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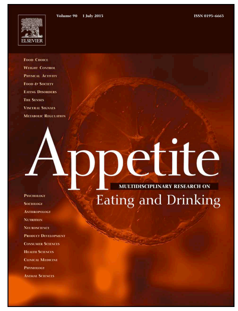

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Inge Kersbergen, Victoria Whitelock, Ashleigh Haynes, Maite Schroor, Eric Robinson

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Hypothesis awareness as a demand characteristic in laboratory-based eating behaviour research: an experimental study

Inge Kersbergen [a]*, Victoria Whitelock [bc]*, Ashleigh Haynes [d]*,
Maite Schroor [e], & Eric Robinson [c]

*Indicates shared first authorship in random order

[a] School of Health and Related Research, University of Sheffield, UK,

[b] Cancer Intelligence, Cancer Research UK,

[c] Department of Psychological Sciences, University of Liverpool, UK,

[d] Centre for Behavioural Research in Cancer, Cancer Council Victoria, Australia,

[e] Department of Nutrition and Movement Sciences, NUTRIM School of Nutrition and Translational Research in Metabolism, Maastricht University, The Netherlands

Corresponding author: Eric Robinson, at address above, eric.robinson@liv.ac.uk

Abstract

Demand characteristics are thought to undermine the validity of psychological research, but the extent to which participant awareness of study hypotheses affects laboratory-measured eating behaviour studies has received limited attention. Participants (N = 84) attended two laboratory sessions in which food intake was measured. In session 1 baseline food intake was measured. In session 2 participants were allocated to either a 'hypothesis aware' or 'hypothesis unaware' condition. Participants were led to believe in the 'hypothesis aware' condition that they were expected to increase their food intake in session 2 relative to session 1. Participants in the 'hypothesis unaware' condition were not provided with hypothesis information. Contrary to our pre-registered predictions, the experimental manipulation of hypothesis awareness did not affect session 2 food intake. However, the manipulation was less effective than anticipated as some participants did not appear to believe the hypothesis information provided. Post-hoc exploratory analyses revealed that participants who believed the study hypothesis was that their food intake would increase in session 2 ate more in session 2 than participants who did not believe this was the study hypothesis. Further confirmatory research is required to understand the causal effect that participant awareness of study hypotheses has on laboratory measured eating behaviour.

What and how much people choose to eat is influenced by their social environment and people will sometimes eat in order to ‘fit in’ with others (Cruwys, Bevelander, & Hermans, 2015; Vartanian, Herman, & Polivy, 2007) . Eating behaviour is often studied in controlled laboratory-based settings, which allows for greater control over extraneous influences and more precise manipulation of independent variables than naturalistic field settings. However, participant beliefs about whether their eating behaviour will be measured may affect food intake in the laboratory. Awareness that food intake is being monitored by an experimenter has been shown to affect behaviour in the laboratory (Robinson, Hardman, Halford, & Jones, 2015; Robinson, Kersbergen, Brunstrom, & Field, 2014) and is a potential demand characteristic of laboratory eating behaviour research. For example, in multiple studies it has been shown that participants who are made aware that their food intake will be measured consume significantly less food than participants who are not made aware (Robinson, Hardman, Halford, & Jones, 2015; Robinson, Kersbergen, Brunstrom, & Field, 2014). Participant awareness of study hypotheses (e.g., how much participants are expected to eat, or the effect of some independent variable on how much is eaten) is a different demand characteristic that may also affect food intake, but has not yet been empirically studied in the context of eating behaviour.

Blinding participants to the true aims of a study (i.e. ensuring participants are unaware of the study hypothesis or research question) has long been used in social psychology research to reduce the potential influence of demand characteristics, i.e. participant behaviour being influenced by experimenter beliefs (Orne, 1962; Sharpe & Whelton, 2016). To achieve this, experimenters can directly or indirectly deceive participants about the true aims of the study by providing a ‘cover story’ that offers a plausible explanation for the measures completed in a study that does not draw attention to the study hypotheses or aims. Deception is widely used in social psychology research but its use is more controversial in other research areas (Krasnow, Howard, & Eisenbruch, 2018; Ortmann & Hertwig, 2002). A recent survey of laboratory-based eating studies published in nutrition and eating behaviour journals during 2016 found that almost half (46%) of studies did not report attempting to blind participants to the study hypotheses (e.g. by using a cover story to conceal the true study hypothesis or research question), and 24% of studies did not assess participants' awareness of the study aims (Robinson, Bevelander, Field, & Jones, 2018). This is a potential cause for concern because participant awareness of a study hypothesis may undermine the validity of the conclusions of a study by causing participants to alter their eating behaviour.

