

Context matters: Self-regulation of healthy eating at different eating occasions

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Abstract

Self-regulation plays an important role in healthy eating behaviors. The current research explores temporary fluctuations in self-regulation next to variations between individuals. In an online observational study, 892 participants ($M^{\text{age}} = 44.3$, $SD^{\text{age}} = 12.7$) monitored their self-regulation three times a week before a meal moment for 3 weeks. To analyze the data, a random intercept and slopes model was used, including variables on within-individual level (i.e. meal moment, tiredness, distractedness, social, and physical environment) and variables on between-individual level (i.e. self-efficacy, intrinsic motivation, and perception of social and physical opportunity). Self-regulation was found to be higher at breakfast compared with dinner (estimate = -0.08 , $p < .001$), higher at home than out-of-home (estimate = -0.08 , $p < .001$) and lower when individuals are more tired (estimate = 0.04 , $p < .001$) and distracted (estimate = 0.07 , $p < .001$). Moreover, self-regulation was higher for individuals with higher levels of intrinsic motivation (estimate = 0.19 , $p < .001$) and self-efficacy (estimate = 0.41 , $p < .001$). Insights from this research advance our knowledge regarding temporal influences on self-regulation and can provide input for behavior change tools such as personalized dietary advice.

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KEYWORDS

context, healthy eating, meal moment, self-regulation, temporal factors

INTRODUCTION

Diet-related noncommunicable diseases, including obesity and heart diseases, are the largest global burden of disease (Willett et al., 2019), and their prevalence is increasing with nearly 2 billion adults being overweight or obese (WHO, 2020). Consumers' daily dietary choices play a central role in these health problems, and to understand how to guide people towards healthy dietary choices, it is important to address the intention–behavior gap (Webb & Sheeran, 2006).

An important mechanism contributing to the intention–behavior gap is self-regulation (Social Cognitive Theory; Bandura, 1991). Self-regulation is the ability of individuals to plan and monitor their actions through goal-setting, self-monitoring, feedback, self-reward, self-instruction, and social support (McAlister et al., 2008). Individuals with a high level of self-regulation can set a goal, achieve it, monitor it, and adjust their behavior in line with the goal. Thus, individuals with a high level of self-regulation will more likely translate their intentions into behavior than individuals with a low level of self-regulation (Millar, 2017).

Self-regulation mechanisms in health behavior change have been previously studied (Hennessy et al., 2020) and have been found to play an important role in dietary behaviors and following through with dietary goals (Dohle et al., 2018). Generally, self-regulation has been investigated as a trait that differs between individuals (Enkavi et al., 2019). However, in a review paper, Millar (2017) argues that the ability to self-regulate also depends on the time of day, with self-regulation impairment being more likely at the end of the day. Boland et al. (2013) confirm this with a between-subject experiment, where they found that the activation of health goals is effective in decreasing snack consumption in the afternoon but not in the morning when self-regulatory resources are high. A first study to examine self-regulation mechanisms and health behaviors with a within-subjects design is a study by Francis et al. (2020), who found that limited willpower beliefs were associated with less physical activity and more snacking later in the day. However, to our knowledge, longitudinal studies have not yet been carried out that investigate the within-individual variability of healthy eating self-regulation at different meal moments (i.e. breakfast, lunch, and dinner; Millar, 2017; Scholz, 2019).

The current study aims to investigate the temporal changes in healthy eating self-regulation by measuring self-regulation at different meal moments (breakfast, lunch, and dinner). In addition, we examine different temporal factors that may lead self-regulation to vary within individuals (i.e. with whom and where does a person eat and experiencing feelings of tiredness and distraction). Moreover, we include factors that we measure at one point in time, at baseline, that are expected to be important drivers of self-regulation and behavior. These drivers are based on the Motivation, Opportunity, Ability (MOA) model (Rothschild, 1999) that can be seen as a prerequisite for behavior change (i.e. intrinsic motivation to eat healthy and perception of social and physical opportunity and self-efficacy). By including these factors, we can compare them with the temporal factors, placing those findings in perspective.

Within-individual fluctuations in self-regulation

An integrative paper by Millar (2017) that highlights which temporary factors might play a role in self-regulation was used as a guide for the selection of within-individual predictors in the current study. This has led to the inclusion of the following predictors: meal moment, feelings of distraction and tiredness, the physical location where a meal is being consumed, and the social context in which a meal is being consumed.

