WORLD JOURNAL OF PHARMACEUTICAL RESEARCH
SJIF Impact Factor 8.453
Volume 13, Issue 4, 26-36. Research Article ISSN 2277–7105

HUNGER, SATIETY AND MEAL ACCEPTABILITY: ASSOCIATIONS WITH MOOD, CARDIOVASCULAR FUNCTION, AND SELECTIVITY IN MEMORY AND ATTENTION

***Andrew P. Smith, PhD.**

School of Psychology, Cardiff University, 70 Park Place, Cardiff CF10 3AT, UK.

Article Received on
01 January 2024,

Revised on 22 Jan. 2024,
Accepted on 11 Feb. 2024

DOI: 10.20959/wjpr20244-31409

***Corresponding Author**
Dr. Andrew P. Smith, PhD.
School of Psychology, Cardiff University, 70 Park Place, Cardiff CF10 3AT, UK.

ABSTRACT

Background: There has been considerable research on hunger and food acceptability but much less on whether these are associated with mood and cognition. The present study investigated associations between ratings of hunger, satiety, meal acceptability, mood, cardiovascular function and selectivity in memory and attention. Previous analyses had shown that the selectivity measures were not sensitive to the consumption of lunch or the time of testing. **Method:** A parallel groups design was used, and 120 university students (50% male) participated in the experiment. Baseline measurements were taken between 9.30 and 11.30 am, and ratings of hunger were taken at this time. Volunteers were assigned to one of the following experimental conditions: (1) Pre-lunch testing, (2) Early afternoon post-lunch testing, (3) Early afternoon post- no lunch testing, (4) Late afternoon post-lunch testing, and (5) Late afternoon post-no lunch testing. In each session, mood was rated, pulse and blood pressure recorded, and tests measuring selectivity in memory and attention were carried out. Hunger was rated again in those participants who had no lunch. Satiety and meal acceptability were rated in the lunch conditions. **Results:** Baseline hunger ratings showed that participants were not very hungry at this time. Greater hunger was significantly associated with a more negative mood (lower alertness and hedonic tone scores). Hungrier participants also had a significantly lower category dominance effect. Hunger ratings were higher in those who had no lunch. Prior to their test session, greater hunger was associated with a more negative mood and reduced performance in the high-priority recall task. The mood effect and the priority effect were not related. Satiety ratings from those who consumed lunch were negatively correlated with

systolic blood pressure and with feeling less anxious. Satiety was also correlated with recall of order (the high-priority task). Acceptability ratings were correlated with a more positive mood (higher alertness and hedonic tone) and were negatively correlated with the priority effect in the order/location recall task. **Conclusion:** The present analyses demonstrated that ratings of hunger are associated with mood changes and that hunger also changes the effects of dominance and priority in memory. Satiety was associated with lower systolic blood pressure, feeling less anxious and a reduction in the priority memory effect. Higher acceptability ratings were associated with a more positive mood and a reduction in the memory priority effect. These results show that it is important to measure hunger, satiety and acceptability in studies of the effects of meals on mood and performance.

KEYWORDS: Hunger; Satiety; Meal acceptability; Lunch; Mood; Heart rate; Blood pressure; Selective Attention; Biased probability choice reaction time; Category Instances; Stroop Task; Task priority.

INTRODUCTION

There has been extensive research on the effects of lunch on mood and cognition.[1] Some effects, such as those observed with sustained attention tasks[2,3], are due to consumption of the meal. Research has shown that the type of lunch may influence performance. One study[4] showed that consuming a high carbohydrate lunch led to more focused attention, with reaction times being slower to targets in the periphery. In contrast, high-protein meals were associated with greater distraction.[4] Meal size is also important, with larger meals being associated with more occasional errors.[5] The size of the post-lunch dip is reduced by increasing arousal, and this has been demonstrated by using alerting noise[6,7] and by ingesting caffeine.[8] The present research examined associations between hunger, satiety, meal acceptability, mood, and tasks involving selectivity in attention and memory. This involved secondary analyses of data from a study of lunch and selectivity in memory and attention.[9,10] Lunch does not change the performance of these tasks[9,11], which makes them very suitable to examine the effects of food-related cognitions. Hunger, satiety, and acceptability may influence performance by changing physiology, resource allocation, task-related cognitions, or mood. Mood and cardiovascular measures were also taken to examine certain underlying mechanisms.