Participants may change their behaviour in response to knowing a study hypothesis in several different ways. The first possibility is that being aware of a study hypothesis prompts an individual to exhibit behaviour that then confirms that hypothesis (Orne, 1962). The laboratory can be argued to represent a peculiar social environment, into which a participant voluntarily enters but may be uncertain about how to behave (Klein et al., 2012). The experimenter on the other hand, presents as an authority figure and participants may therefore attempt to infer what the experimenter wants them to do and act accordingly (Klein et al., 2012; Orne, 1962). The 'good subject effect' was demonstrated by Nichols and Maner (2008): Participants were informed that the experimenter predicted that participants would prefer pictures shown on the left side of a screen over those on the right, and subsequently exhibited preferences that confirmed the researchers' hypothesis. Participants with greater social desirability concerns were more likely to behave in this way, suggesting a possible social approval or ingratiation motive. In the context of eating, individuals with a stronger desire to please others may be more likely to conform to what other people want them to eat (Exline, Zell, Bratslavsky, Hamilton, & Swenson, 2012), and therefore conform to a study hypothesis in the context of an experiment on eating behaviour.

A different possibility is that, rather than confirming a hypothesis, participants may attempt to disconfirm a study hypothesis once they become aware of it. According to reactance theory, people resent being controlled by others and will react to a perceived attempt to manipulate their behaviour by reasserting their agency (Brehm & Brehm, 1981). There is some evidence to suggest that people can sometimes be motivated to deny the effect of external influences on their eating behaviour (e.g., the effect of the presence of others or the portion size of food), and instead are more inclined to attribute eating to internal states (e.g., hunger, food preferences) (Vartanian et al., 2017). Therefore, participant awareness of a study hypothesis could in theory result in a 'bad subject' effect or 'screw you' effect (Masling, 1966), whereby awareness results in some participants changing their eating to disconfirm any apparent study hypothesis.

We are aware of no research that has directly examined the influence that participant awareness of study hypotheses has on food intake. However, a recent meta-analysis of studies suggested that the extent to which an environmental factor proposed to influence food intake (plate size) impacted on participant measured food intake was in part dependent on whether or not participants were likely to believe that the study they were participating in was about eating behaviour (Holden, Zlatevska, & Dubelaar, 2015). This finding is consistent with the notion that participant awareness of study hypotheses may impact on the findings of laboratory eating behaviour research. Given how common it is for studies of laboratory measured eating behaviour not to blind participants to study aims or hypotheses (Robinson et al., 2018) and the lack of direct research examining the consequences of participant awareness of study hypotheses on eating behaviour, the present study investigated whether participant awareness of a study hypothesis about food intake affects food intake in a laboratory setting and can potentially lead to erroneous study conclusions.

Methods

Overview

Participants' intake of snack food was measured in a bogus taste test in two experimental sessions on separate days. We introduced an environmental stimulus in the second session that would have no known reason to influence eating behaviour, but we reasoned would sound relatively plausible (exposure to the colour purple). Participants were randomly allocated to experimental conditions in which they were either informed of a false hypothesis (that being exposed to the colour purple in the second session would increase food intake relative to session 1) or not. We hypothesised that there would be no change in food intake between sessions when participants were unaware of the false hypothesis, but consistent with the 'good subject' effect we tentatively predicted that participants who were made aware of the false hypothesis would conform to the hypothesis by eating more in the second session than the first session. The study protocol was preregistered on the Open Science Framework (DOI 10.17605/OSF.IO/6RKPF).

Design

The study followed a mixed 2 (session, within subjects: session 1, session 2) x 2 (hypothesis awareness, between subjects: aware, unaware) design, with cookie intake in kilocalories (kcal) as the dependent variable.

