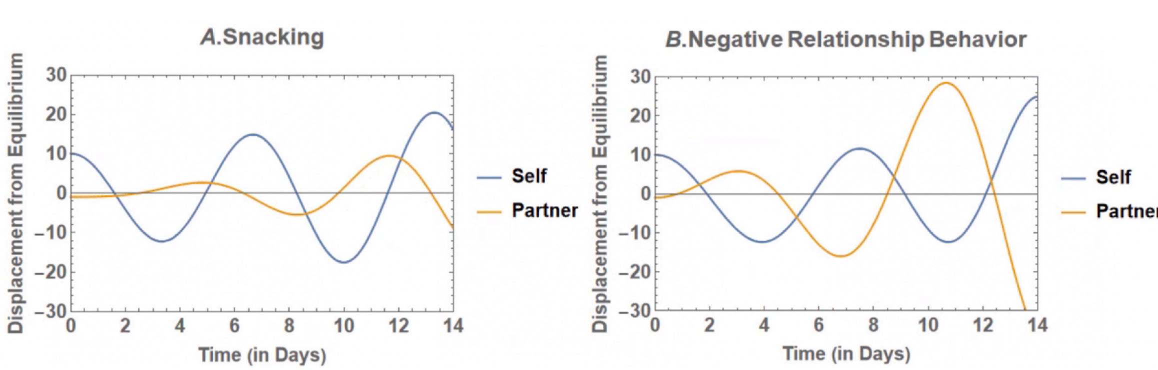

Fig. 3. Simulated graphs using Mathematica v13.1, based on parameters estimated from coupled DEM. Fig. 3A simulated the association between time (in days) and displacement from equilibrium of snacking behavior within the person and partner; Fig. 3B simulated the association between time (in days) and displacement from equilibrium of negative partner relationship behavior perceived by the person and the partner.

considering the general distribution and optimal levels of thresholds entered into the model, individuals consuming three snacks or above were recoded as the same category. The new ordinal snacking variable thus contained four levels ranging from 0 to 3.

We examined both the displacement and changes in displacement of perceived negative partner behavior and their association with snacking behavior in the same model. We observed a negative association between the displacement of individuals' perceived negative partner behavior and snacking behavior of the self (parameter estimate = −0.113, SE = 0.040, $\Delta\chi\ (1)^2$ = 8.719, p = 0.003) and the partner (parameter estimate = −0.112, SE = 0.040, $\Delta\chi\ (1)^2$ = 8.544, p = 0.003). Thus, the displacement from equilibrium of negative partner behavior was negatively associated with self and partner snacking behavior such that for individuals who perceived more negative partner behavior deviating from the equilibrium, both they and their partner consumed significantly fewer snacks in general overall.

However, this displacement from equilibrium only reflects overall deviation from equilibrium, without characterizing the *dynamical change* in behaviors. As such, after accounting for the average level of negative relationship behaviors, we observed a positive relation between the dynamics (i.e., changes in displacement) of individuals' perceived negative partner behavior and snacking behavior both for the self (parameter estimate = 0.128, SE = 0.053, $\Delta\chi\ (1)^2$ = 5.949, p = 0.015) and the partner (parameter estimate = 0.117, SE = 0.053, $\Delta\chi\ (1)^2$ = 5.046, p = 0.025). In other words, general amplifications of perceived negative partner behavior were associated with increases in self and partner snacking; similarly, damped negative partner behavior were associated with decreases in self and partner snacking. As such, the most snacking occurred when negative partner behavior was in an initial state lower than equilibrium but was starting to increase—perhaps indicative of a moment of relational conflict wherein negative partner behavior began to escalate. On the other hand, the least snacking occurred when the negative partner behavior was in an initial state higher than equilibrium but was starting to decrease—perhaps indicative of a moment of relational resolution wherein negative partner behavior began to fall back towards equilibrium. The effects remained significant after adjusting for age, gender, and BMI (self: displacement: parameter estimate = −0.156, SE = 0.052, $\Delta\chi\ (1)^2$ = 11.082, p < 0.001; changes: parameter estimate = 0.121, SE = 0.054, $\Delta\chi\ (1)^2$ = 5.155, p = 0.023; partner: displacement: parameter estimate = −0.148, SE = 0.051, $\Delta\chi\ (1)^2$ = 9.837, p = 0.002; changes: parameter estimate = 0.105, SE = 0.054, $\Delta\chi\ (1)^2$ = 3.874, p = 0.049).

3.3. Hypothesis 4: Does emotional over-eating style moderate the relationship between negative partner behavior and snacking behavior?

Emotional over-eating style score was centered and entered as a moderator of the previous model. Adjusting for age, gender, and BMI, we observed a significant moderation effect of emotional over-eating between the displacement from equilibrium ("individual average") of negative partner behavior and snacking behavior of the self (parameter estimate = −0.092, SE = 0.043, $\Delta\chi\ (1)^2$ = 4.749, p = 0.029), and the partner (parameter estimate = −0.090, SE = 0.042, $\Delta\chi\ (1)^2$ = 4.654, p = 0.031). On the other hand, we did not observe the same moderation effect within the association between the dynamics or changes in displacement of negative partner behavior and snacking behavior of the self (parameter estimate = −0.019, SE = 0.060, $\Delta\chi\ (1)^2$ = 0.102, p = 0.750), and the partner (parameter estimate = 0.034, SE = 0.058, $\Delta\chi\ (1)^2$ = 1.385, p = 0.239). These findings suggested when considering gender, age, and BMI, individuals who perceived higher negative partner behavior than the equilibrium value (i.e., "individual average") still consumed fewer snacks, but this effect was less negative for those who endorsed an emotional over-eating style. In other words, individuals who endorsed an emotional over-eating style ate more snacks in general relative to non-emotional eaters when perceiving higher negative partner behavior. Nevertheless, this moderation only occurred for the deviation from equilibrium effects but were not observed when examining the dynamics or changes in displacement between associated negative partner behavior and snacking behavior.