Self-regulation is believed to decline during the day, which may affect an individual's ability to control for, for example, (un)healthy eating (Millar, 2017). Khare and Inman (2006) demonstrate that while foods consumed earlier in the day (e.g. breakfast) tend to be associated with nutrients contributing to a healthy diet (e.g. calcium), those consumed later in the day (e.g. lunch and dinner) tend to be dominated by nutrients contributing to an unhealthy diet (e.g. saturated fat). Similarly, McKee et al. (2014) found that lapses among dieters are most common in the evening or the night. Hence, we hypothesise the following:

H1. Healthy eating self-regulation is higher during breakfast than during lunch and dinner.¹

Furthermore, an individual's cognitive abilities that are needed to regulate impulses and emotions fluctuate during the day due to challenges in daily life and tend to decline as the day proceeds. For example, individuals are generally less alert after 6 pm (Åkerstedt et al., 2004), and individuals perform worse on various cognitive tasks when awake for a long time (van der Helm & Walker, 2012). Being less alert and more distracted hinders behavioral monitoring and following through with long-term goals (van Dillen et al., 2013) and is often linked to increased food intake (Ogden et al., 2013). Thus, we hypothesise the following:

H2. Feelings of distraction negatively influence self-regulation.

According to Millar (2017), this worsening of self-regulation as the day proceeds also coincides with growing levels of sleep-related fatigue (i.e. becoming more tired). Millar (2017, p. 349) observes “the longer and more tiring the day has been, the more likely individuals will be struggling under this cumulative ‘wear and tear,’ contributing to the sense of being ‘worn out’ or ‘drained’ later in the day.” Therefore, we also hypothesise the following:

H3. Feeling tired negatively influences self-regulation.²

The location where meals are consumed (i.e. at home vs. out-of-home) may also affect individuals' dietary self-regulation. Out-of-home, especially in Western cultures, individuals are confronted with abundantly available and easily accessible foods, placing a high burden on individuals' capacity to control food intake (de Vet et al., 2013). Although individual's variation in self-regulatory competence implies that the negative effects of the obesogenic environment are not the same for everyone (Stok et al., 2015), de Vet et al. (2013) showed that an increased access to unhealthy foods contributed positively to unhealthy food intake. Environmental food cues weaken the intention–behavior relationship because they typically elicit responses that are fast and automatic and therefore influence behavior before reflective processing

(Orbell & Verplanken, 2015). To override these automatic responses, self-regulation skills are needed, and as such, we expect the following:

H4. Having a meal out-of-home will negatively influence someone's level of self-regulation of healthy eating.

Finally, the social environment during a meal (i.e. alone versus with others) can also play a role in successfully regulating healthy eating behavior. Previous studies showed that the social environment exerts an important influence on food choice behavior (Robinson et al., 2014) and that peer influence and group conformity can be considered as important determinants in food acceptability and selection (Kalavana et al., 2010). A lack of clear, shared standards that guide eating behavior can also compromise the self-regulation of healthy eating (de Ridder et al., 2013). There is less need to rely on self-regulation when there are standards that guide eating behavior. When eating alone, these standards are less visible and easier to ignore compared with when eating with others. Thus, we hypothesise the following:

H5. Eating alone negatively influences individuals' level of self-regulation of healthy eating.

Between-individual drivers of self-regulation

In this study, important between-individual drivers of self-regulation are measured at one moment in time (at baseline) to place the effect of within-individual fluctuations in healthy eating self-regulation in perspective. These factors are derived from the MOA model (Rothschild, 1999). The importance of considering motivation when studying self-regulatory processes has been highlighted by recent research (Werner & Milyavskaya, 2019). Motivational resources play a role in successful self-regulation (Teixeira et al., 2011), and autonomous motivation for healthy eating has been cross-sectionally associated with healthier eating patterns (Pelletier et al., 2004). Furthermore, a facilitating physical environment can positively influence self-regulation (Millar, 2017), as well as a facilitating social environment, as social support is often reported in combination with self-regulation to contribute to nutrition behavior (Anderson et al., 2007). Finally, a proximal determinant of self-regulation is self-efficacy (i.e. the belief of being able to successfully execute a behavior), which influences several subfunctions of self-regulation, including goal-setting, self-monitoring, and cognitive processing (Bandura, 1977). As such, we hypothesise the following:

H6. The MOA variables will positively influence healthy eating self-regulation.

METHOD

Design and procedure

To answer our research questions an observational within-subjects, study design was used where participants' level of self-regulation of healthy eating, feelings of distraction, and feelings of tiredness were monitored, as well as where and with whom the meal was consumed. This

was done three times a week right before a meal moment for 3 weeks. In total, nine repeated measurements took place, and each measurement took approximately 5 min to complete. At the end of the measurement, we assessed whether participants followed the instructions to fill in the questionnaire before the meal moment. Participants who did not follow these instructions received a warning text asking them to follow the instructions the next time. To control for order effects, participants were randomly divided into six conditions, and within every condition, the order of the three meal moments was varied by using a Latin Square design (see Supporting Information). The repeated measurement was made available for participants on the day and occasion that they were allocated to through a push notification. The notification was sent at the start of the measurement (breakfast: 5:00 a.m.; lunch: 11:00 a.m.; dinner: 4:00 p.m.), and the measurement disappeared after 5 or 6 h (breakfast: 11:00 a.m.; lunch: 4:00 p.m.; dinner: 9:00 p.m.).