Randomisation and researcher blinding

The randomisation sequence used to allocate participants to hypothesis awareness conditions was created using Random Allocation Software (Saghaei, 2004) with a 1:1 allocation using random block sizes of 2 and 4, stratified by sex. Details of the allocated awareness condition were contained in sequentially numbered opaque sealed envelopes. The envelope remained sealed until session 2, ensuring that the experimenter (MS) was blinded to condition in session 1.

Participants

Adults aged 18-60 years old, with no food allergies, and who were not taking medication affecting appetite were recruited. Using G*Power (Faul, Erdfelder, Lang, & Buchner, 2007) we calculated that 34 participants per awareness condition would be required to detect a small to medium interaction between awareness condition and session (Cohen's f = .17) in a two-tailed mixed ANOVA (α = .05 at 80% power). We used residualised change scores (cookie intake post - pre) as our primary outcome measure rather than adopting a repeated-measures analysis approach, because change scores tend to provide greater statistical power in randomised pre-post test designs (Maxwell & Howard, 1981), but calculated power for a repeated-measures ANOVA because it enabled specification of a mixed interaction effect in G*Power. In order to account for having to exclude a small number of participants from analyses (e.g. extreme outliers on dependent variables) we aimed to recruit approximately 44 participants per awareness condition. Participants were recruited from staff and students at the University of Liverpool, UK.

Measures

Mood and appetite ratings

A set of ten 100-point visual analogue scales (anchors: 'not at all' to 'extremely') were used to measure hunger, fullness (e.g. 'how hungry do you feel right now?') and various mood dimensions to bolster the cover story advertised to participants ('Mood and taste perception').

Study belief measures

On separate pages of a paper-pencil questionnaire, participants answered the following questions (in order) using an open-ended response format: (1) “What do you think was the aim of the study?” (2) “What do you think the researcher was predicting to find?”, and (3) “Did you notice anything different about the experiment between the two sessions?” Participants were then asked to complete additional questions about their awareness of monitoring of eating behaviour: (4) “I felt as though the amount of food I was eating would be measured by the researcher” (5-point Likert scale response format with anchors ‘strongly disagree’ to ‘strongly agree’), how the researcher predicted them to act between the two sessions: (5) “compared to yesterday, the researcher expected me to eat ___ today” (response options: more, less, the same; with response ‘more’ coded as ‘aware’, and other responses coded as ‘unaware’); and awareness of the purple piece of paper: (6) “thinking about today’s session, what colour was the paper with the taste ratings?” (response options: green, yellow, purple, white).

Responses to questions (1) to (3) were coded by two researchers blinded to participants’ condition. The researchers coded whether each participant was (a) aware of the true aims of the study or not (i.e., the effect of demand characteristics on eating behaviour) (b) aware of the stated (fake) study predictions or not, and (c) aware of the colour ‘manipulation’ or not. To standardise coding of a-c researchers used the same coding method; participants indicating that the study was about investigating whether knowing the hypothesis of a study influences behaviour (or similar) were coded as being ‘aware’ of the *true* aims of the study (a). Participants indicating that the study aimed to investigate the impact of paper colour on food intake (or similar) were coded as aware of the *stated* aims of the study (b). Participants indicating that they received a purple taste rating sheet in the experimental session, but not the baseline session were coded as aware of the colour ‘manipulation’ (c).

Any disagreements between researchers on coding were resolved through discussion with a third researcher.

Socially desirable response tendencies

Participants' tendency to behave in a socially desirable manner was measured using the Marlowe-Crowne Social Desirability Scale 13-item short form (Reynolds, 1982). Responses were averaged to form a social desirability score, with higher scores indicating greater concern over behaving in a socially desirable manner.

Eating habits

Participants completed the Three Factor Eating Questionnaire (cognitive restraint, emotional eating, and external eating subscales) (Cappelleri, et al., 2009) and Dutch Eating Behaviour Questionnaire (external eating subscale) (Van Strien, Frijters, Bergers, & Defares, 1986) to measure individual differences in eating habits. Scores within each subscale were averaged to form four variables, with higher scores reflecting stronger tendencies in the respective subscale.