It's worth noting that with the moderation path added, we still observed a significant negative relation between the displacement from equilibrium of individuals' perceived negative partner behavior and snacking behavior of the self (parameter estimate = −0.100, SE = 0.039, $\Delta\chi\ (1)^2$ = 6.827, p = 0.009) and the partner (parameter estimate = −0.102, SE = 0.040, $\Delta\chi\ (1)^2$ = 6.866, p = 0.009). The significant negative parameter suggested that for individuals who perceived more negative partner behavior from the equilibrium (i.e., "individual average"), that same individual and their partner consumed fewer snacks in general overall, even after considering their emotional over-eating style. Similarly, with the moderation path added, we still observed a positive association between the dynamics (i.e., changes in displacement) of individuals' perceived negative partner behavior and snacking behavior of the self (parameter estimate = 0.124, SE = 0.053, $\Delta\chi\ (1)^2$ = 5.530, p = 0.019) and the partner (parameter estimate = 0.115, SE = 0.054, $\Delta\chi\ (1)^2$ = 4.581, p = 0.032). The findings suggested that changes in individual perceived negative partner behavior were still positively associated with changes in self and partner snacking behavior, even after considering the effect of emotional over-eating style. These effects remained significant after adjusting for age, gender, and BMI (self: displacement: parameter estimate = −0.134, SE = 0.052, $\Delta\chi\ (1)^2$ = 7.371, p = 0.007; changes: parameter estimate = 0.119, SE = 0.054, $\Delta\chi\ (1)^2$ = 4.842, p = 0.028; partner: displacement: parameter estimate = −0.116, SE = 0.052, $\Delta\chi\ (1)^2$ = 5.394, p = 0.020; changes: parameter estimate = 0.108, SE = 0.055, $\Delta\chi\ (1)^2$ = 4.006, p = 0.045).

4. Discussion

The present study applied a dynamical system approach to examine the daily fluctuations of negative relationship behavior and snacking behavior. We found that differential equation models helped account for a dynamical process between negative relationship behavior and snacking behavior. Furthermore, the association between these two depended on the components of the dynamical system examined.

First, our findings suggest that via a dynamical process, the self and partner snacking behavior likely reflected oscillating model with a significant negative frequency parameter. We did not observe damping changes or coupling effect between self-snacking and partner snacking behavior. In other words, individual snacking behavior revolved around an equilibrium (i.e., increased and decreased around an individual "average"), perhaps indicative of energy balance processes regulating appetite within individuals. However, we did not observe social facilitation effects of snacking behavior, at least insofar as snacking was not coordinated within romantic dyads.

Our study is among the first to investigate the dynamics of snacking behaviors involving linear and nonlinear changes. Although to our knowledge no study has directly examined the individual fluctuation and dyadic coordination process of snacking behavior using a dynamical system approach, existing studies observed fluctuations in snacking behaviors based on hunger cues (Chapelot, 2011), location (Marshall & Bell, 2003), social environment (Verhoeven et al., 2015), presence of distraction (Robinson et al., 2013), and rewarding properties of the food (Franken & Muris, 2005). Over the span of a day, Chapelot (2011) found that snackers adjusted the timing and size of their meals, following consumption of snacks, suggesting inherent regulatory process related to eating in general. Studies using leptin and ghrelin—metabolic hormones signaling satiety and hunger respectively—have indicated orderly fluctuations for both hormones in a 24-h cycle (Yildiz et al., 2004), and ghrelin levels tend to steadily increase with time during fasting (Solomon et al., 2008). Thus, it is reasonable to speculate that fluctuations in high frequency meals (e.g., snacking) would act accordingly to fluctuations in metabolic hormones as well. Indeed, our findings confirmed this idea: we found evidence of an oscillating model indicative of an intrinsic process within a dynamic system such that snacking behavior increased and decreased–fluctuated around an individual average over time. This finding has significance in understanding the pattern of snacking behaviors over time. Although previous research found no evidence of a biological cue prompting a desire to snack (Chapelot, 2011), our findings indicated that across location, timing, and social influence, we still observed something intrinsic that draws individuals to snack around an assumed equilibrium (i.e., "average"), suggesting that snacking might ultimately be tied to energy balance in appetite regulation. Future research could measure similar fluctuations in metabolic hormones and associations with relationship-related distress to explore the physiological process.

Previous research established social facilitation as a phenomenon within animals (Hsia & Wood-Gush, 1984) and humans: when paired with someone who eats a large amount of food, participants also increased their own snack intake; on the other hand, when paired with someone who eats no food, participants decreased snack intake (Conger et al., 1980). Although in the current study, we failed to observe significant dyadic coordination of snacking behaviors within partners, individual differences might exist in the process. For instance, Mori et al. (1987) found that when female participants were accompanied by a desirable companion, their food consumption decreased significantly. Similarly, Ruddock et al. (2019) found that social facilitation of eating is moderated by familiarity between eaters. As such, the lack of significant dyadic coordination of snacking in our study can be explained by a mix of factors including gender, familiarity, and desirability of companion that potentially moderate the social facilitatory effect of snacking. Furthermore, the current dataset used a 14-day daily diary design, spanning across weekdays and weekends, which allowed us to capture couples across a diversity of daily rhythms (e.g., workdays, off days); but we did not measure the amount of time couples spent together each day. As such, we cannot properly quantify the extent to which a facilitatory effect of social meal eating and social snacking might have occurred. To address this, future research could incorporate questions related to shared meals and snacks with social others (e.g., partner, friends, family, coworkers) in addition to the snack intake, which could then shed further insights on the power of social facilitation on eating and snacking dynamics.

Similar to snacking behavior, perceptions of partner negative relationship behavior fluctuated around an equilibrium; and furthermore, as the negative relationship behavior oscillated, the amplitude of the oscillation amplified over time, forming an amplified oscillator model. When individuals initially perceived more negative relationship behavior from their partner, this perceived behavior gradually decreased over time towards an individual average value, perhaps indicative of successful conflict resolution or "moving on" from negative relational events. However, if individuals initially perceived less negative relationship behavior from their partner (i.e., viewed their partner in a more positive light), then when perceived negative partner behavior inevitably increased—this perturbation became more extreme or exacerbated over time, such that perceived negative partner behaviors became more extreme or farther away from equilibrium, prolonging the time it would take for those perceptions to return to equilibrium. This may suggest that during conditions of relational conflict or stress, individuals go through a period of intensifying negative perceptions of their partners' behaviors which may be "sticky," taking longer to reach a point of resolution. Interestingly, negative partner behavior for the self and the partner were negatively coupled, meaning that partners were not aligned in their interpretations of self and other negative relationship behaviors. When an individual perceived high levels of negative relationship behavior from their partner, their partner was at that time perceiving themselves as enacting lower levels of negative relationship behavior and vice versa.

