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The effect of hunger on emotions and the moderating role of reward and punishment sensitivity

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Abstract

As dieting has become an increasingly normal part of everyday life, many young women must deal with the feeling of hunger on a regular basis. In line with people's common experiences, former research has already found hunger to negatively affect human emotions. While increases of negative emotions had been found in different studies, studies on the effects of hunger on positive emotions on the other hand have revealed more mixed results. This current study therefore examined the effect of hunger on positive and negative emotions in a sample of female undergraduate students with a BMI of > 18.5. Furthermore, as the concepts of Reward and Punishment Sensitivity have already been investigated in the setting of dietary behavior and restrained eating, this study also investigated the possible influences of the concepts on the relationship between hunger and emotions. The participants in this study were recruited through the SONA system of the University of Groningen. They answered the Profile of Moods States twice, once in an online condition when satiated (having eaten something within the last 2 hours) and once in a laboratory setting after having fasted for at least 14 hours. In the laboratory they also answered questions from the Reward and Punishment Responsivity and Motivation Questionnaire. It was found that participants scored higher on negative emotions (Tension, Fatigue, Confusion, Depression, and Anger) and lower on positive emotions (Vigour and Esteem-related affect) when hungry compared to when being satiated. Reward and Punishment Sensitivity were not found to significantly differ this relationship. This study therefore adds to the supporting evidence that hunger negatively affects emotions. It also provides first insights into the role of Reward and Punishment Sensitivity in the research context of hunger and emotions.

Keywords: hunger, emotions, punishment sensitivity, reward sensitivity

The effect of hunger on emotions and the moderating role of reward and punishment sensitivity

Dieting has become an increasingly normal part of everyday life, especially among young women (Wardle, Haase & Steptoe, 2006). Thus, many young women must deal with the feeling of hunger and its accompanying effects on a fairly regular basis. One such effect, that people seem to commonly experience, is that hunger negatively affects their overall mood (MacCormack and Lindquist, 2018). Past research studying the connection between hunger and emotions also already reported supporting evidence for hunger affecting both negative and positive emotions. A 21-day experience sampling phase, for example, in which individuals indicated their hunger, irritability, anger, and arousal at five-time points each day, reported to have found greater levels of self-reported hunger to be associated with feelings of anger and irritability (Swami et al., 2022). Furthermore, women who had fasted for one or two days every eight days over a time period of 48 days reported to feel more nervous, more tired, less strong, and less happy on those days compared to normal eating days (Wojciak et al., 2014). Additionally, low glucose levels due to food deprivation were found to be linked to greater aggression and tiredness (Bushman et al., 2014).

Regarding the effect of hunger on positive emotions, there is supporting evidence that hunger reduces positive emotions, as a study that compared a satiated group of healthy weight female undergraduates with a group that fasted for 14 hours and found that the hungry group reported fewer positive emotions than the satiated group (Ackermans, 2022).

Many other studies that looked at positive and negative emotions separately, however, reported more mixed results and partly even revealed contrasting evidence to the former findings. A study conducted on a group of smoking women, for example, reported that the women showed reduced positive emotions after an 18 hour fasting period but also revealed that the women had no changes in negative emotions (Kendzor et al., 2008). Similarly, a

study on healthy weight females found the females to show no changes in positive emotions after a 20-hour fasting period but an increase in negative emotions (Moreno-Dominguez et al., 2012). Moreover, in a study conducted on fasting women during Ramadan the female participants surprisingly even reported to have an overall better mood during the fasting period than before it (Molavi et al., 2016).

As there are many different possible factors that could have influenced the relationship between hunger and emotions and led to these mixed findings, the current study suggests the investigation of one of these factors, namely the concepts of reward sensitivity (RS) and punishment sensitivity (PS). Former empirical research has already shown that both RS and PS can be related to an individual's dietary behavior (Jonker et al. 2021).

RS refers to an individual's tendency to show more approach behaviour in response to cues of reward, to respond more positively to reward, and to pay more attention to cues of reward (Gray & MacNaughton, 2000. RS was found to be linked to an increase in an individual's perceived dieting success through increasing the rewarding value of food restriction, thereby facilitating it (Bergh and Södersten, 1996).

PS refers to an individual's tendency to show more avoidance behaviour in response to cues of punishment, to respond more negatively to punishment, and to pay more attention to cues of punishment (Gray & MacNaughton, 2000). PS was found to be linked to restrained eating (Jappe et al., 2011) by relating to a stronger fear of becoming fat as well as to general concerns of dieting (Dalley, 2016).