In addition to the repeated measurements, participants filled in a 15-min online survey at the start of the study after they were deemed eligible to participate. The baseline survey consisted of demographic and psychological factors that could influence the variability of self-regulation. All participants were also given a definition of healthy food consumption based on the guidelines of the Dutch Nutrition Centre at the start of the study. Once the sufficient sample size for the baseline measurement was recruited, all participants started with the repeated measurements at the same time in the second week of January 2020 and was completed after the 3 weeks of data collection at the end of the month.

Sample

Participants were recruited through a professional market research company (Ipsos), who used their own smartphone application to collect the repeated measurement. They were recruited based on sex, age, education, and region to represent a cross section of the Dutch population. As the study focused on meal moments, a selection criterion was applied that participants had to eat breakfast, lunch, and dinner at least three times a week. Participants received incentives for their participation in the form of loyalty points, which can be exchanged for gift vouchers. To reduce dropout rates even more, participants received an extra incentive of 10 Euros if they completed the baseline as well as all the nine repeated measurements.

A total of 3846 participants responded to the initial study invitation, of which 115 did not give consent; 762 did not eat enough breakfast, lunch, or dinner; 603 did not have a suitable smartphone; and 863 did not want to participate in research with an app. This resulted in 1503 participants who filled out the baseline survey, of which 895 participants filled out at least one repeated measurement. Additionally, three participants were excluded because they indicated that they were not going to eat a meal at that moment. Thus, for the analyses, we considered the remaining 892 participants who started with the repeated measurements. On average, the repeated measurements were filled in 5.5 times ($SD = 2.8$), and 154 participants filled in all nine measurements. We believe this sample size is sufficient to draw meaningful conclusions, because we analyzed our data with a multilevel model, which enabled individuals with missing data points to be analyzed as well, as standard errors are appropriately adjusted for unbalanced designs due to missing data (Schneider et al., 2012). Moreover, our sample size is similar to the sample size of a previous study with a similar design and variables (Francis et al., 2020). Informed consent was obtained from all individual participants included in the study. The study

was reviewed and approved by the Social Sciences Ethics Committee of Wageningen University & Research, and the study complies with the Netherlands Code of Conduct for Research Integrity.

Measures³

Baseline questionnaire

The baseline questionnaire started with a series of screening questions, including questions needed to recruit a representative sample. These questions consisted of the consumption frequency of breakfast, lunch, and dinner; the possession of a smartphone; and the following demographics: sex, age, education, and region. Intrinsic motivation to eat healthy ($M = 5.3$; $SD = 1.0$; $\alpha = .884$) was measured with six items based on Kato et al. (2013) on a 7-point Likert scale from 1 (*totally disagree*) to 7 (*totally agree*). Examples of items are “I want to eat healthy, because I can enjoy eating healthy” and “I want to eat healthy, because I think it is interesting to find new ways to eat healthy.” Self-efficacy regarding healthy eating ($M = 5.0$; $SD = 1.0$; $\alpha = .869$) was measured with the healthy eating self-efficacy scale (Wilson-Barlow et al., 2014), with seven items and a 7-point Likert scale from 1 (*totally disagree*) to 7 (*totally agree*). An example of an item is “I am able to consume fruits and vegetables in most of my meals.” Whether participants had the opportunity to eat healthy in their physical environment ($M = 5.1$; $SD = 1.1$; $\alpha = .891$) was measured with four items on a 7-point Likert scale from 1 (*totally disagree*) to 7 (*totally agree*) based on Bos et al. (2016). One of the items is “Healthy food is easy to find.” Lastly, the opportunity to eat healthy in their social environment ($M = 4.8$; $SD = 1.1$; $\alpha = .756$) was measured with four items on a 7-point Likert scale from 1 (*totally disagree*) to 7 (*totally agree*) based on Lea and Worsley (2001). An item example is “My family normally doesn't eat that healthy.” The scores on the social opportunity scale were reversed for the analysis, as the original scale measured social barriers.