Our findings are consistent with the extant relationship literature that applied a similar approach. For example, Boker and Laurenceau (2006) found an undamped oscillator model of husbands' and wives' intimacy and disclosure trajectories and some degrees of mutual dependency between husbands' and wives' scores. Self- and co-regulation processes measured via physiological data (e.g., heart rate and respiratory data, Ferrer & Helm, 2013; autonomic physiological data, Zee & Bolger, 2022) found a damped oscillator model fit the dynamic process of both partners, as well as cross-partner coupling effects to different extents that varied by gender. According to the Temporal Interpersonal Emotion System model (TIES), components of a relationship should be viewed as a dynamical system through which one's current states act as functions of their past states and that of their partner (Butler, 2011). The significant dynamics and coupling parameters found in the model are consistent with the TIES model. Relationship behavior are outcomes of an interpersonal process where the experience of one partner is dependent upon that of the other partner, the timing of the exchange, and perceived responsiveness of the system–all contributing to a trajectory that is unlikely to remain at a static phase. If an individual perceives more negative behavior from their partner, they may actively engage in tactics to resolve the conflicts to allow the individual fluctuation to come down towards an individual average (Karney & Bradbury, 1997). Furthermore, the current study found amplifications in negative partner behavior over time and negative coupling between the self and the partner. The factors (e.g., personality traits, communication style) through which individuals differ by their response patterns remain unexplored.

Most importantly, we found an association between daily snacking behavior and negative relationship behavior as well as a two-fold association using different components of the modeled dynamical system. The first part of the association was that displacement from the equilibrium ("individual average") of negative partner behavior was negatively associated with self and partner snacking behavior. In other words, when individuals were perceiving higher than average negative partner behavior, they tended to consume fewer than average snacks overall. Although contrary to our hypothesis, this finding is consistent with post-stress hunger reduction responses wherein distress is associated with physiological responses, including inhibition of gastric motility, in preparation for a fight or flight response (Stone & Brownell, 1994). However, this finding is inconsistent with other research that found a positive link between interpersonal stressors and hunger (Jaremka et al., 2014, 2015). We note some discrepancy in terms of study design and interpretation of findings. Perhaps most importantly, previous studies that found a positive link between interpersonal stressors and hunger measured ghrelin–metabolic hormone signaling hunger directly, but acute ghrelin response to psychological stress does not translate unilaterally to the urge to eat (Rouach et al., 2007). Instead, this association may instead be subject to emotional eating style (Raspopow et al., 2014), consistent with findings of our study discussed below. Second, previous studies examined interpersonal stress via self-report questionnaires at a lab visit, instead of using a daily diary design that assesses negative relationship behaviors as they happen. Similarly, although Jaremka et al. (2014) assessed for diet, food consumption reported by the participants were reflective of their "typical diet", instead of measuring food intake fluctuation on a daily basis. As such, it is possible that previous studies portrayed a relation between eating and interpersonal stress that is influenced by chronic processes (much as those depicted by Social Baseline Theory), instead of day-to-day dynamic associations between these two as reflected in our findings.

The second part of our associational findings was that *change* in negative partner behavior was positively associated with self and partner snacking behavior. Thus, after accounting for the level of negative partner behavior, when an individual perceived increasing negative partner behavior, they tended to consume more than average snacks. Conversely, when an individual perceived decreasing negative partner behavior, they consumed fewer than average snacks. In other words, although greater negative relationship behavior is associated with fewer snacking in general, whether the negative relationship behavior is on an "upward" or "downward" trend matters. For instance, if individuals are perceiving higher than average negative partner behaviors but both partners are in a relationship "conflict exacerbating" state (i.e., negative relationship behavior above equilibrium and increasing), their snacking behaviors are more than if they are in a "conflict resolving" state (i.e., negative relationship behavior above equilibrium and decreasing). Thus, at any given time, one's snacking depends both on the amount of negative relationship behaviors one perceives and the state of behavior resolution a dyad is engaging in (i.e., whether the negative relationship behavior is "exacerbating" or "resolving"). Although the above interpretation is speculative, future studies should consider including both dynamic components to test this interpretation (i.e., whether the negative relationship behavior is "exacerbating" or "resolving" can be translated to an amplifying or declining trend), in order to examine their distinctive effects on snacking and eating in romantic partners.

This two-fold relationship resembles discrepancies observed in current literature (Debeuf et al., 2018; Stone & Brownell, 1994) and holds implications for the methods used in future studies. If we examine each study closely, for example, Stone and Brownell (1994) found the association between stress and snacking differed by gender and intensity of stress level such that for females, the tendency to eat less as opposed to eat more emerged under moderate stress. Similarly, although no association was found between stress and snacking itself, Debeuf et al. (2018) found that daily stress was associated with trajectories of desire to eat and hunger eating motives, such that higher level of daily stress was associated with a less steep decrease in desire to eat and hunger eating motives, in line with De Vriendt et al. (2009) and Reichenberger et al. (2018). Our finding, together with past research, suggests that the trajectories of changes were of interest. Examining the first and second derivatives using differential equation modeling captures the dynamics of a dyadic system and furthermore, allows researchers to investigate differential associations between components of a dynamic system (i.e., displacement and changes) and their corresponding behavior outcomes. While traditional research uses multi-level modeling to examine the equilibrium (typically the average value) of variables, our results emphasize the importance of analyzing both equilibrium *and* change over time with a dynamical system approach.

Furthermore, when taking covariates into account, emotional over-eating style significantly moderated the association between displacement of negative relationship behavior and daily snacking behavior. However, the moderation path was not significant when examining the association between dynamics of relationship behavior and daily snacking behavior. Individuals who were high on emotional over-eating showed a less negative association between overall displacement of negative relationship behavior and snacking, meaning that individuals who identify more as emotional overeaters snacked more when they perceived higher negative relationship behaviors from their partner. This finding is consistent with existing literature, suggesting individual differences exist in the stress-eating relation (O'Connor et al., 2008; Oliver et al., 2000; Wallis & Hetherington, 2004), such that the link between acute stress and food consumption may be altered by eating related problems. Physiologically, van Strien et al. (2013) found that emotional over-eating moderated the association between changes in the cortisol reactivity of the HPA-axis in response to chronic stress and food intake. This response is potentially related to early learning as carbohydrate-rich food (e.g. sweet and high fat snacks) intake allows greater energy uptake for the brain (Markus et al., 1998), and thus, emotional overeaters might have learnt to self-medicate by eating carbohydrate-rich food to promote better coping strategies and elevated mood (Oliver et al., 2000). Snacks could also be viewed as a "distraction" as individuals shift their attention away from the general distress and negative thoughts and their level of self-awareness (O'Connor et al., 2008). These explanations are of course speculative, as we did not test either of these theories directly.