Based on these findings, the current study suggests that RS and PS could be important moderators in the effect of hunger on emotions. We suggest that RS might lead to a weaker negative influence of hunger on emotions because the hunger feeling might be perceived as a cue for the rewarding value of the effects of dieting (e.g. weight loss, improved body shape). Hunger might therefore be seen as a "step in the right direction", which subsequently might

decrease its negative impact on a person's overall mood. PS on the other hand is expected to increase the negative influence of hunger on emotions, because hunger might be perceived as a cue for the punishing value of the effects of dieting ("food restriction to avoid becoming fat"), which would elicit extra negative emotions.

This current study hypothesizes, first, that individuals in a hungry state show more negative and, secondly, fewer positive emotions than when they are satiated. Third, individuals in a hungry state with higher RS are expected to show less negative and more positive emotions compared to individuals in a hungry state that are lower in RS. Fourth, individuals in a hungry state with higher PS are expected to show more negative and less positive emotions compared to individuals in a hungry state with lower PS.

Method

Participants

Eligible participants for the study were female individuals with a minimum BMI of 18.5. A total of 142 participants had completed both parts of the study of which 93 were used in the analysis. The participants were recruited through the SONA research system of the University of Groningen. Most of the participants in the analysis (n = 96) were undergraduate students from the University of Groningen and they were compensated with course credits for completing the study. The remaining participants (n = 9) signed up through the paid research pool of the University of Groningen and received financial compensation for their participation. The participants used in the analysis had an average BMI of 22.7 (SD = 3.02).

A power analysis for repeated measures MANCOVA with two levels of the independent variable, two dependent variables, and four covariates revealed a required sample size of 128 to reach an effect size of 0.20 with an alpha level < 0.05 and a power of 0.8. With 93 participants we could detect an effect size of 0.12.

Materials

Hunger. To assess hunger, the participants were first asked to indicate how long it had been since the last time they ate something with the question "How long has it been since the last time you ate" from the Hunger Scale (Grand, 1968). They indicated their scores in hours and minutes. After that, participants were asked the question "How hungry are you right now" from the Hunger Scale, which they answered on a scale from 1 ("Not hungry at all'') to 7 ("Extremely hungry'').

Positive and negative emotions. Participants' positive and negative emotions were assessed using the Profile of Moods States (POMS; Grove & Prapavessis, 1992). The POMS is a 40 items rating scale in which individuals can indicate how much each item applies to them from 0 ("Not at all") to 4 ("Extremely"). Each item is a different emotion belonging to one of 7 subscales. The subscales are Tension (6 items, e.g. "tense" and "uneasy"; Cronbach's alpha = .83), Anger (6 items, e.g. "angry" and "annoyed"; Cronbach's alpha = .78), Fatigue (5 items, e.g. "fatigued" and "worn out"; Cronbach's alpha = .86), Depression (7 items, e.g. "hopeless" and "miserable"; Cronbach's alpha = .91), Confusion (5 items, e.g. "confused" and "unable to concentrate"; Cronbach's alpha = .66), Esteem-related affect (6 items, e.g. "proud" and "competent"; Cronbach's alpha = .63), and Vigour (5 items, e.g. "lively" and "energetic"; Cronbach's alpha = .79).

For the analysis, the scores for the five negative subscales (Tension, Anger, Fatigue Depression, and Confusion) were summed to create a score for "Negative Emotions" for each participant in each hunger state (satiated and fasted). The same was done for the two positive subscales (Esteem-related affect and Vigour) to create a score for "Positive Emotions" for each participant in each hunger state (satiated and fasted).

Reward and punishment sensitivity. To assess reward and punishment sensitivity the Reward and Punishment Responsivity and Motivation Questionnaire (RPRM-Q; Jonker et al., 2022) was used. The RPRM-Q is an 18-item questionnaire designed to measure responsivity

to and motivation for reward and punishment. Each item is a statement referring to one of four factors. The factors are Reward Responsitivity (RR; 4 items, e.g. “Winning makes me enthusiastic”; Cronbach’s alpha = .73), Motivation to Approach Reward (MR) (5 items, e.g. “I go out of my way to get things I want”; Cronbach’s alpha = .76), Punishment Responsitivity (PR; 5 items, e.g. “I feel lousy after doing something wrong”; Cronbach’s alpha = .82) and Motivation to Avoid Punishment (MP; 4 items, e.g. “I do everything in my power to avoid receiving punishment”; Cronbach’s alpha = .74). Individuals can indicate how much each statement applies to them on a 5-point scale ranging from 1 (“This does not apply to me at all”) to 5 (“This applies to me completely”).

