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Commentary: Methodological and reporting practices for laboratory studies assessing food intake using fixed and ad libitum test meals.

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A number of expert reports have provided methodological recommendations on how to conduct rigorous and scientifically sound laboratory studies to investigate appetite control (most recently: Blundell et al., 2010, Blundell et al., 2009, Gibbons et al., 2014). However, a recent examination of the methodologies used in laboratory food intake studies by Robinson, Bevelander, Field, and Jones (2018) showed that many failed to adopt basic methodological procedures and reporting practices. Based on their examination Robinson et al. proposed recommendations that should be adopted as best practice in appetite-related research. We wholly support Robinson et al.'s effort to highlight where scientific rigour needs to be improved in this research area. Indeed, in one of our recent meta-analyses on studies assessing food intake we also concluded that most studies were of low methodological quality (Buckland et al., *under review*).

While we support the recommendations of Robinson et al. (2018), we propose that in their current form the recommendations are limited and overlook other important '*basic'* methodological factors that should be considered when designing and reporting studies that assess food intake. Such factors include adopting additional pre-manipulation control procedures (e.g. controlling for alcohol intake and physical activity levels), designing (and reporting) an appropriate order for study procedures to ensure that any manipulations are not confounded by other study measures (e.g. weighing participants or administering psychometric questionnaires before assessing food intake), detailed reporting of sample type (e.g. student, community-based, dieting status), reporting whether measures taken were objective or subjective (e.g. self-reported versus researcher measured body weight and height) and appropriate design and reporting of standardised test meals. Reporting information on these additional methodological factors would facilitate the replication of studies. Further, recommendations may need to be tailored according to study aims. For example, when considering the issue of standardised test meals, recommendations will vary if the study is examining processes affecting satiation or satiety or if it is examining food hedonics and food choice.

A thorough review and examination of each of these additional factors are beyond the scope of this commentary, so we will focus on extending Robinson et al. (2018) recommendations with regards to developing criteria for appropriate standardised test meal design.

Appropriate design and reporting of standardised test meals

The focus of Robinson et al. (2018) examination was on laboratory studies of human food intake. The advantage of laboratory assessments of eating behaviour is that they allow for the precise assessment of food intake in a controlled environment that is free from potential confounding variables such as extraneous smells, sounds, competing activities and social stimuli (Blundell et al., 2009). Broadly speaking there are two forms of food intake assessment within the laboratory; the first is a measure of fixed intake (termed as "fixed energy meals") where the type and amount of food consumed by the participant is pre-determined by the researcher and is less susceptible to confounding variables. The second is a measure of ad libitum intake where the amount (and in some cases type) of food consumed is determined by the participant (ideally in response to the experimental manipulation) within the limitations of the experimental design. This second measure is more vulnerable to confounding factors (Stubbs et al., 1997). For both fixed and ad libitum test meals the type and amount of food provided requires careful consideration as variation in these factors has been shown to influence the amount of food consumed (Beaulieu et al., 2017; Hetherington & Blundell-Birtill, 2018). Within their examination, Robinson et al. assessed whether the studies reported the types of foods provided but they did not provide recommendations on which variables are important to consider when designing and reporting fixed and ad libitum test meals used in laboratory studies of human food intake.

Fixed energy meals

Fixed energy test meals are those in which the researcher provides the participant with a compulsory "fixed" test meal that they are instructed to consume in its entirety. Fixed energy test meals allow for the composition of food to be manipulated and standardised across participants. Fixed energy test meals allow for increased experimental control in designs where food is being used as an independent

variable. However, fixed energy test meals are not suitable for studies examining satiation as they do not account for individual differences in energy requirements.

Fixed energy test meals are also useful to standardise participants' appetite before they are exposed to an experimental manipulation. When used to standardise appetite, ideally fixed meals should be tailored to individual daily energy needs (e.g. based on Schofield equations or measured resting metabolic rate). The proportion of daily energy requirements a fixed meal provides will be determined by study aims and time of day the test meal is served (Dalton et al., 2015). An alternative method when there are multiple conditions is to have participants self-determine their fixed meal by providing an ad libitum amount in the first condition and asking them to eat to comfortable fullness. The amount consumed can then be provided in the experimental conditions that follow (for an example see Beaulieu et al., 2017). It is important to consider individual energy requirements as providing the same portion to all participants does not account for energy needs differing depending on individual characteristics such as age, gender, body weight and body composition (Ravussin & Bogardus, 1989). This may lead to some participants receiving too little and still feeling hungry and others receiving too much and feeling too full which can interfere with any subsequent assessments of food intake.