However, emotional over-eating style did not affect the association between the dynamics of negative relationship behavior and snacking. Thus, it is possible that the displacement and dynamics of negative relationship behavior hold different predictive values regarding one's snacking behavior. Although the displacement might be influenced by individual traits such as the emotional over-eating style, the predictive value of changes in displacement remains unaffected by individual characteristics. Another way to interpret this finding is that changes in displacement of a given phenomenon (e.g., snacking behavior) may reflect something generalizable across populations, consistent with the Social Baseline Theory, which indicated social proximity is energy efficient and linked to calorie consumption and eating behaviors through an ecological perspective. The dynamical system approach further provides novel methodology testing for Social Baseline Theory and examines association between eating and relationship stress that is unaltered by individual differences such as emotional eating styles.

4.1. *Limitations and future directions*

This study took a daily diary approach, following heterosexual, lesbian, gay, and other non-binary couples over a 14-day time period. That being said, we acknowledge several limitations to our study sample. First, a large proportion of the participants were white. Ethnic minorities may face unique challenges in romantic relationships. For example, Kogan et al. (2016) found that socioeconomic status, harsh parenting style, and exposure to racial discrimination serve as disadvantages during early adolescence for young African American men and predict commitment related behavior in their romantic relationship. Other research suggests that strong family bonds, hallmarks of traditional Mexican family values (Cauce & Domenech-Rodríguez, 2002) lead to varying degrees of romantic relationship involvement and intimacy (Ha et al., 2010). Furthermore, interracial relationship quality was found to be associated with racial-ethnic worldview, intergroup attitudes, and ethnic identity (Brooks & Morrison, 2022). As such, future research with a larger sample of couples from racial and ethnic minority backgrounds is needed for replication. Second, our sample was based in the United Kingdom. Relationship science has been largely based in Western contexts and few studies have examined this association within varying cultural contexts. We know that there are differing cultural constructions of romantic relationships in the Eastern and Western context (Adams et al., 2004). Tasfiliz et al. (2018) compared the role of perceived partner responsiveness and well-being across the United States and Japan–two countries with contrasting view of self-other relation. Their results suggested a nuanced picture of the role of culture in the association between relationship and health: although perceived partner responsiveness predicted well-being for both the U.S. and Japan samples, the prediction was stronger for U.S. participants than their Japanese counterparts after adjusting for demographic factors and personality traits. Other researchers speculated that in non-Western settings, meeting social obligations may be a more important indicator of closeness and intimacy (Adams et al., 2004). Studies that involve non-Western samples have the potential of advancing our understanding of complex relationship dynamics across cultures and further refine theoretical construction between relationship and health.

While the findings and analytic approach of the current study are innovative, we note several limitations to the study design and analyses. First, while our analytic approach is dynamic, it still reflects cross-sectional associations. Therefore, we do not draw causal inferences based on current findings and acknowledge that although most of the discussion revolves around interpretation of negative perception of relationship behaviors associating with snacking behaviors, it's possible that the reverse pathway could be true, such that snacking behavior might somehow alter perceptions of partner behaviors.

Additionally, snacking behavior was calculated as the total number of snacks consumed each day, across all categories (i.e., sweets, salty or savory snacks, fast food, sugary drinks, fruit or vegetables, nuts or seeds, non-sweet dairy, and cereal or granola). A limitation here is that we did not collect any information regarding the specific snack consumed, which limits us from being able to rigorously evaluate snack ingredients and assess the role of snack type (e.g., high sugar snacks). In the current study, as the original parent study focused on the number of snacks consumed, we opted to sum the amount of snack (regardless of types) consumed as their daily snack consumption. This is consistent with Conner et al.'s (1999) approach while other studies used different ways to code snacking behavior. For example, O'Connor and colleagues (2008) categorized snacks as being high in fat and/or sugar based upon food composition tables. Debeuf et al. (2018) calculated the amount of Kcal using the Nobelguide. Other research has identified snack volume as a stronger determinant of intake during an eating episode (Westerterp-Plantenga, 2004). As such, in our current study, because we only focused on the number of snacks consumed and did not ask detailed information of snacks participants consumed, whether the findings will differ if snacking was measured in another way warrants further investigation. For instance, the analysis could separate "healthy" vs. "unhealthy snacks" but distinction necessary to establish categories requires detailed information of ingredients specified for individual snack consumed, aligned with World Health Organization, 2020 guidelines and USDA SR Legacy nutritional information (U.S. Department of Agriculture, 2019). As such, the "unhealthy" vs. "healthy" categories are ambiguous. For consistency and clarity, we note this as a limitation for future studies to explore.

Although we assessed snacking behavior reports each day which should help reduce retrospective memory biases, these daily diary measures still may be susceptible to some degree of memory failures (forgetting), reporting in line with schemas and beliefs (i.e., retrospective memory biases), and even social desirability biases relative to approaches such as ecological momentary assessment (EMA). In comparison to other methods (e.g., real-time monitoring), snacking data collected through retrospective self-report even at the daily level is subject to measurement error including memory-related bias (Brouwer-Brolsma et al., 2020), potentially underestimating actual food intakes (Goran & Poehlman, 1992). Demand characteristics in response to awareness that one's food consumption is being monitored might also change participants' snacking behavior as a result of knowing they will need to report them later during the day (Robinson et al., 2014). More recently, studies assessing diet and eating behaviors use EMA which allows for overcoming the shortcomings of self-report retrospective approach. Maugeri and Barchitta (2019) summarized that EMA methods utilize event-contingent (i.e., recording food and beverage consumption at each eating occasion) and signal contingent approach (i.e., recording food and beverage consumption through notifications), successfully increasing accuracy and reducing burden of participants. Future studies assessing for eating and snacking behaviors could implement one or both of these approaches in support of the end-of-day survey, while taking participant accessibility (i.e., open-source software) and compliance (i.e., gift card, higher compensation) into consideration. An end-of-study survey about the usability of the measurement tool can be collected and reported so that readers can assess validity and reliability.

Alternative measures of hunger (e.g., desire to eat and hunger eating motives; Debeuf et al., 2018) and metabolic hormones such as ghrelin and leptin might also provide additional physiological evidence to the existing findings. For example, van Strien et al. (2014) found that by evaluating hunger ratings after stress, emotional eating behaviors moderated the distress induced food intake for females with a lack of typical reduction of hunger following stress, consistent with previous studies focusing on emotional over-eating and post-stress hunger reduction (van Strien et al., 2012). Bruch (1964) further hypothesized that the observed moderation might be due to poor interoceptive awareness–a confusion of physiological symptoms of stress and those associated with hunger. As such, alternative measures of hunger can also shed light to explain underlying mechanisms of the moderating effect of emotional over-eating that we observed in our study.