Procedure

The study was advertised as investigating 'mood and taste perception' and took place over two sessions scheduled 2-4 days apart on weekdays between 14:00-17:30. Participants were instructed not to eat anything for one hour prior to each session. In session 1, all participants provided informed consent and read and signed a study information sheet detailing what would happen in the session, including that their cookie intake would be measured (to ensure this was consistent across conditions). Participants then completed a medical history questionnaire, baseline mood and appetite ratings, and were administered a bogus taste test to measure cookie intake (Robinson et al., 2017). The experimenter presented participants with a well-stocked bowl of 12 chocolate chip cookies (Tesco, approximately

127g, 626kcal) and asked them to taste the cookies and rate their sensory properties on paper-pencil rating sheets (e.g., ‘how crunchy is this cookie?’). Participants were informed they would have 10 minutes to complete the taste test, and that they could eat as much as they wanted. After the taste test, participants completed post-test mood and appetite ratings and reported the time they last ate before the study session.

The second (‘experimental’) session followed an identical procedure to the baseline session except that the cookie rating sheets were printed on purple paper instead of white. For participants in the ‘hypothesis unaware’ condition, the researcher drew attention to the colour of the paper, without giving them the impression that it was part of the experiment: “Sorry about the colour, someone must have left purple paper in the photocopier!” In the ‘hypothesis aware’ condition, the researcher informed participants of the purpose of the purple sheet of paper: “Today we would like you to taste and rate the cookies again. In line with ethical approval for this study, we are required to inform you of the true aims of the study. We are testing the prediction that you’ll eat more cookies today than you did last time because research has shown that seeing the colour purple reminds people of indulgence and makes them want to eat more.” Information about the purpose of the purple paper was also presented to participants on a study information sheet that outlined the session procedure to participants (hypothesis omitted for the ‘unaware’ condition, see online supplementary materials). After completing the taste test and mood and appetite ratings, participants completed questionnaires (in order) assessing demographics, eating habits, and social desirability response tendencies, reported the last time they ate, and completed the awareness questions. Finally, the experimenter measured participant height and weight (with shoes and heavy clothing removed), and participants were debriefed and provided with reimbursement or course credit for their time.

Analysis plan

Manipulation check

We conducted two chi-square tests to assess whether participants in the hypothesis aware condition were more likely to be aware of the stated study prediction than participants in the unaware condition. We predicted that participants in the hypothesis aware condition would be more likely to freely recall the hypothesis and more likely to recognize the stated hypothesis when prompted. We also conducted two chi-square tests to assess whether participants in the hypothesis awareness condition were more likely to be aware of the purple paper than participants in the unaware condition. We predicted no significant difference in the likelihood of free recall of the purple paper or prompted-recall of the purple paper between hypothesis awareness conditions.

Cookie intake

We conducted an independent samples *t*-test comparing residualised change in cookie intake (session 2 - session 1) between hypothesis awareness conditions. We predicted that participants in the hypothesis aware condition would show a greater increase in cookie consumption from session 1 to session 2 than participants in the hypothesis unaware condition.

Planned sensitivity analysis

We repeated the primary analysis of cookie intake after excluding participants whose written responses indicated that they were aware of the true aims of the study (i.e., the effect of awareness of a researchers' hypothesis on behaviour in an experiment). We also repeated the primary analysis of cookie intake between hypothesis awareness conditions including factors as covariates that we believed may predict the primary outcome measure. Specifically, we included BMI, hunger prior to the taste-test, dietary restraint and uncontrolled eating as covariates in separate between-subjects ANCOVAs with residualised change in cookie intake between sessions as the dependent variable and hypothesis awareness (aware, unaware) as the independent variable.

Planned additional analyses

The effect of demand characteristics on food intake may be moderated by social desirability response tendencies (high motivation to conform may increase susceptibility to demand characteristics) and dietary restraint (high dietary restraint may reduce susceptibility to demand characteristics due to dieting goals). The macro PROCESS for SPSS (Model 1) was used to investigate the interaction between awareness condition (aware, unaware) and social desirability response tendencies, and awareness condition and dietary restraint, respectively, in predicting residualised change in cookie intake. We also reasoned that awareness of the study hypothesis may cause some participants to increase their food intake to confirm the hypothesis (‘good subject’ effect) but may cause other participants to decrease their food intake to disconfirm the hypothesis (‘bad subject’ effect) and these two effects may cancel each other out when mean food intake is examined between hypothesis awareness conditions. Therefore, we also tested whether variability in residualised change scores differed significantly between conditions using a Levene’s Test for Equality of Variances. All analyses were conducted in SPSS 24 (SPSS INC., Chicago). The study dataset is available on the Open Science Framework (DOI 10.17605/OSF.IO/6RKPF).