Repeated questionnaire

Self-regulation of eating behavior ($M = 5.1$; $SD = 1.1$; Kliemann et al., 2016) was measured with five items on a 7-point Likert scale from 1 (*totally disagree*) to 7 (*totally agree*). The leading question was “To what extent do you agree with the following statements at this moment?” Examples of items are “I'm good at resisting tempting food” and “If I am not eating in the way I intend to, I make changes.” To gain insight into the factors that could influence self-regulation, we asked with whom the current meal is being eaten (social environment; alone: 48%, not alone [with household, with family, with friends, with colleagues, other]: 52%), where the current meal is being eaten (physical environment; home: 76.5%, out-of-home [school, work, on the go, catering facility, at someone else, other]: 23.5%), and to what extent participants were currently feeling tired ($M = 4.3$; $SD = 1.7$) and distracted ($M = 4.9$; $SD = 1.4$). Tiredness and distractedness were assessed with two items based on Hammersley et al. (2014) on a 7-point semantic differential scale ranging from 1 (*tired*) to 7 (*energetic*) and from 1 (*distracted*) to 7 (*concentrated*). Moreover, to explore the relationship between meal moment and self-regulation, meal moment (breakfast, lunch, dinner) was included as a variable in the dataset.

Data analysis

Daily diary data have a multilevel structure, as observations at different time points are nested within individuals. Therefore, we used a multilevel model approach to analyze our data. Multilevel modeling with longitudinal data employs the same statistical techniques as multilevel modeling with clustered data, except that the measurement occasions are nested within cases (i.e. individuals) (Hoffman & Rovine, 2007). With this approach, we could examine between-individual variation and within-individual variation in the same model (Hoffman, 2015). In a multilevel model, the Level 1 predictors consist of the repeated measures for each subject, and the Level 2 unit is the individual.⁴ In addition to estimating overall parameter estimates, multilevel modeling allows regression equations at the level of the individual. Moreover, this model enabled individuals with missing data points to be analyzed as well, as standard errors are appropriately adjusted for unbalanced designs due to missing data (Schneider et al., 2012).

A random intercept and slopes model was estimated using the maximum likelihood method with self-regulation as the outcome variable, with fixed effects of first-level predictors meal moment1 (breakfast, lunch), meal moment2 (breakfast, dinner), physical environment (at home, out-of-home), social environment (alone, with others), tiredness (“1” *tired*–“7” *energetic*), and distractedness (“1” *distracted*–“7” *focused*) and second-level predictors intrinsic motivation, self-efficacy, physical opportunity, and social opportunity. Meal Moment was dummy coded as well as Condition (1–6). Condition was included in the model to control for order effects; however, we did not include this factor in the final model because it was not a significant predictor of self-regulation and did not improve the fit of the model. All predictors were added to the model as fixed factors, to capture effects on average across all participants.

To control for the correlated errors that result from coherence of the within-individual scores, Username was included as a random factor, creating a random intercept for every participant. Additionally, to decide which predictors to add as random factors, we estimated the random slopes of all our predictors, to see if there was significant variation in the slopes and if including random factors would improve our model. Because the number of our observations (4862) was not high enough to run our model with all predictors at once, we did it in steps. First, our model was estimated with meal moment1 (breakfast, lunch), meal moment2 (breakfast, dinner), physical environment (at home, out-of-home), and social environment (alone, with others) as random factors. Results show that the random effects of these variables were not significant ($p > .05$). In a second model, we included tiredness (“1” *tired*–“7” *energetic*), and distractedness (“1” *distracted*–“7” *focused*), and for these variables, results showed that the random effects were significant ($p < .001$). Finally, we estimated a model where we added the second-level predictors intrinsic motivation, self-efficacy, physical opportunity, and social opportunity as random factors of which the results showed that the random effects of these variables were not significant ($p > .05$). Based on this, in the final model, only tiredness and distractedness were added as random factors to capture individual differences in these factors.

The data were checked for homoscedasticity by comparing residuals to the fitted items in a scatterplot. The plot indicates randomly distributed data, indicating our data are homoscedastic. Moreover, we checked for normality of residuals of our final model and of the random effects with quantile–quantile (Q–Q) plots. Results show that there are no drastic deviations from normality.

The multiple equation of the model is as follows⁵:

Level 1:	$Y_{ij} = \beta_{0j} + \beta_{1j}\text{Meal Moment}1_{ij} + \beta_{2j}\text{Meal Moment}2_{ij} + \beta_{3j}\text{Physical Environment}_{ij} + \beta_{4j}\text{Social Environment}_{ij} + \beta_{5j}\text{Tiredness}_{ij} + \beta_{6j}\text{Distractedness}_{ij} + e_{ij}$
Level 2:	$\beta_{0j} = \gamma_{00} + \gamma_{01}\text{Motivation}_j + \gamma_{02}\text{Self-Efficacy}_j + \gamma_{03}\text{Physical Opportunity}_j + \gamma_{04}\text{Social Opportunity}_j + u_{0j}$
	$\beta_{5j} = \gamma_{50} + u_{5j}$
	$\beta_{6j} = \gamma_{60} + u_{6j}$

As a final step, we used a step-down procedure to examine to what degree adding Levels 1 and 2 predictors to the model would improve model fit.