For the analysis, the scores on the items of the four factors were summed to create a score for RR, RM, PR, and PM for each participant.

Procedure

The current study was approved by the ethical committee of the psychology department of the University of Groningen (PSY-2122-S-0426).

The participants completed the study in two parts. They first filled out an online questionnaire and then took part in a laboratory experiment. They were instructed to eat at least 2 hours before the online part to make sure they were in a satiated state. Therefore, they met with a researcher via Google Meet and filled out the online questionnaire where they first gave their informed consent to participate in the research and then indicated in hours and minutes the time since they last had eaten. Afterward, the participants answered the questions on the Hunger Scale and filled out the POMS and eventually they made an appointment for the laboratory experiment, for which the researcher would instruct them not to eat anything for 14 hours and not to drink alcohol for 24 hours prior to coming to the laboratory.

When arriving in the laboratory, a researcher would ask each participant if she had complied with the fasting instructions. If she did, she would be able to proceed with the

study. If not, she would be asked to make a second appointment for another time. During the laboratory study, the participants then filled out the hunger scale and the POMS for the second time, and additionally also answered the RPRM-Q. At the end, participants' height and weight were measured to calculate their BMI. The laboratory part subsequently also entailed an experiment concerning emotion regulation and food intake, but this is not relevant to the current thesis.

Analysis Plan

To check the participants compliance to the fasting instructions, the question "How long has it been since the last time you ate?" from the Hunger Scale (Grand, 1968) was used. The participants indicated their scores in hours and minutes. The participants were instructed to eat within at least 2 hours prior to answering the online questionnaire, and they had to fasten for at least 14 hours to participate in the laboratory part of the study.

A manipulation check was performed by examining group differences in the participants' last eating time using a paired-sample t-test.

To examine whether hunger resulted in an increase in negative emotions or positive emotions, a repeated measures multivariate analysis of variance (MANOVA) was performed with state hunger (satiated and fasted) as the independent variable and the summed scores for negative and positive emotions as dependent variables. All MANOVA assumptions were checked and reported if they were not met.

To assess whether RS and PS influenced the relationship between the participants' hunger and their positive and negative emotions respectively, a repeated measure multivariate analysis of covariance (MANCOVA) was performed with participants' hunger as an independent variable, their positive and negative emotion scores as dependent variables and RR, RM, PR, and PM as covariates.

Results

Compliance and Manipulation Check

Based on the compliance check, 48 participants were excluded because they failed to adhere to the fasting condition for either the online (eating within < 2 h) or the laboratory part of the study (fasting > 14 h) or both. One additional participant was excluded because she fell below the required minimum BMI of 18.5.

Regarding the manipulation check, as expected, the participants showed a significant difference with large effect between the two hunger states (hungry vs satiated) in the time since they had last eaten $t(92) = -83.7$, $p < .001$, 95% CI [-14.83; -14.15], $d = 1.67$, as well as in their reported hunger feeling $t(92) = -17.61$, $p < .001$, 95% CI [-3.30; -2.63], $d = 1.62$.

Descriptive statistics

The participants had an average BMI of 22.81 ($SD = 3.09$) with most of them ($N = 73$) being between 17 and 21 years of age. The rest ($N = 20$) was over 21.

Does hunger increase negative emotions?

In the fasting state, participants scored higher on negative emotions compared to when they were satiated and this effect was large ($F(1, 92) = 10.02$, $p < .001$, Wilk's $\Lambda = .64$, $\eta_p^2 = .36$).

Regarding each emotion separately, the participants, when fasted, showed a significant difference in Confusion $F(1, 92) = 7.83$, $p = .006$, $\eta_p^2 = .078$, Fatigue $F(1, 92) = 12.94$, $p < .001$, $\eta_p^2 = .123$, and Anger $F(1, 92) = 30.64$, $p < .001$, $\eta_p^2 = .25$ compared to when they were satiated. The mean POMS scores for each negative emotion per hunger state are depicted in Fig. 1, and raw scores can be seen in the Appendix.