Results

Ninety participants were recruited to the study. In line with pre-registered exclusion criteria, six participants were excluded from the main analyses (because they either did not return for the second study day, n=4, or cookie intake was >2.5 SD above the sample mean, n=2). The final sample was N=84 (hypothesis aware n=41, hypothesis unaware n=43). See Table 1 for sample characteristics.

Table 1.
Sample characteristics as a function of condition.

	Hypothesis aware M/N (SD/%) n=41	Hypothesis unaware M/N (SD/%) n=43
BMI (kg/m^2)	24.7 (4.5)	25.2 (5.3)
Age (years)	30.7 (12.0)	30.4 (11.1)
Sex (female)	35 (85.4)	35 (81.4)
Uncontrolled eating[b]	2.4 (0.5)	2.2 (0.6)
Dietary restraint[b]	2.3 (0.6)	2.5 (0.6) [a]
Emotional eating[b]	2.2 (0.7)	2.2 (0.7)
External eating[b]	3.4 (0.6)	3.2 (0.6)[a]

[a] Data missing for 1 participant.
[b] Uncontrolled eating (α = 0.84), cognitive restraint (α = 0.79) and emotional eating (α = 0.90) are all scored 1-4, higher scores indicating greater eating style tendencies. External eating (α = 0.86) is scored 1-5, with higher scores indicating greater external eating tendencies.

Manipulation check

Awareness of the fake study predictions significantly differed across conditions both when freely recalled, X^2 (1) = 22.42, $p < 0.001$, and prompted (Fisher's exact test, $p <$ 0.001)[1]. Participants in the hypothesis aware condition were more likely than those in the unaware condition to freely recall the fake hypothesis (46.3% and 2.3% respectively) and were more likely to report that the researcher expected them to eat more in the second session than the baseline session when prompted (82.9% and 41.9% respectively).When prompted to recall the paper colour from session 2, participants in the aware and unaware conditions were equally likely to report that the paper was purple (both 48.8%, Fisher's exact test, p = 0.49). However, awareness of the purple paper significantly differed across conditions when participants were asked to freely recall whether they noticed anything different between

[1] Non-parametric Fisher's exact test is reported as >20% of cells had an expected count <5.

sessions, X^2 (1) = 27.75, $p < 0.001$. Participants in the hypothesis aware condition were more likely than those in the hypothesis unaware condition to mention that the colour of the paper changed (82.9% and 51.2%, respectively), although when explicitly asked about the colour of the paper in session 2 participants in both conditions tended to accurately report the colour of the paper (100% and 95.3%, respectively).

Primary analysis: effect of hypothesis awareness manipulation on change in intake

There was no significant effect of awareness condition on residualised change in cookie intake from session 1 to session 2, $t(82) = -0.40$, $p = 0.69$, $\eta^2 = 0.002$ (see Figure 1). Raw cookie intake (kcal) at each session was as follows: hypothesis aware, session 1 M = 201.1, SD = 98.6, session 2 M = 231.0, SD = 112.8; hypothesis unaware, session 1 M = 216.6, SD = 99.6, session 2 M = 237.8, SD = 122.4. See figure 2.