The cognitive tasks used were taken from research on the effects of noise and selectivity.[12-15] Selectivity in memory can be measured using a category instances verification task, and this

was used in the present study.[16] A category name is shown (e.g. An animal) followed by either a good example of that category (e.g., Cat) or a weaker example (e.g., Ferret). A longer time is taken to verify the weaker example, and this effect was found to be greater when performing in noise. Task priorities can also be given (e.g. one feature of a list of words has a high priority, e.g. order of presentation, and another, e.g. location of presentation, has a lower priority). Noise improves recall of high-priority information at the expense of information with a lower priority, and this task was used here.[17] Noise has been shown to reduce the effect of a distracting colour name in the Stroop Colour-Word test[18], and this task was used in this study. A biased probability choice reaction time task was also used. One stimulus is more probable than the others, and reaction times to the more probable stimulus are faster. This effect of a biased probability is greater when the person performs in noise.[19] In summary, the present research used tasks known to be sensitive to changes of state produced by noise to investigate whether differences in selectivity in memory and attention were associated with ratings of hunger, satiety and meal acceptability. Analyses of baseline data identified the expected significant indicators of selectivity in attention and memory. Consumption of lunch also increased heart rate, and mood varied as a function of combinations of times of testing and consumption of lunch. This shows that a sensitive methodology was used, but there were no significant main effects of lunch or time of day on selectivity in memory and attention. Further analyses also failed to find any significant interactions between personality, lunch and time of day. These results suggest that any associations with hunger, satiety and acceptability are unlikely to reflect the direct effects of the meal or time of testing on selective attention and memory.

METHOD

A detailed account of the methodology has been given in earlier papers[9,10], and the next section summarises the main points.

The study was carried out following approval from the Psychology Ethics Committee and the informed consent of the participants.

Study Design

Participants were familiarised with the procedure prior to the test session. Baseline data were collected on the morning of the test day, starting at either 09.30 or 10.30. Participants were allocated to one of the experimental conditions (24 participants, half male, in each condition):

- pre-lunch group (session started at either 11.30 or 12.30).

- afternoon group, 1-hour post-lunch (session started at either14.15 or 15.15).
- afternoon group, 2-hours post-lunch (session started at either 15.15 or 16.15).
- afternoon group, no lunch, 1 hour after break (session started at either 14.15 or 15.15).
- afternoon group, no lunch, 2 hours after break (session started at either 15.15 or 16.15).

Participants

One hundred and twenty university students (mean age of 20.4 +/- 2.4 years) participated in the study.

Nature of the meal

Lunch consisted of a two-course meal at the university refectory.

Measurement of blood pressure and heart rate

Heart rate and blood pressure were measured before the test battery.

Mood rating

Subjective mood was rated both before and after the battery of performance tasks. Bi-polar visual analogue mood rating scales (e.g., Drowsy-Alert, Happy-Sad, Tense-Calm) were used. These scales have three factors: Alertness, Hedonic tone and Anxiety.

Four-choice biased probability reaction time task.

This task involved the presentation of one of four letters: A, B, C or D. The stimuli were presented in the four corners of the computer screen. Responses were made by pressing the appropriate key on a response box. One of the letters was presented twice as often as the others. A difference score (mean RT less probable keys – mean RT high probability key) was used in the present analyses.

Memory for high/low priority information

Eight words were presented one after another in one of the four corners of the screen (two per corner). The high-priority task was to recall the order in which the words were presented, and the low-priority task was to recall the location of the words. A difference score (mean order correct – mean location correct) was used in the present analyses.

Category Instances Task

A category name (e.g. Animal) was shown on the screen, followed by either a dominant instance of that category (e.g. Dog) or a non-dominant instance (e.g. Mole) or a non-instance

(e.g. Chair). The participant had to respond "True" if an instance was shown and "False" if it was not an instance of the category. A difference score (Non-dominant RT – Dominant RT) was used in the present analyses.