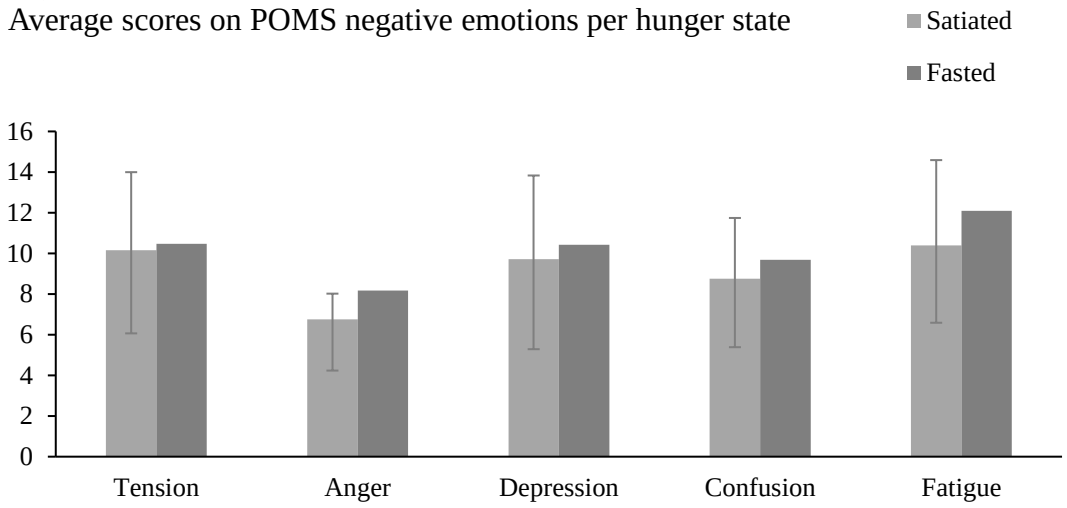
Does hunger decrease positive emotions?

Participants in the fasting state scored lower on positive emotions compared to when they were satiated and this effect was large ($F(1, 92) = 18.72$, $p < .001$, Wilk's $\Lambda = .71$, $\eta_p^2 = .29$).

Regarding each emotion separately, the participants, when fasted, showed a significant difference in both Vigour $F(1, 92) = 31.70$, $p < .001$, $\eta_p^2 = .25$, and Esteem-related affect $F(1, 92) = 21.44$, $p < .001$, $\eta_p^2 = .19$ compared to when they were satiated. The mean POMS scores for each positive emotion per hunger state are depicted in Fig. 2, and the raw scores can be seen in the Appendix.

Figure 1

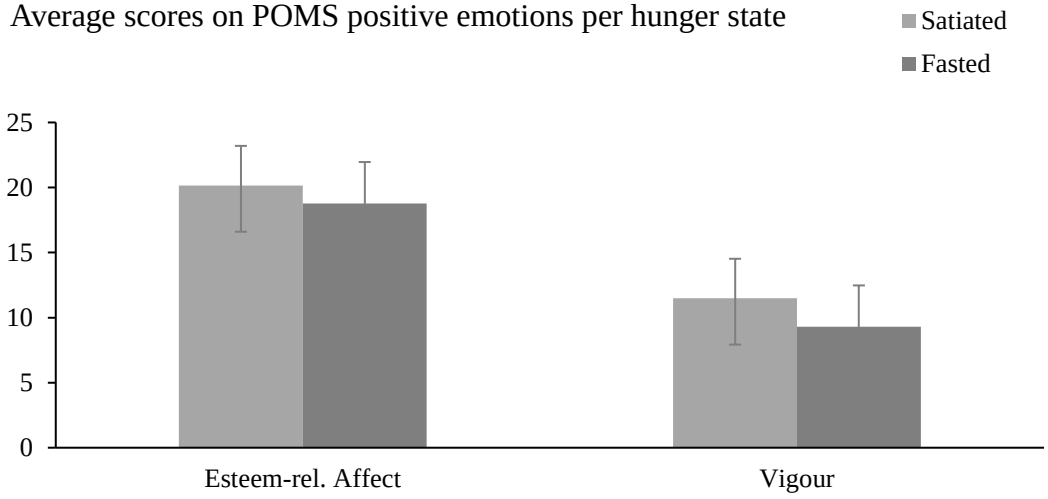
Average scores on POMS negative emotions per hunger state



Note. Error bars represent standard deviations.