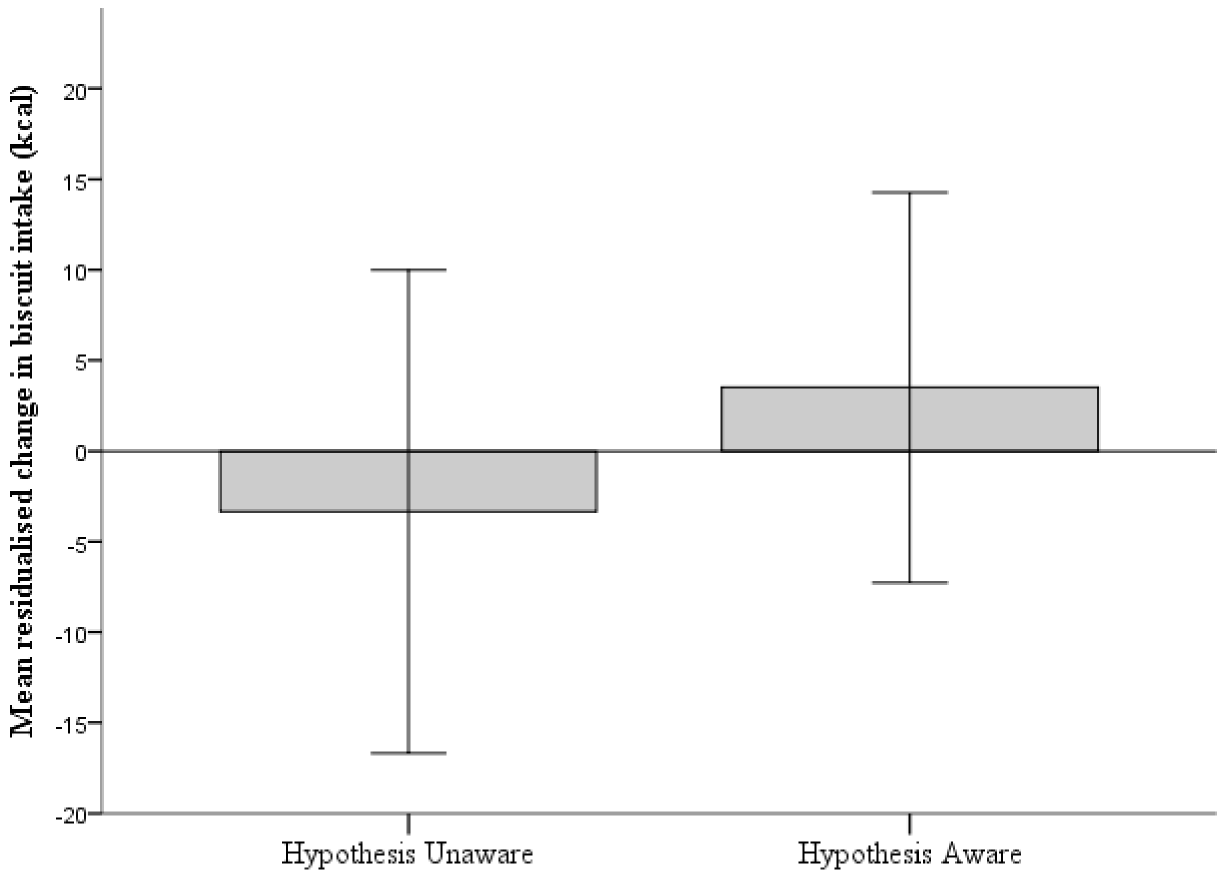

Figure 1. Mean residualised change in cookie intake from session 1 to session 2. Error bars represent the standard error of the mean.