The data were analyzed with SPSS version 25 and R version 3.6.1. The R-package lme4-R was used for the random intercept and slopes model. The data that support the findings of this study are available from the corresponding author upon reasonable request.

RESULTS

Sample

The baseline sample ($N = 1503$) comprised 58% females, and the mean age was 44.3 (12.7) years in an age range of 18–65 years. Furthermore, 13.4% had a low education, 36.2% had a medium education, and 50.4% had a higher education.

In comparison, the repeated measurements sample ($N = 892$) comprised 62% females and had a mean age of 44.3 (12.7) years and an age range of 18–65 years. Furthermore, 11.2% had a low education, 34.8% had a medium education, and 54% had a higher education. As compared with the baseline sample, the relative number of females as well as the education level is slightly higher.

Furthermore, additional analyses were performed to gain insight into differences between completers ($N = 892$) and noncompleters ($N = 611$) on demographics. An analysis of variance (ANOVA) shows that completers did not significantly differ in age from noncompleters ($F(1,1501) = .045, p = .831$). Chi-square tests show that completers include more women (62%) than noncompleters (52%, $p < .001$) and that completers are more highly educated (54%) than noncompleters (45%, $p < .001$) but do not significantly differ regarding the region they are from ($p = .989$).

Within- and between-individual differences

First, a random intercept model was estimated including self-regulation as the outcome variable and Username as the random factor to examine the variances between and within individuals for the repeated measurements of self-regulation of healthy eating. Table 1 shows the mean and variance components displayed as standard deviations for self-regulation of healthy

TABLE 1 The mean and standard deviations for self-regulation of healthy eating

	Mean	SD		Within-individual variance (%)
		Between-individual	Within-individual	
Self-regulation	5.1	0.987	0.549	24

Note: Number of observations = 4862. Number of groups (Username) = 892.

eating. The mean was 5.1 on a 7-point scale, indicating a slightly positive self-reported level of self-regulation with respect to healthy eating. The variance components show that self-regulation of healthy eating varies both between and within individuals. The percentage of the total variance attributable to within-individual day-to-day fluctuations was 24%. The intraclass coefficient (ICC), which indicates the amount of variance in the model that can be explained by differences between individuals, is the opposite, namely, .76. Furthermore, the within-individual *SD* shows that the amount of fluctuation in self-regulation of healthy eating for the average person varied 0.549 scale points on the 7-point scale. The between-individual *SD* shows that on average, the amount of fluctuation between individuals for self-regulation of healthy eating varied 0.987 scale points on the 7-point scale. This indicates that self-regulation of healthy eating varies more between individuals than within individuals.

Psychological factors as predictors of within-individual variability in self-regulation⁶

Results for the random intercept and slopes model are shown in Tables 2 and 3. The level of self-regulation of healthy eating is predicted to be higher at breakfast compared with dinner (estimate = -0.08, *SE* = 0.02, *p* < .001), higher at home than out-of-home (estimate = -0.08, *SE* = 0.02, *p* < .001), and lower with higher levels of tiredness (i.e. lower levels of energy; estimate = 0.04, *SE* = 0.01, *p* < .001) and higher levels of distractedness (i.e. lower levels of concentration; estimate = 0.07, *SE* = 0.01, *p* < .001). To illustrate the interpretation of these results, for distractedness, this means that a one unit decrease in the concentration level was associated with a 0.07-point decrease in self-regulation.

Second-level factors are also significant predictors of self-regulation of healthy eating. Higher levels of intrinsic motivation to eat healthy (estimate = 0.19, *SE* = 0.04, *p* < .001) and higher levels of self-efficacy to eat healthy (estimate = 0.41, *SE* = 0.04, *p* < .001) predicted higher levels of self-regulation of healthy eating. The reported estimates are unstandardised.

Additionally, in total 595 of the 4862 measurement moments were filled in after the meal moment. To be sure that the results are not largely influenced by retaining these 595 measurement moments, we ran our model with and without these moments. Results show that the significant effects remain the same, with one exception, namely, that the second-level predictor social opportunity goes from being marginally significant (*p* < .1) to being significant (*p* < .05) when the 595 moments were excluded. The additional effect is in line with our expectations, namely, that when participants regard their social environment as less of a barrier to eat healthy, their self-regulation to eat healthy is higher.