5. Conclusion

In sum, we applied a dynamical system approach to daily snacking and negative relationship behavior and examined the intra-individual and inter-individual fluctuations as well as their associations within romantic partners. Results revealed oscillating individual snacking behavior, oscillating negative relationship behavior that was amplified over time, and more importantly, a two-fold association between negative relationship behavior and daily snacking. Specifically, there was a negative association between the displacement of negative relationship behavior and daily snacking behavior but after accounting for the level of negative partner behavior, when an individual perceived increasing negative partner behavior, they tended to consume more than average snacks. Thus, one's snacking depends both on the amount of negative relationship behavior one perceives and whether the negative relationship behavior is on an "upward" or "downward" trend. The former association was further moderated by emotional over-eating style after adjusting for covariates while the latter was not. These findings highlight that while a couple's negative relationship dynamics are tied to their subsequent snacking behavior, more importantly, an individual's snacking behavior changes and is moderated by their emotional over-eating style when there is a change from equilibrium (i.e., displacement) in the couple's negative close relationship behavior. These findings not only offer new empirical and methodological insights but can also inform couples' daily experiences and the health significance of their close relationship interactions.

Ethical statement

The current research involving human participants, human material, or human data has been performed in accordance with the Declaration of Helsinki. The study was approved by the PPLS Research Ethics Committee (protocol reference: #15–1920/3) at the University of Edinburgh. Further information and documentation is available upon request. Participants provided written consent to all parts of the study. The manuscript was prepared in line with the Recommendations for the Conduct, Reporting, Editing and Publication of Scholarly Work and aimed for the inclusion of representative human populations as per recommendations.

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CRediT authorship contribution statement

Jingrun Lin: Writing – review & editing, Writing – original draft, Formal analysis, Conceptualization. **Jennifer K MacCormack:** Writing – review & editing, Supervision. **Steven M. Boker:** Writing – review & editing, Supervision, Methodology, Formal analysis. **James A. Coan:** Writing – review & editing, Supervision. **Sarah C.E. Stanton:** Writing – review & editing, Supervision, Project administration, Funding acquisition, Data curation.

Declaration of competing interest

We have no financial or personal relationships with other people or organizations that could inappropriately influence (bias) our work to disclose.

Data availability

Data will be made available on request.

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Appendix A. Supplementary data

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References

Ackerman, R., & Kenny, D. (2016). APIMPowerR: An interactive tool for actor-partner interdependence model power analysis. *Computer Software*. Retrieved from https://Robert-a-Ackerman.shinyapps.io/APIMPowerRdis.

Adams, G., Anderson, S. L., & Adonu, J. K. (2004). The cultural grounding of closeness and intimacy. In D. J. Mashek, & A. P. Aron (Eds.), *Handbook of closeness and intimacy* (pp. 321–339). Lawrence Erlbaum Associates Publishers.

Beckes, L., & Coan, J. A. (2011). Social baseline theory: The role of social proximity in emotion and economy of action. *Social and Personality Psychology Compass, 5*(12), 976–988. https://doi.org/10.1111/j.1751-9004.2011.00400.x

Boker, S. M. (2001). Differential models and "differential structural equation modeling of intraindividual variability. In L. M. Collins, & A. G. Sayer (Eds.), *New methods for the analysis of change* (pp. 5–27). American Psychological Association. https://doi.org/10.1037/10409-001.

Boker, S. M., & Laurenceau, J.-P. (2006). Dynamical systems modeling: An application to the regulation of intimacy and disclosure in marriage. In T. A. Walls, & J. L. Schafer (Eds.), *Models for intensive longitudinal data* (pp. 195–218). Oxford University Press. https://doi.org/10.1093/acprof:oso/9780195173444.003.0009.

Brooks, J. E., & Morrison, M. M. (2022). Stigma and relationship quality: The relevance of racial-ethnic worldview in interracial relationships in the United States. *Frontiers in Psychology, 13*, Article 923019. https://doi.org/10.3389/fpsyg.2022.923019

Brouwer-Brolsma, E. M., et al. (2020). Dietary intake assessment: From traditional paper-pencil questionnaires to technology-based tools. In I. Athanasiadis, S. Frysinger, G. Schimak, & W. Knibbe (Eds.), *Environmental software systems. Data science in action. ISESS 2020. IFIP advances in information and communication technology* (Vol. 554). Cham: Springer. https://doi.org/10.1007/978-3-030-39815-6_2.

Bruch, H. (1964). Psychological aspects of overeating and obesity. *Psychosomatics, 5*, 269–274. https://doi.org/10.1016/s0033-3182(64)72385-7

Brydon, L., O'Donnell, K., Wright, C. E., Wawrzyniak, A. J., Wardle, J., & Steptoe, A. (2008). Circulating leptin and stress-induced cardiovascular activity in humans. *Obesity, 16*, 2642–2647. https://doi.org/10.1038/oby.2008.415

Butler, E. A. (2011). Temporal interpersonal emotion systems: The "TIES" that form relationships. *Personality and Social Psychology Review: An Official Journal of the Society for Personality and Social Psychology, Inc, 15*(4), 367–393. https://doi.org/10.1177/1088868311411164

Cauce, A. M., & Domenech-Rodríguez, M. (2002). Latino families: Myths and realities. In J. M. Contreras, K. A. Kerns, & A. M. Neal-Barnett (Eds.), *Latino children and families in the United States: Current research and future directions* (pp. 3–25). Praeger Publishers/Greenwood Publishing Group.

Chao, A. M., Jastreboff, A. M., White, M. A., Grilo, C. M., & Sinha, R. (2017). Stress, cortisol, and other appetite-related hormones: Prospective prediction of 6-month changes in food cravings and weight. *Obesity, 25*(4), 713–720. https://doi.org/10.1002/oby.21790

Chapelot, D. (2011). The role of snacking in energy balance: A biobehavioral approach. *Journal of Nutrition, 141*(1), 158–162. https://doi.org/10.3945/jn.109.114330

Chuang, J.-C., & Zigman, J. M. (2010). Ghrelin's roles in stress, mood, and anxiety regulation. *International Journal of Peptides*, 1–5. https://doi.org/10.1155/2010/460549, 2010.