Stroop task

This task had four conditions and involved responding to colours or colour names. In the simple conditions, participants responded to patches of colour (C; red, blue, green and yellow) and to colour names (W) in black ink. In one interference condition (CI), participants had to respond to the colour and ignore a distracting word, e.g., RED – correct response blue). In the other distraction condition (WI), they had to respond to the word and ignore the distracting colour (e.g., RED – correct response red). The participant pressed the appropriate keys corresponding to each colour on a response box. Difference scores were used in the present analyses (mean RT CI-mean RT C; mean RT WI- mean RT W).

Personality Questionnaires

Based on our research on selective attention and personality,[20] the following personality dimensions were measured: Obsessional personality,[21] Extraversion,[22] Impulsivity,[22] Sociability,[22] and Trait anxiety.[23]

Ratings of hunger, satiety and meal acceptability

Hunger, satiety and meal acceptability were rated using 100mm visual analogue scales. The hunger rating was carried out at all sessions, and the satiety and acceptability ratings were at the start of the session after lunch.

Analysis strategy

Initial analyses compared the experimental conditions to see if they differed in psychosocial scores, health-related behaviours, and baseline measures. The baseline performance of the selective attention and memory tests, mood and cardiovascular measures was analysed to check that the selective attention and memory effects were present and that there were no differences between the groups at baseline. These analyses are described in detail in an earlier paper.[9]

Correlational analyses were used here. The first analyses examined associations between the outcome measures to determine whether these variables were independent or related. Correlations between hunger ratings prior to the baseline session and the baseline outcomes

were then computed (N=120). This was then repeated for the test session, with hunger ratings being provided by those who did not have a meal before the test session (N=72). Finally, correlations between the satiety and acceptability ratings and the test session scores were computed (N=48).

RESULTS

Differences between the experimental groups at baseline

The five experimental groups were not significantly different in terms of age, hours of sleep, smoking, caffeine consumption or units of alcohol consumed. Similarly, they did not differ in terms of regular breakfast or lunch consumption. There were no significant differences between the groups for any of the personality measures, baseline cardiovascular measures, mood, and selectivity scores. At baseline, the expected factor structure was observed for the mood ratings. The performance tasks at baseline showed the expected indicators of selectivity in attention (the biased probability effect; Stroop interference) and memory (the category dominance effect and a significant effect of memory priority).

Correlations between baseline outcome measures

The alertness and hedonic tone mood factors were not significantly correlated with the cardiovascular or performance variables. The anxiety factor was correlated with heart rate ($r=0.20$ $p < 0.05$), with highly anxious individuals having a faster heart rate. Heart rate was negatively correlated with the category dominance effect ($r=-0.19$ $p < 0.05$), with a high heart rate being associated with a reduced dominance effect. None of the other correlations were significant, showing that the outcomes were largely unrelated.

Correlations with hunger at baseline

The mean rating of hunger at baseline was 23.0, which showed that participants were not very hungry at this time. Baseline hunger was significantly negatively correlated with the alertness factor ($r=-0.19$ $p < 0,05$). It was also significantly correlated with the category instances dominance effect ($r = -0.30$ $p < 0.001$). In summary, even relatively low levels of hunger reduce alertness and slow the processing of dominant instances of categories.

Correlations with hunger prior to the test session

The mean hunger rating was 65.7 (range 1 to 100), showing that hunger greatly increased from baseline levels. Hunger was significantly negatively associated with the alertness ($r=-0.28$ $p <0.05$) and hedonic tone ($r=-0.32$ $p <0.01$) factors. Many individual mood scales were

significantly associated with hunger (correlations ranged from 0.25 to 0.35), with the hungrier participants reporting that they felt.

- more clumsy.
- more lethargic.
- more discontented.
- more troubled.
- more mentally slow.
- more dreamy.
- more incompetent.
- more sad.
- more antagonistic.
- more withdrawn.
- and more depressed.