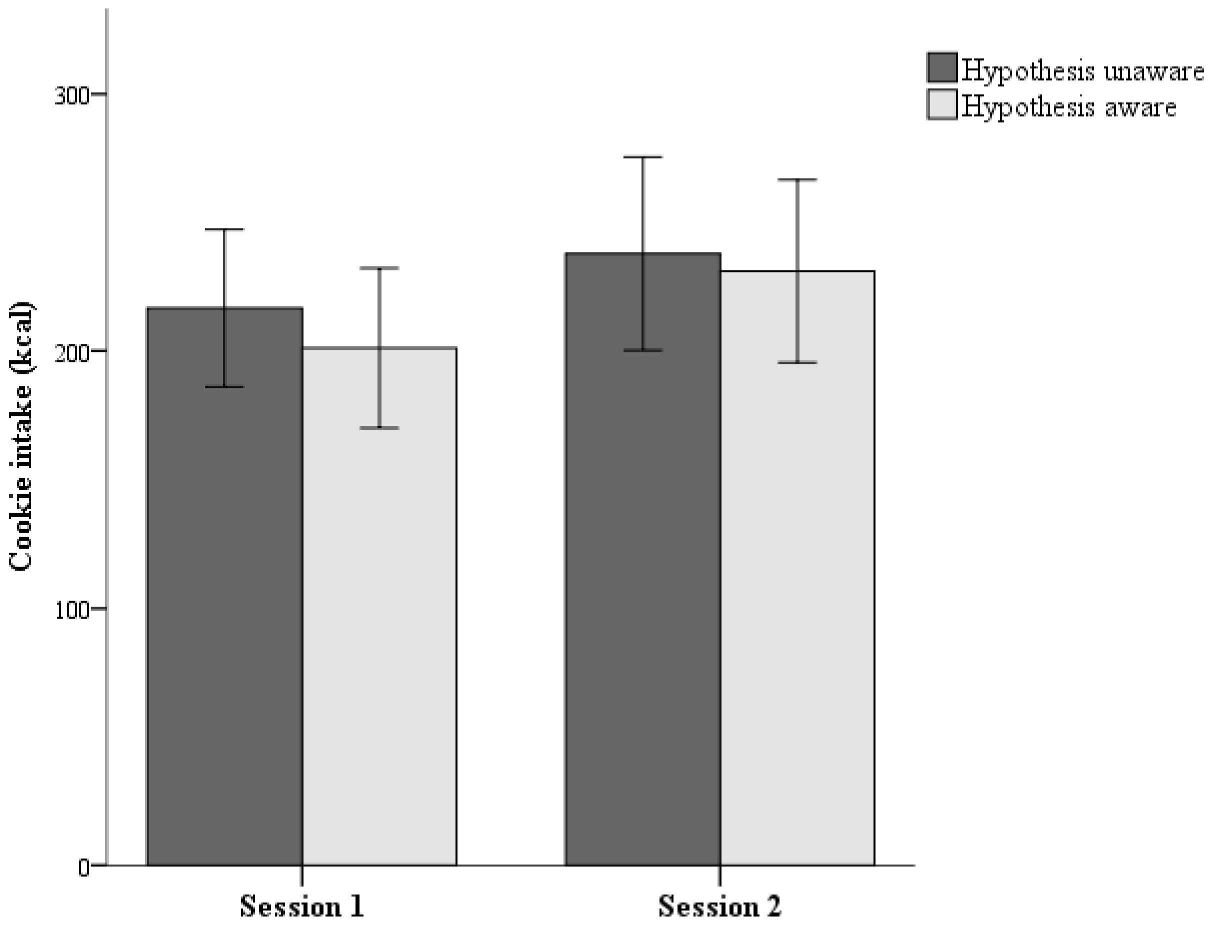

Figure 2. Mean cookie intake in session 1 and session 2 split by hypothesis awareness condition. Error bars represent 95% CIs.

Planned sensitivity and additional analyses

Excluding 11 additional participants who guessed the true aims of the study did not affect the statistical significance of the main findings. Controlling for BMI, dietary restraint, uncontrolled eating and pre-taste test hunger measured at both sessions[2] did not affect the pattern of the results or the significance for change in cookie intake (results not reported).

There was no evidence that dietary restraint (α = 0.79) or social desirability concerns (α = 0.69) moderated the effect of hypothesis awareness on residualised change in cookie intake as neither the interaction between awareness condition and social desirability concerns

[2] Including hunger as a covariate in the sensitivity analyses was not included in the pre-registered protocol in error.

on change in cookie intake, $b = 0.66$, $t(79) = 0.13$, $p = .90$, nor the interaction between condition and dietary restraint significantly predicted change in cookie intake, $b = 48.56$, $t(79) = 1.60$, $p = 0.11$. Levene's test indicated similar variability in residualised change in cookie intake across conditions, $F = 2.77$, $p = 0.10$.