Conger, J. C., Conger, A. J., Costanzo, P. R., Wright, K. L., & Matter, J. A. (1980). The effect of social cues on the eating behavior of obese and normal subjects. *Journal of Personality, 48*(2), 258–271. https://doi.org/10.1111/j.1467-6494.1980.tb00832.x

Conner, M., Fitter, M., & Fletcher, W. (1999). Stress and snacking: A diary study of daily hassles and between-meal snacking. *Psychology and Health, 14*(1), 51–63. https://doi.org/10.1080/08870449908407313

Crowther, J. H., Sanftner, J., Bonifazi, D. Z., & Shepherd, K. L. (2001). The role of daily hassles in binge eating. *International Journal of Eating Disorders, 29*(4), 449–454. https://doi.org/10.1002/eat.1041

De Vriendt, T., Moreno, L. A., & De Henauw, S. (2009). Chronic stress and obesity in adolescents: Scientific evidence and methodological issues for epidemiological research. *Nutrition, Metabolism, and Cardiovascular Diseases: Nutrition, Metabolism, and Cardiovascular Diseases, 19*(7), 511–519. https://doi.org/10.1016/j.numecd.2009.02.009

Debeuf, T., Verbeken, S., Van Beveren, M. L., Michels, N., & Braet, C. (2018). Stress and eating behavior: A daily diary study in youngsters. *Frontiers in Psychology, 9*, 2657. https://doi.org/10.3389/fpsyg.2018.02657

Epel, E., Lapidus, R., McEwen, B., & Brownell, K. (2001). Stress may add bite to appetite in women: A laboratory study of stress-induced cortisol and eating behavior. *Psychoneuroendocrinology, 26*(1), 37–49. https://doi.org/10.1016/s0306-4530(00)00035-4

Evers, C., Marijn Stok, F., & de Ridder, D. T. (2010). Feeding your feelings: Emotion regulation strategies and emotional eating. *Personality and Social Psychology Bulletin, 36*(6), 792–804. https://doi.org/10.1177/0146167210371383

Ferrer, E., & Helm, J. L. (2013). Dynamical systems modeling of physiological coregulation in dyadic interactions. *International Journal of Psychophysiology: Official Journal of the International Organization of Psychophysiology, 88*(3), 296–308. https://doi.org/10.1016/j.ijpsycho.2012.10.013

Ferrer, E., & Steele, J. (2012). Dynamic systems analysis of affective processes in dyadic interactions using differential equations. In J. R. Harring, & G. R. Hancock (Eds.), *Advances in longitudinal methods in the social and behavioral sciences* (pp. 111–134). IAP Information Age Publishing.

Finkenauer, C., Wijngaards-de Meij, L., Reis, H. T., & Rusbult, C. E. (2010). The importance of seeing what is not there: A quasi-signal detection analysis of positive and negative behavior in newlywed couples. *Personal Relationships, 17*(4), 615–633. https://doi.org/10.1111/j.1475-6811.2010.01300.x

Franken, I. H., & Muris, P. (2005). Individual differences in reward sensitivity are related to food craving and relative body weight in healthy women. *Appetite, 45*(2), 198–201. https://doi.org/10.1016/j.appet.2005.04.004

Gable, S. L., Reis, H. T., & Elliot, A. J. (2003). Evidence for bivariate systems: An empirical test of appetition and aversion across domains. *Journal of Research in Personality, 37*(5), 349–372. https://doi.org/10.1016/S0092-6566(02)00580-9

Goran, M. I., & Poehlman, E. T. (1992). Total energy expenditure and energy requirements in healthy elderly persons. *Metabolism - Clinical and Experimental, 41*(7), 744–753. https://doi.org/10.1016/0026-0495(92)90315-2

Gottman, J. M., & Levenson, R. W. (2002). A two-factor model for predicting when a couple will divorce: Exploratory analyses using 14-year longitudinal data. *Family Process, 41*(1), 83–96. https://doi.org/10.1111/j.1545-5300.2002.40102000083.x

Ha, T., Overbeek, G., de Greef, M., Scholte, R. H. J., & Engels, R. C. M. E. (2010). The importance of relationships with parents and best friends for adolescents' romantic relationship quality: Differences between indigenous and ethnic Dutch adolescents. *International Journal of Behavioral Development, 34*(2), 121–127. https://doi.org/10.1177/0165025409360293

Hsia, L. C., & Wood-Gush, D. G. (1984). Social facilitation in the feeding behaviour of pigs and the effect of rank. *Applied Animal Ethology, 11*(3), 265–270. https://doi.org/10.1016/0304-3762(84)90033-6

Hu, Y., Boker, S., Neale, M., & Klump, K. L. (2014). Coupled latent differential equation with moderators: Simulation and application. *Psychological Methods, 19*(1), 56–71. https://doi.org/10.1037/a0032476

Hunot, C., Fildes, A., Croker, H., Llewellyn, C. H., Wardle, J., & Beeken, R. J. (2016). Appetitive traits and relationships with BMI in adults: Development of the adult eating behaviour questionnaire. *Appetite, 105*, 356–363. https://doi.org/10.1016/j.appet.2016.05.024

Jaremka, L. M., Belury, M. A., Andridge, R. R., Malarkey, W. B., Glaser, R., Christian, L., Emery, C. F., & Kiecolt-Glaser, J. K. (2014). Interpersonal stressors predict ghrelin and leptin levels in women. *Psychoneuroendocrinology, 48*, 178–188. https://doi.org/10.1016/j.psyneuen.2014.06.018

Jaremka, L. M., Fagundes, C. P., Peng, J., Belury, M. A., Andridge, R. R., Malarkey, W. B., & Kiecolt-Glaser, J. K. (2015). Loneliness predicts postprandial ghrelin and hunger in women. *Hormones and Behavior, 70*, 57–63. https://doi.org/10.1016/j.yhbeh.2015.01.011

Kaplan, H. I., & Kaplan, H. S. (1957). The psychosomatic concept of obesity. *The Journal of Nervous and Mental Disease, 125*(2), 181–201. https://doi.org/10.1097/00005053-195704000-00004

Karney, B. R., & Bradbury, T. N. (1997). Neuroticism, marital interaction, and the trajectory of marital satisfaction. *Journal of Personality and Social Psychology, 72*(5), 1075–1092. https://doi.org/10.1037/0022-3514.72.5.1075

Kiecolt-Glaser, J. K., Fisher, L. D., Ogrocki, P., Stout, J. C., Speicher, C. E., & Glaser, R. (1987). Marital quality, marital disruption, and immune function. *Psychosomatic Medicine, 49*(1), 13–34. https://doi.org/10.1097/00006842-198701000-00002