Recall of the high-priority component (order) was also negatively correlated with hunger ($r = -0.25$ $p < 0.05$). In summary, greater hunger was associated with a more negative mood and reduced performance in the high-priority recall task. The mood effect and the priority effect were not related.

Correlations with satiety

These correlations were based on the ratings of those who consumed lunch. The mean satiety rating was 74.0 (range 29 to 99). Satiety was negatively correlated with systolic blood pressure ($r = -0.30$ $p < 0.05$). In terms of mood, satiety was correlated with feeling less anxious ($r = -0.21$). Satiety was also correlated with recall of order ($r = 0.29$ $p < 0.05$). In summary, satiety was associated with mood, cardiovascular functioning, and selectivity in memory. The observed associations were not just the reverse of the effects of hunger.

Correlations with Meal Acceptability

Acceptability was correlated with a more positive mood (Alertness: $r = 0.24$ $p < 0.05$, 1-tail; Hedonic tone: $r = 0.23$ $P < 0.05$, 1-tail). Acceptability ratings were negatively correlated with the priority effect ($r = -0.33$ $p < 0.05$) in the order/location recall task.

DISCUSSION

There has been extensive research on hunger, satiety, and food acceptability but very little on whether these cognitions are associated with mood and performance. The present study investigated whether ratings of hunger, satiety, and meal acceptability were associated with mood, blood pressure, heart rate and selectivity in attention and memory. Previous analyses of data from the present study had shown that the measures of attention and memory were not sensitive to the time of testing or consumption of lunch.

Baseline measurements were taken between 9.30 and 11.30 am, and ratings of hunger were taken at this time. The hunger ratings showed that participants were not very hungry at this time. Greater hunger was significantly associated with lower alertness and hedonic tone. Hungrier participants also had a significantly lower category dominance effect. Hunger was rated again by those participants who had no lunch. These hunger ratings prior to the test session were much higher than those at baseline. Again, greater hunger was associated with a more negative mood and reduced performance in the high-priority recall task. The mood effect and the priority effect were not related. These results show two distinct patterns associated with hunger. A more negative mood is frequently reported in everyday life, with an extreme example being that some hungry people are described as HANGRY. The reduction in the dominance or priority effect in memory could reflect changes in arousal, task-irrelevant thoughts, or changes in resource allocation due to this additional load.

Satiety ratings from those who consumed lunch were negatively correlated with anxiety and systolic blood pressure. This shows that the effects of satiety on mood are not just the reverse of hunger. However, satiety was also correlated with recall of order (the high-priority task), which is the opposite to the result found in the hunger analyses.

As expected, acceptability ratings were correlated with a more positive mood (higher alertness and hedonic tone). However, these ratings were negatively correlated with the priority effect in the order/location recall task. This shows that hunger, satiety, and acceptability have distinct behavioural correlates. In terms of mood, hunger is associated with lower alertness and hedonic tone, acceptability with higher alertness and hedonic tone, and satiety with lower anxiety. All these factors also influence the effects of dominance or recall priority, suggesting that further study of the performance strategies related to these states is required.

One must now ask whether the methodology of the study was appropriate for the issues addressed in this paper. Analysis of the baseline data revealed that the selective effects of task parameters were present in all tasks.[9] However, neither the consumption of lunch nor the time of testing had significant effects on the selectivity measures.[9] Consumption of lunch increased heart rate, showing that physiological changes were produced by the meal.[9] Hedonic tone changed as a function of the time of day and meal consumption,[9] This suggests that the present findings are not due to confounding factors or to a lack of sensitive measures.

CONCLUSION

The present analyses demonstrated that ratings of hunger are correlated with mood changes, with greater hunger being associated with lower alertness and hedonic tone scores. Hunger also changed the effects of dominance and priority in memory, with greater hunger being associated with lower dominance and priority effects. Greater satiety was associated with feeling less anxious, lower systolic blood pressure, and a reduction in the priority memory effect. Higher acceptability ratings were associated with higher alertness and hedonic tone scores and a reduction in the memory priority effect. These results demonstrate the importance of measuring hunger, satiety and acceptability in studies of the effects of food on mood and performance. Further research is now required to identify the mechanisms underlying these effects and their practical impact.

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