Post-hoc analyses: participant beliefs about experimenter's expectations

Given that we found our experimental manipulation was less pronounced than anticipated (e.g. approximately 1/5 of participants in the hypothesis aware condition were unaware that the hypothesis was that they would increase their food intake in session 2 and more than 1/3 of participants in the unaware condition reported that they believed the hypothesis was that they would increase their food intake), we examined the association between participants' beliefs about how the researcher expected their cookie intake to change across the two study sessions on residualised change in cookie intake. Participants were grouped as either believing the researcher expected their intake to increase between sessions vs. not (i.e. stay the same or decrease, as only a minority of participants believed the hypothesis was for their intake to decrease). An independent-samples *t*-test with participants' belief about how the researcher expected consumption to change in the second session (increase versus not) as the independent variable showed a significant effect on change in cookie intake between sessions, $t(82) = 3.10$, $p = .003$. Change in cookie intake increased significantly more from session 1 to 2 in those who believed the researcher expected their cookie intake to increase, compared to participants who did not believe the researcher expected their cookie intake to increase. See Table 2.

Table 2.

Cookie intake and participants' belief about the researchers' expectations about change in cookie intake between sessions.

	Expected increase M(SD) (n = 52)	Expected decrease or no change M(SD) (n = 32)
Residualised change in cookie intake (kcal)	19.8 (69.0)	-32.2 (83.4)
Cookie intake session 1 (kcal)	210.6 (105.6)	206.5 (88.3)
Cookie intake session 2 (kcal)	255.7 (124.0)	200.0 (97.2)

Discussion

The present study tested whether participant awareness of a bogus study hypothesis influences food intake in a laboratory setting. Results of our primary analysis revealed that the experimental manipulation of awareness of study hypothesis did not affect food intake and participant-level individual differences (social desirability and dietary restraint) did not moderate the effect of awareness of study hypothesis on food intake. However, analyses also showed that our experimental manipulation was less effective than intended (e.g. a substantial proportion of participants in the hypothesis aware condition were unaware of the bogus hypothesis). In further unplanned exploratory analysis we found that across conditions participants did exhibit eating behaviour that was consistent with their beliefs about the study hypotheses, suggesting that the null findings in our primary analysis could be attributable to the effectiveness of the experimental manipulation. However, the results of our exploratory analyses could have been in part caused by reverse causality and/or whether there are differences between the type of participants who believes a study hypothesis is that their food intake will increase and those who do not. For example, because participants' beliefs about the study hypothesis were reported after the measurement of food intake, it is possible that self-reported beliefs about the study hypotheses were influenced by the amount of food eaten in the taste test ('I ate a lot in this session, so that must have been the study hypothesis'), as opposed to reflecting participants' true beliefs during the taste test. Likewise, it is not clear why a substantial proportion of participants did not believe (or remember) the information provided to them about the study. Because our exploratory findings were unplanned and based on this data they would benefit from being replicated in confirmatory research.

A consideration of the present study was that across both conditions we made participants aware that their food intake would be measured to ensure the two experimental conditions[1] were matched for this factor known to influence food intake (Robinson et al., 2014), as not doing this would have resulted in our manipulation of hypothesis awareness being confounded with awareness that food intake was being measured. On the one hand, people tend to eat less when they are aware their intake is being monitored, suggesting a desire to avoid being perceived as 'greedy' (Robinson et al., 2014; Robinson, Proctor, Oldham, & Masic, 2016). On the other hand, there is some evidence to suggest that research participants conform to what they expect the researcher wants them to do (Nichols & Maner, 2008). These two motives could have produced asymmetric effects in the present study and because laboratory studies rarely inform participants explicitly that their food intake will be measured, this methodological aspect of our design may affect the generalizability of the present study findings. Given that we sampled predominantly young women and only examined consumption of a sweet snack food, the extent to which the findings of the present study would generalise to other populations and food or meal types is also unclear.

The present results may have implications for the conduct of lab-based studies in eating behaviour. Although we did not demonstrate causal evidence for hypothesis awareness affecting eating behaviour, we did find some observational evidence that participants may have conformed to their beliefs about the study hypotheses. These findings are consistent with the idea that laboratory eating behaviour studies would benefit from routinely attempting to blind participants from study aims/hypotheses and measuring how successful this blinding is (e.g. Rubin, 2016), as otherwise study findings may be biased or caused by participant beliefs (otherwise known as 'demand characteristics'). However, further confirmatory research is required to provide causal evidence on the influence that participant awareness of study hypotheses has on laboratory measured eating behaviour.

Notes

[1] Manipulation check data confirmed this was the case as 96% of participants strongly agreed or agreed that they believed their food intake would be measured and this did not differ by condition.

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