The results of the random effects show that the slope of both tiredness (variance = 0.006; *p* < .001) and distractedness (variance = 0.012; *p* < .001) significantly vary across participants. Moreover, there is a negative correlation between the intercept and the slope of feelings of tiredness (*r* = -0.034) and distractedness (*r* = -0.63), indicating that if the intercept of a

TABLE 2 Estimated model fixed effects

	Self-regulation			Confidence intervals	
	Estimate	SE	t		
Fixed effects				2.5%	97.5%
Intercept	1.48	0.20***	7.317	1.09	1.88
First level					
Meal moment1 (breakfast, lunch) ^a	-0.03	0.02	-1.258	-0.07	0.01
Meal moment2 (breakfast, dinner) ^a	-0.08	0.02***	-3.455	-0.12	-0.03
Social environment (alone, with others) ^b	0.04	0.02	1.692	-0.01	0.08
Physical environment (at home, out-of-home) ^c	-0.08	0.02***	-3.372	-0.13	-0.03
Tiredness (1 “tired”–7 “energetic”)	0.04	0.01***	4.730	0.02	0.05
Distractedness (1 “distracted”–7 “focused”)	0.07	0.01***	6.585	0.05	0.09
Second level					
Intrinsic motivation	0.19	0.04***	5.324	0.12	0.26
Self-efficacy	0.41	0.04***	11.038	0.33	0.48
Physical opportunity	-0.03	0.03	-1.147	-0.08	0.02
Social opportunity	0.04	0.03	1.770	-0.005	0.09

Note: *p*-values estimated via *t*-tests using the Satterthwaite approximations to degrees of freedom; confidence intervals determined with the Wald method.

^aBreakfast is coded 0, and lunch and dinner are coded 1.

^bAlone is coded 1, and with others is coded 2.

^cAt home is coded 1, and out-of-home is coded 2.

p* < .05. *p* < .01. ****p* < .001.

TABLE 3 Estimated model random effects

Grouping	Effect	Variance	SD	Correlation
Username	Intercept	1.02	1.01	
	Tiredness (1 “tired”–7 “energetic”)	0.006	0.076	-.34
	Distractedness (1 “distracted”–7 “focused”)	0.012	0.108	-.63
Residual		0.273	0.522	.18

participant increases by one unit of standard deviation, the participant's slope decreases by, respectively, 0.34 and 0.63 standard deviations.

Model comparison

We examined to what degree adding Levels 1 and 2 predictors to the model would improve model fit. In a step-down procedure, we fitted a model without any predictors (Model 1), a model with only Level 1 predictors (Model 2), and a model with both Levels 1 and 2 predictors (Model 3) and then carried out likelihood ratio tests between these three nested models, as well

TABLE 4 Model comparison of Models 1–3

Model	<i>df</i>	AIC	BIC	logLik	Deviance	X^2	X^2 <i>df</i>	<i>p</i>
Model 1 (no predictors)	3	10,429	10,448	−5211	10,423			
Model 2 (Level 1 predictors)	14	10,252	10,343	−5112	10,224	198.62	11	<.001
Model 3 (Levels 1 & 2 predictors)	18	9916	10,032	−4940	9880	344.87	4	<.001

Abbreviations: AIC, Akaike information criterion; BIC, Bayesian information criterion.

as a comparison of Akaike information criterion (AIC) and Bayesian information criterion (BIC). See Table 4 for an overview.

The first model without predictors resulted in a BIC of 10,448. Adding first-level predictors improved the BIC (10,343) and significantly improved the model ($X^2 = 198.62$, $p < .001$). Moreover, adding second-level predictors further improved the BIC (10,032) and further improved the model significantly ($X^2 = 344.87$, $p < .001$).

DISCUSSION

The importance of contextual and temporal influences on psychological mechanisms that drive behavior is becoming more acknowledged (Inauen et al., 2016; Millar, 2017; Scholz, 2019). Understanding these influences can create a more accurate picture of what is needed to help consumers make healthier consumption choices in different contexts. The goal of the current study was to map how individuals differ in their healthy eating self-regulation from one another and within themselves across meal moments and to investigate whether differences within an individual (meal moment, tiredness, distractedness, social, and physical environment) and differences between individuals (self-efficacy, intrinsic motivation, and perception of social and physical opportunity) predict differences in healthy eating self-regulation.

Our results show that, as expected and in accordance with previous studies (Boland et al., 2013; Francis et al., 2020; Millar, 2017), the level of self-regulation of healthy eating varies both within and between individuals. With regard to temporary fluctuations in self-regulation, we found that self-regulation was higher at breakfast than at dinner (partly confirming H1). This is in line with Millar (2017) and Masterson et al. (2016) who discuss that self-regulation in the evening is influenced by impairing factors, such as fatigue. Moreover, this “time of day” effect may be explained by the fact that individuals think about eating and want to eat more in the evening compared to the morning (Masterson et al., 2016) and that an individual’s physiological cravings will likely increase later during the day (Millar, 2017). However, no indication has been found that self-regulation is higher at breakfast than at lunch (partly rejecting H1). Possibly, the drop in self-regulation between breakfast and lunch is more gradual, and therefore, no difference was found between breakfast and lunch. This lack of difference may also be explained by the similarity between breakfast and lunch in the Netherlands as both are often cold and include bread.