Ad libitum test meals

In ad libitum test meal designs participants are normally provided with a larger than can be consumed portion of food, which the researcher weighs before and after consumption. A range of foods are often provided for participants to choose from which allows for the assessment of quantitative aspects of eating behavior (i.e. how much) and qualitative aspects of eating behavior (i.e. nutrient and/or sensory food choice). When used correctly ad libitum test meals are useful to assess the process of satiation (i.e. meal size and termination) however there are several important considerations when designing ad libitum test meals. Research has shown that factors such as variety, texture, physical form (liquid or solid), palatability and energy density can induce over- and under-eating in laboratory conditions (Buckland et al., *in press*; de Graaf, 2012; Hetherington, Foster, Newman, Anderson &

Norton, 2006; Raynor & Epstein, 2001; Rolls, Van Duijvenvoorde, & Rolls, 1984). Additionally, care must be taken with regards to the portion size of the ad libitum test meal items as larger portion sizes have been shown to lead to greater intake (for a review see Hetherington & Blundell-Birtill, 2018; Zlatevska et al., 2014) whereas providing small portions may constrain participants' food intake and limit the opportunity to observe effects of the independent variable. It is recommended that the portion size of ad libitum test meals is clearly reported in each study and the range of food consumed is provided.

Furthermore, it is recommended that researchers assess participants' liking of study foods as an inclusion criterion; a factor that was not examined by Robinson et al. (2018). Liking for food has a positive effect on food intake (De Graaf et al., 1999) and therefore to accurately assess the effects of a manipulation, the foods provided must be liked by participants (Blundell et al., 2010). If study foods differ between study conditions, then food liking should be matched across conditions to ensure any differences in intake can be attributed to the study manipulation rather than the extent to which participants like the food. For example, one study compared whether intake differed if participants were provided with the same (fish and chips or beef stew) or different (lemon mousse) food to that previously eaten (Ferriday et al., 2016). Compared to when eating the same food, participants ate less of the different food and reported feeling less full. Crucially, the authors did not check pre-study whether participants liked the lemon mousse (any pre-screening attempts were not reported) and as such as the authors discussed, it was unclear whether participants ate less of the mousse because of the study manipulation (varied the test foods to be either the same or different to foods previously eaten) or due to a dislike for the lemon mousse. Such issues can easily be prevented by assessing liking for study foods in a pre-study screening questionnaire, with the aim of including low liking for the study foods (e.g. ratings of <4 on a 7-point Likert scale) as an exclusion criterion (Gibbons et al., 2014) In addition, study foods should adequate undergo pilot testing to ensure they are equally palatable.

Lastly, studies should also report the test meal environment, including the presence or absence of social others, participants' focus on the test meal and the time of day that test meals were administered. The presence of social others (social influences) has been shown to influence food intake (Herman et al., 2003). As such, if social cues are not part of the research question then participants should be tested in individual cubicles. Distractions such as watching television, listening to audiobooks and completing computer tasks increase food intake (Oldham-Cooper et al., 2011, Higgs and Woodward, 2009, Bellisle et al., 2004). Therefore, food intake should also be assessed in a distraction-free environment where participants do not have access to their mobile phone, computer or other distractions to ensure their attention is focussed on the test meal. The time of day that the test session takes place can also influence food intake. Certain foods will be more culturally appropriate at particular times of the day compared to others. As such, to avoid confounding the variable of interest, test foods should be appropriate for the time of day that the test session takes place (Blundell et al., 2010).

These methodological aspects related to study foods are not exhaustive of the "*basic*" methods that researchers should consider when assessing food intake within the laboratory using standardized test meals (see Blundell et al., 2010). We have raised these points to demonstrate that Robinson et al. (2018) did not discuss or provide recommendations for a large number of "*basic*" methodological and reporting practices. While we are aware that Robinson et al. acknowledged that "*it was not feasible (however), to evaluate all aspects of study design and reporting*" (p.490) we believe that providing restricted recommendations risks future studies overlooking important methods. Overlooking such methods can lead to the collection of low quality data and make it difficult to form justifiable conclusions (Brown et al., 2018). As such, in line with Robinson, we call for experts in the laboratory assessment of food intake to agree and establish a comprehensive set of recommendations that can be used by researchers and reviewers of manuscripts to encourage and promote scientifically sound research.

Conclusions

We support Robinson et al. (2018) recommendations to promote scientific rigour in laboratory studies investigating food. However, to avoid important aspects of research design being overlooked we strongly urge experts in eating behaviour to collaboratively establish more thorough recommendations.

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