Figure 2

Average scores on POMS positive emotions per hunger state



Note. Error bars represent standard deviations.

Is there a difference in the relationship between negative emotions and hunger due to RS/PS?

There was no significant difference found in the relationship between state hunger (fasted and satiated) and negative emotions when RR, RM, PR, and PM were added as covariates ($F(1, 88) = .25$, $p = .62$, $\eta_p^2 = .08$).

Regarding each of the covariates seperately, neither RR ($F(1, 88) = .332$, $p = .56$, $\eta_p^2 = .02$), nor RM ($F(1, 88) = .19$, $p = .02$, $\eta_p^2 = .26$), nor PR ($F(1, 88) = .12$, $p = .73$, $\eta_p^2 = .001$), nor PM ($F(1, 88) = .03$, $p = .95$, $\eta_p^2 = .00$) were found to be signficiantly associated with differences in negative emotions.

Is there a difference in the relationship between positive emotions and hunger due to RS/PS?

There was no significant difference found in the relationship between state hunger (fasted and satiated) and positive emotions when RR, RM, PR, and PM were added as covariates ($F(1, 88) = .42$, $p = .52$, $\eta_p^2 = .005$).

Regarding each of the covariates seperately, neither RR ($F(1, 88) = 2.12$, $p = .15$, $\eta_p^2 = .02$), nor RM ($F(1, 88) = 1.65$, $p = .20$, $\eta_p^2 = .02$), nor PR ($F(1, 88) = .37$, $p = .54$, $\eta_p^2 = .004$), nor PM ($F(1, 88) = .07$, $p = .79$, $\eta_p^2 = .001$) were found to be signficiantly associated with differences in positive emotions.

Discussion

This study found that, as expected, hunger induced by a 14-hour fasting period leads to an increase in negative emotions and a decrease in positive emotions. The participants' scores in Reward- and Punishment Sensitivity, specifically their scores in Reward Responsivity, Motivation to Approach Reward, Punishment Responsivity and Motivation to Avoid Punishment, however, were not found make a difference in the relationship between hunger and emotions.

The findings of this study concerning the negative influence of hunger on emotions enqueue with what previous research had already found (Ackermans, 2022; MacCormack &

Linquist, 2018), namely, that hunger had already been shown to increase negative emotions, as well as to decrease positive emotions (Ackermans, 2022; MacCormack & Linquist, 2018). This study found an increase in each negative emotions of the POMS subscales when the participants were fasted compared to when they were satiated. The smallest effect was found on depression, the highest on anger. Only for anger, fatigue and confusion significant effects were found. This goes along with former findings that had found no score difference for depression when comparing a fasted group of participants with a satiated one, but an increase for each other negative emotion including anger (Ackermans, 2022). The findings on anger (high-arousal emotion) and depression (low-arousal emotion) might go together with the regulatory depletion hypothesis, which states that high-arousal emotions are difficult to regulate in a hungry state (MacCormack & Lindquist, 2018). The significant effect on fatigue on the other hand might be explained by the participants' lower glucose levels due to the fasting, which had already been linked to greater aggression and tiredness (Bushman et al., 2014)

For the increase in negative emotions through hunger in general, there is also the psychological constructionist theory, according to which the presence of a negative context brings hunger to be interpreted as a negative emotion (MacCormack & Lindquist, 2016). It could be the case that the laboratory setting was interpreted as such a negative context by the participants, but since subjective experience was not part of this study, it remains unclear.

The decreasing effect of hunger on positive emotions found in this study was also in line with former research that had found hunger decreasing vigour and esteem-related affect (Ackermans, 2022). Vigour, as a high-arousal emotion could go along with the regulatory depletion hypothesis. As for esteem-related affect, it might be an important finding that there is a possible reducing effect through hunger, because low self-esteem had already been linked to being a risk factor for disturbed eating and eating disorders (Ghaderi, 2001). If according

to the findings of this study hunger itself would reduce self-esteem, it could be the starting point to a vicious cycle for people with eating disorders.