As expected, self-regulation is found to be negatively influenced by feelings of distraction and tiredness (confirming H2 and H3). This is in accordance with the literature that states that self-regulation declines during the day as individuals become more tired (Millar, 2017) and that distraction also negatively affects self-regulation as it hinders individuals in monitoring their behavior and in reaching their goals (van Dillen et al., 2013).

Finally, concerning eating context, our results show that self-regulation is lower when consuming out-of-home as compared with at home (confirming H4). When consuming out-of-home, individuals might have more access to unhealthy foods (de Vet et al., 2013), and therefore, individuals have more difficulty to self-regulate healthy eating behavior (Orbell & Verplanken, 2015). However, unexpectedly, we found no indication for an effect of social context on self-regulation (rejecting H5), even though it was expected that a lack of social standards when eating alone would impair self-regulation of healthy eating (de Ridder et al., 2013). Perhaps these social standards are still present when eating alone, even though they are less visible. From research on norms, it is known that when individuals are focused on social standards, they are likely to conform to these standards even when they are alone (Reno et al., 1993). Another explanation could be that social standards that are experienced with others can spill over to when individuals eat alone (Bech-Larsen & Kazbare, 2014), resulting in no differences in self-regulation when eating alone or when eating with others.

In addition to these within-individual predictors, several individual characteristics are found to be relevant in predicting self-regulation of healthy eating. Self-regulation is higher for individuals with a higher level of intrinsic motivation to eat healthily and a higher general feeling of self-efficacy regarding healthy eating (partially confirming H6). The important role of motivation (Teixeira et al., 2011) and self-efficacy (Bandura, 1991) in enabling self-regulation has been previously acknowledged. In contrast to our expectation and to Millar (2017), the level of self-regulation of healthy eating was not significantly predicted by the physical and social opportunity to eat healthily (partially rejecting H6). An explanation for this finding is that we operationalized physical and social opportunity as a stable factor, whereas Millar (2017) describes it as a contextual factor. Apparently, the availability of healthy food in general and general behavioral patterns of important others (e.g. friends and family) regarding healthy food are not predictive for context-specific levels of self-regulation.

Implications

The current study has both theoretical and practical implications. First, this study is one of the few studies that investigates the influence of temporal factors on the level of healthy eating self-regulation, which advances our knowledge of self-regulation and how it can change in different contexts (Scholz, 2019). Our results also have the potential to advance tailored and personalized nutrition advice. Self-regulation plays an important role when it comes to adhering to an advice (Noar et al., 2007), as it seems to be an important mechanism that contributes to declining the intention-behavior gap (Millar, 2017). Moreover, it has been argued that the day-to-day variance within individuals could be more important for personalized dietary advice than the inter-individual differences that separate people (Betts & Gonzalez, 2016). Therefore, the outcomes of this study on temporal influences on self-regulation of healthy eating could be used in personalized or tailored dietary advice and, as such, lead to more effective advice in terms of healthy dietary choices.

Limitations and future research

While this study presents valuable insights, it also has limitations. First, the repeated measurements that we used during weekdays may have only partly uncovered within-individual

differences in self-regulation over time. Future research should focus on fluctuations in self-regulation not only during the day but also during the week (Millar, 2017). Interesting in that respect is that previous research linked consecutive nights of inadequate or inconsistent sleep to increased psychological strain and poorer self-regulation towards the weekend (Barber & Munz, 2011). Thus, with insufficient sleepover consecutive weeknights, it can be expected that the cumulative effects of fatigue will become more pronounced later in the week. This is concerning, especially because social opportunities for various temptations typically arise more often on Thursday, Friday, and Saturday nights (Dvorak et al., 2016).

In addition, our study does not demonstrate causality. Although this observational longitudinal study enables us to disentangle between- and within-individual relationships with self-regulation measured at different moments in time, this study has no experimental design in which a treatment is assigned and which allows us to establish causal effects. We recommend future research to include longitudinal experimental studies where variables of interest are manipulated to obtain further insight into how they may affect fluctuations in self-regulation at different points in time.

Furthermore, our sample was slightly biased towards more women and highly educated individuals despite our efforts to reduce dropout with extra incentives. The observation that men and less educated participants tend to drop out more often than women and more educated individuals is something that is more commonly found in online survey research (Ross et al., 2003). However, this bias should be taken into account when interpreting the results. Moreover, the measures in our study were self-reported. Even though our study design tried to minimize response bias by asking participants about their situation and feelings at that specific time, participants may have exhibited social desirability in their reporting. Future research could test whether similar results are obtained when self-regulation is measured more objectively, for example, by taking actual food choices into account. Furthermore, the measurement items used to measure self-regulation of healthy eating behaviors (Kliemann et al., 2016) have not been validated in a longitudinal study design examining, for example, the responsiveness to change. Therefore, it is possible that this has influenced our results, as there are indications that repeated measurements are more sensitive to change than single measurements (Moore et al., 2016). However, we did use more than three items to measure self-regulation, which is recommended for the reliability and validity of complex constructs measured repeatedly (Trull & Ebner-Priemer, 2020). Moreover, we controlled for order effects of the three meal moments by using a Latin Square design.