Kiecolt-Glaser, J. K., Glaser, R., Cacioppo, J. T., & Malarkey, W. B. (1998). Marital stress: Immunologic, neuroendocrine, and autonomic correlates. *Annals of the New York Academy of Sciences, 840*, 656–663. https://doi.org/10.1111/j.1749-6632.1998.tb09604.x

Kogan, S. M., Yu, T., & Brown, G. L. (2016). Romantic relationship commitment behavior among emerging adult african American men. *Journal of Marriage and Family, 78*(4), 996–1012. https://doi.org/10.1111/jomf.12293

Laugero, K. D. (2001). A new perspective on glucocorticoid feedback: Relation to stress, carbohydrate feeding and feeling better. *Journal of Neuroendocrinology, 13*(9), 827–835. https://doi.org/10.1046/j.1365-2826.2001.00706.x

MacCormack, J. K., & Muscatell, K. A. (2019). The metabolic mind: A role for leptin and ghrelin in affect and social cognition. *Social and Personality Psychology Compass, 13*(9). https://doi.org/10.1111/spc3.12496. Article e12496.

Markus, C. R., Panhuysen, G., Tuiten, A., Koppeschaar, H., Fekkes, D., & Peters, M. L. (1998). Does carbohydrate-rich, protein-poor food prevent a deterioration of mood and cognitive performance of stress-prone subjects when subjected to a stressful task? *Appetite, 31*(1), 49–65. https://doi.org/10.1006/appe.1997.0155

Marshall, D., & Bell, R. (2003). Meal construction: Exploring the relationship between eating occasion and location. *Food Quality and Preference, 14*(1), 53–64. https://doi.org/10.1016/S0950-3293(02)00015-0

Maugeri, A., & Barchitta, M. (2019). A systematic review of ecological momentary assessment of diet: Implications and perspectives for nutritional epidemiology. *Nutrients, 11*(11), 2696. https://doi.org/10.3390/nu11112696

Maunder, R. G., & Hunter, J. J. (2001). Attachment and psychosomatic medicine: Developmental contributions to stress and disease. *Psychosomatic Medicine, 63*(4), 556–567. https://doi.org/10.1097/00006842-200107000-00006

Mikulincer, M., Shaver, P. R., & Pereg, D. (2003). Attachment theory and affect regulation: The dynamics, development, and cognitive consequences of attachment-related strategies. *Motivation and Emotion, 27*(2), 77–102. https://doi.org/10.1023/A:1024515519160

Mori, D., Chaiken, S., & Pliner, P. (1987). "Eating lightly" and the self-presentation of femininity. *Journal of Personality and Social Psychology, 53*(4), 693–702. https://doi.org/10.1037//0022-3514.53.4.693

Neale, M. C., Hunter, M. D., Pritikin, J. N., Zahery, M., Brick, T. R., Kirkpatrick, R. M., Estabrook, R., Bates, T. C., Maes, H. H., & Boker, S. M. (2016). OpenMx 2.0: Extended structural equation and statistical modeling. *Psychometrika, 81*(2), 535–549. https://doi.org/10.1007/s11336-014-9435-8

O'Connor, D. B., Jones, F., Conner, M., McMillan, B., & Ferguson, E. (2008). Effects of daily hassles and eating style on eating behavior. *Health Psychology: Official Journal of the Division of Health Psychology, American Psychological Association, 27*(1S), S20–S31. https://doi.org/10.1037/0278-6133.27.1.S20

O'Connor, D. B., & O'Connor, R. C. (2004). Perceived changes in food intake in response to stress: The role of conscientiousness. *Stress and Health: Journal of the International Society for the Investigation of Stress, 20*(5), 279–291. https://doi.org/10.1002/smi.1028

Oliver, G., Wardle, J., & Gibson, E. L. (2000). Stress and food choice: A laboratory study. *Psychosomatic Medicine, 62*(6), 853–865. https://doi.org/10.1097/00006842-200011000-00016

Orth-Gomér, K., Wamala, S. P., Horsten, M., Schenck-Gustafsson, K., Schneiderman, N., & Mittleman, M. A. (2000). Marital stress worsens prognosis in women with coronary heart disease: The Stockholm Female Coronary Risk Study. *JAMA, 284*(23), 3008–3014. https://doi.org/10.1001/jama.284.23.3008

Pickett, C. L., & Gardner, W. L. (2005). The social monitoring system: Enhanced sensitivity to social cues as an adaptive response to social exclusion. In K. D. Williams, J. P. Forgas, & W. von Hippel (Eds.), *The social outcast: Ostracism, social exclusion, rejection, and bullying* (pp. 213–226). Psychology Press.

R Core Team. (2021). *R: A language and environment for statistical computing*. Vienna, Austria: R Foundation for Statistical Computing. URL https://www.R-project.org/.

Raspopow, K., Abizaid, A., Matheson, K., & Anisman, H. (2014). Anticipation of a psychosocial stressor differentially influences ghrelin, cortisol and food intake among emotional and non-emotional eaters. *Appetite, 74*, 35–43. https://doi.org/10.1016/j.appet.2013.11.018

Reichenberger, J., Kuppens, P., Liedlgruber, M., Wilhelm, F. H., Tiefengrabner, M., Ginzinger, S., & Blechert, J. (2018). No haste, more taste: An EMA study of the effects of stress, negative and positive emotions on eating behavior. *Biological Psychology, 131*, 54–62. https://doi.org/10.1016/j.biopsycho.2016.09.002

Reis, H. T., Maniaci, M. R., & Rogge, R. D. (2014). The expression of compassionate love in everyday compassionate acts. *Journal of Social and Personal Relationships, 31*(5), 651–676. https://doi.org/10.1177/0265407513507214

Robinson, E., Aveyard, P., Daley, A., Jolly, K., Lewis, A., Lycett, D., & Higgs, S. (2013). Eating attentively: A systematic review and meta-analysis of the effect of food intake memory and awareness on eating. *American Journal of Clinical Nutrition, 97*(4), 728–742. https://doi.org/10.3945/ajcn.112.045245

Robinson, E., Kersbergen, I., Brunstrom, J. M., & Field, M. (2014). I'm watching you. Awareness that food consumption is being monitored is a demand characteristic in eating-behaviour experiments. *Appetite, 83*, 19–25. https://doi.org/10.1016/j.appet.2014.07.029

Rouach, V., Bloch, M., Rosenberg, N., Gilad, S., Limor, R., Stern, N., & Greenman, Y. (2007). The acute ghrelin response to a psychological stress challenge does not predict the post-stress urge to eat. *Psychoneuroendocrinology, 32*(6), 693–702. https://doi.org/10.1016/j.psyneuen.2007.04.010