Regarding reward and punishment sensitivity, neither RS nor PS, or more specifically, none of the factors that were assessed in the RPRM-Q (RR, PR, RM, and PM) were found to have a significant effect on the relationship between hunger and positive emotions or hunger and negative emotions. While former research had related RS and PS to behavior during a fasting period, this study aimed at establishing a connection between RS and PS and an individual's emotion during a fasting period. As former studies had linked RS to successful food restriction (Bergh & Södersten, 1996), as well as to an increase in perceived dieting success (Jonker 2021), this study proposed that higher RS could also lead to a reduction of the negative impact of hunger on emotions. It was suggested that the rewarding value of food restriction (e.g. "staying in shape") might counteract the negative feeling induced by hunger. The reason this study could not find any significant results in that regard, might have something to do with the fact that the former studies had never directly established that the connection between RS and perceived dieting success or successful food restriction existed because higher RS increased the rewarding value of food restriction. Therefore, before further exploring the role of RS in emotions during a diet, it might be useful to first investigate whether higher RS actually facilitates the rewarding value of food restriction, or if an increase in the rewarding value of food restriction could lead to an increase in an individual's success in sticking to a diet.

This study's other suggestion, namely, that high PS might be linked to a stronger decrease in positive emotions when hungry, followed a similar premise. Former research had linked high PS to increased restrained eating (Jonker et al., 2021), as well as to more concerns and fears about the negative consequences of not dieting (Dalley, 2016). As the main commonality in these findings lay in the potential fear of the punishing values of food

intake (e.g. “becoming fat”), the current study suggested that there might be a direct connection between higher PS and negative emotions when hungry. It was suggested that individuals with higher PS might have even stronger negative emotions when hungry due to the hunger feeling working as a reminder of the punishing values of food restriction. Similar to the connection between RS and perceived dieting success, however, former research so far had focused on the relation between PS and a certain dietary behavior (like restrained eating) and not on an individual’s emotions during a diet. There had also not not been any evidence for the relationship between PS and restrained eating being based on PS eliciting negative affect. All of this together might explain the lack of significant findings in this current study.

Strenghts, Limitations and Future Research

The main strength of this study consisted first of all of the insight it gave into the potential role of an individual’s Reward and Punishment Sensitivity in the context of hunger and emotions compared to former studies that only looked at dietary behavior. It also created a more nuanced insight into the role of RS and PS and hunger by using the RPRM-Q which integrated assessments of the participants’ Reward Responsivity, Motivation to Approach Reward, Punishment Responsivity and Motivation to Avoid Punishment in the context of hunger research. This study furthermore experimentally manipulated hunger and thereby supported former findings that hunger not only influences negative emotions but also positive emotions. Additionally it investigated the impact of hunger on specific emotions and therefore allowed for more precise conclusions in that regard.

The study also had some limitations. The first was the usage of self-reports which always gives room to potential biases and inaccuracies due to participants not answering the questions truthfully. Another limitation was that the sample only included female participants, so it is unclear whether any of the findings generalize to men or other populations. Thirdly, the study did not control for any other potential factors that could have

influenced the participants' emotions besides hunger, such as general mental health issues, or personal history.

As mentioned before, regarding future research, it might be interesting to further investigate specifically the relationship between Reward Sensitivity and the rewarding value of food restriction. As Reward Sensitivity was suggested to decrease the negative effect of hunger on emotions through interpreting the hunger feeling as rewarding, it might be interesting to further explore if a subjective feeling in this sense can in fact adopt such rewarding properties. The same goes for the role of Punishment Sensitivity in the field of eating and emotions. I would be worth exploring if a hunger feeling can in fact adopt the punishing properies necessary to be regarded as a punishing cue of a general behavior like restrained eating. Lastly and closer related to this current study's design it could be promising to also examine the role of hunger on participants Reward and Punishment Sensitivity through comparing between individuals' fasted and hungry scores on the RPRM-Q.

Conclusion

This current study adds to the evidence that hunger negatively affects emotions. It showed supporting evidence that hunger due to a 14-hour fasing period increases negative emotions and decreases positive emotions in female participants. This study was also the first study to investigate Reward and Punishment Sensitivity in association with hunger and emotions. It suggested that higher Reward and Punishment Sensitivity would moderate the effect of hunger on emotions but could not produce significant supporting evidence for that.

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Appendix

Average sum scores on the POMS scale per hunger state

	Satiated		Fasted	
	Mean	SD	Mean	SD
Tension	10.15	3.87	10.47	4.11
Anger	6.75	1.27	8.17	2.53
Depression	9.71	4.14	10.43	4.46
Confusion	8.75	3.01	9.69	3.38
Fatigue	10.39	4.22	12.09	3.82
Esteem-related affect	20.16	3.05	18.78	3.19
Vigour	11.48	3.57	9.30	3.02