Additionally, the factors that we regarded as between-individual differences, measured only at the baseline (i.e. intrinsic motivation to eat healthy and self-efficacy), can also vary over time (Millar, 2017). We included these factors as stable characteristics of individuals, in order to research whether self-regulation of healthy eating shows different patterns across contexts for different types of individuals regarding their overall position towards healthy eating. However, it would be interesting for future research to investigate how motivation and ability vary across contexts.

Another limitation of this study is that self-regulation with regard to healthy eating was measured on a general level. Future research may further distinguish between self-regulation for more specific types of healthy eating behaviors to identify how self-regulation may temporarily differ for different types of (un)healthy food choices. For example, people differ in their preferences for sweet or savory meals or snacks, and the taste of a certain meal significantly altered the preference for certain types of food that followed according to their taste properties; that is, after a savory meal, intake of sweet foods tend to be preferred and vice versa (Griffioen-Roose et al., 2012).

Finally, in this study, we specifically focused on self-regulation as we believe this is an important variable that could play a role in closing the intention–behavior gap for dietary behaviors. Although we think that looking at self-regulation is worth examining in itself, we recommend future research to investigate how temporal fluctuations in self-regulation relate to temporal fluctuations in healthy eating intentions and behavior. Follow-up studies should therefore also include intention and behavior as extra repeated measurements.

CONCLUSION

This study shows the added value of including within-individual predictors in addition to between-individual predictors in understanding self-regulation of healthy eating. More specifically, the level of self-regulation of healthy eating is found to be higher at breakfast than at dinner, higher at home than outside the home, and lower with higher levels of tiredness and distraction. Insights gained from this research advance our knowledge regarding temporal influences on self-regulation and can provide input to further enhance dietary advice.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

ETHICS STATEMENT

Informed consent was obtained from all individual participants included in the study. The study was reviewed and approved by the Social Sciences Ethics Committee of Wageningen University & Research, and the study complies with the Netherlands Code of Conduct for Research Integrity.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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ENDNOTES

¹ Initially, we also hypothesised that self-regulation is higher during lunch than during dinner. However, on the basis of the literature, we can only compare breakfast with lunch and breakfast with dinner (Khare & Inman, 2006). We had no reason to expect anything from lunch compared with dinner, so we decided to drop this hypothesis.

- ² We also initially hypothesised that experiencing an abnormal day negatively influences self-regulation. Although the results revealed that having an abnormal day lowers self-regulation, we removed this from the analyses, because we believe that measuring experiencing an abnormal day in our study did not give a clear picture of someone's actual experience of that day. Our initial hypothesis was that an abnormal day would cost more cognitive resources; however, on the basis of how we measured "abnormal day," we cannot know for certain whether this is the case. Moreover, we believe that our measurements of feelings of distraction and tiredness more accurately measure how someone is actually feeling and whether someone is cognitively drained.
- ³ Exploratory factor analyses (EFAs) and reliability analyses were performed on the between-level constructs that were measured with multiple items, to check whether the scales reliably measure a certain construct. EFA showed that the items measure one construct, and the reliability per construct is mentioned in the text.
- ⁴ For further reading on multilevel modeling with longitudinal data, the authors refer to Hoffman (2015) or Bolger and Laurenceau (2013).
- ⁵ At Level 1, Y_{ij} refers to an individual observation of the dependent variable at Level 1. Subscript i refers to the observation, subscript j refers to the group, in this case, the participant. β_{0j} refers to the intercept of the dependent variable in j . β_1 – β_4 refer to the fixed regression coefficient between the Level 1 predictors and the dependent variable, and β_{5j} – β_{6j} refer to the slope for the relationship in j between the Level 1 predictor and the dependent variable. Finally, e_{ij} refers to the random errors of prediction for the Level 1 equation. With regard to the Level 2 equations, γ_{00} refers to the overall intercept, γ_{01} – γ_{04} refer to the fixed regression coefficient between the dependent variable and the Level 2 predictor, and u_{0j} refers to the random error component for the deviation of the intercept of a group from the overall intercept. Furthermore, γ_{50} and γ_{60} refer to the random slope between the dependent variable and the Level 1 predictor, and u_{5j} and u_{6j} refer to the error component for the slope.
- ⁶ Interaction-terms between the different variables were also explored, however, results indicated no significant interaction-effects. Moreover, when we add demographic factors into the model as fixed factors (sex, age, education and region) significant results remain the same.

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