Ruddock, H. K., Brunstrom, J. M., & Higgs, S. (2021). The social facilitation of eating: Why does the mere presence of others cause an increase in energy intake? *Physiology & Behavior, 240*, Article 113539. https://doi.org/10.1016/j.physbeh.2021.113539

Ruddock, H. K., Brunstrom, J. M., Vartanian, L. R., & Higgs, S. (2019). A systematic review and meta-analysis of the social facilitation of eating. *American Journal of Clinical Nutrition, 110*(4), 842–861. https://doi.org/10.1093/ajcn/nqz155

Sbarra, D. A., & Hazan, C. (2008). Coregulation, dysregulation, self-regulation: An integrative analysis and empirical agenda for understanding adult attachment, separation, loss, and recovery. *Personality and Social Psychology Review: An Official Journal of the Society for Personality and Social Psychology, Inc, 12*(2), 141–167. https://doi.org/10.1177/1088868308315702

Solomon, T. P., Chambers, E. S., Jeukendrup, A. E., Toogood, A. A., & Blannin, A. K. (2008). The effect of feeding frequency on insulin and ghrelin responses in human subjects. *British Journal of Nutrition, 100*(4), 810–819. https://doi.org/10.1017/S000711450896757X

Stanton, S. C. E., Selcuk, E., Farrell, A. K., Slatcher, R. B., & Ong, A. D. (2019). Perceived partner responsiveness, daily negative affect reactivity, and all-cause mortality: A 20-year longitudinal study. *Psychosomatic Medicine, 81*(1), 7–15. https://doi.org/10.1097/PSY.0000000000000618

Steele, J. S., & Ferrer, E. (2011). Latent differential equation modeling of self-regulatory and coregulatory affective processes. *Multivariate Behavioral Research, 46*(6), 956–984. https://doi.org/10.1080/00273171.2011.625305

Steptoe, A., Lipsey, Z., & Wardle, J. (1998). Stress, hassles and variations in alcohol consumption, food choice and physical exercise: A diary study. *British Journal of Health Psychology, 3*(Part 1), 51–63. https://doi.org/10.1111/j.2044-8287.1998.tb00555.x

Stone, A. A., & Brownell, K. D. (1994). The stress-eating paradox: Multiple daily measurements in adult males and females. *Psychology and Health, 9*(6), 425–436. https://doi.org/10.1080/08870449408407469

Tasfiliz, D., Selcuk, E., Gunaydin, G., Slatcher, R. B., Corriero, E. F., & Ong, A. D. (2018). Patterns of perceived partner responsiveness and well-being in Japan and the United States. *Journal of Family Psychology: JFP: Journal of the Division of Family Psychology of the American Psychological Association, 32*(3), 355–365. https://doi.org/10.1037/fam0000378 (Division 43).

Tataranni, P. A., Larson, D. E., Snitker, S., Young, J. B., Flatt, J. P., & Ravussin, E. (1996). Effects of glucocorticoids on energy metabolism and food intake in humans. *American Journal of Physiology, 271*(2 Pt 1), E317–E325. https://doi.org/10.1152/ajpendo.1996.271.2.E317

Tomiyama, A. J., Schamarek, I., Lustig, R. H., Kirschbaum, C., Puterman, E., Havel, P. J., & Epel, E. S. (2012). Leptin concentrations in response to acute stress predict subsequent intake of comfort foods. *Physiology & Behavior, 107*, 34–39. https://doi.org/10.1016/j.physbeh.2012.04.021

U.S. Department of Agriculture. (2019). *Agricultural research service (USDA)*. FoodData Central. https://fdc.nal.usda.gov.

van Strien, T., Herman, C. P., Anschutz, D. J., Engels, R. C., & de Weerth, C. (2012). Moderation of distress-induced eating by emotional eating scores. *Appetite, 58*(1), 277–284. https://doi.org/10.1016/j.appet.2011.10.005

van Strien, T., Ouwens, M. A., Engel, C., & de Weerth, C. (2014). Hunger, inhibitory control and distress-induced emotional eating. *Appetite, 79*, 124–133. https://doi.org/10.1016/j.appet.2014.04.020

van Strien, T., Roelofs, K., & de Weerth, C. (2013). Cortisol reactivity and distress-induced emotional eating. *Psychoneuroendocrinology, 38*(5), 677–684. https://doi.org/10.1016/j.psyneuen.2012.08.008

Verhoeven, A. A., Adriaanse, M. A., de Vet, E., Fennis, B. M., & de Ridder, D. T. (2015). It's my party and I eat if I want to. Reasons for unhealthy snacking. *Appetite, 84*, 20–27. https://doi.org/10.1016/j.appet.2014.09.013

Wallis, D. J., & Hetherington, M. M. (2004). Stress and eating: The effects of ego-threat and cognitive demand on food intake in restrained and emotional eaters. *Appetite, 43*(1), 39–46. https://doi.org/10.1016/j.appet.2004.02.001

Westerterp-Plantenga, M. S. (2004). Effects of energy density of daily food intake on long-term energy intake. *Physiology & Behavior, 81*(5), 765–771. https://doi.org/10.1016/j.physbeh.2004.04.030

Wilkinson, L. L., Rowe, A. C., & Heath, G. H. (2013). Eating me up inside: Priming attachment security and anxiety, and their effects on snacking. *Journal of Social and Personal Relationships, 30*(6), 795–804. https://doi.org/10.1177/0265407512468371

World Health Organization. (2020). *Healthy diet*.

Yildiz, B. O., Suchard, M. A., Wong, M. L., McCann, S. M., & Licinio, J. (2004). Alterations in the dynamics of circulating ghrelin, adiponectin, and leptin in human obesity. *Proceedings of the National Academy of Sciences of the United States of America, 101*(28), 10434–10439. https://doi.org/10.1073/pnas.0403465101

Zakrzewska, K. E., Cusin, I., Sainsbury, A., Rohner-Jeanrenaud, F., & Jeanrenaud, B. (1997). Glucocorticoids as counterregulatory hormones of leptin: Toward an understanding of leptin resistance. *Diabetes, 46*(4), 717–719. https://doi.org/10.2337/diab.46.4.717

Zee, K. S., & Bolger, N. (2022). Physiological coregulation during social support discussions. *Emotion*. https://doi.org/10.1037/emo0001107 (Washington, D.C.), 10.1037/emo0001107. Advance online publication.