The role of odor imagery ability in human food cue reactivity and obesity (#56278)

1) Have any data been collected for this study already?
It's complicated. We have already collected some data but explain in Question 8 why readers may consider this a valid pre-registration nevertheless.

2) What's the main question being asked or hypothesis being tested in this study?
Hypothesis 1 (H1) Self-reported odor imagery ability will positively correlate with psychophysical and neural measures of odor imagery ability.
(H2) Self-reported, psychophysical, and neural measures of odor imagery ability will each positively correlate with BMI.
(H3) Self-reported, psychophysical, and neural measures of odor imagery ability will each positively correlate with FCR measures.
(H4) If measures of odor imagery ability, BMI, and FCR are all positively associated, then we predict that FCR will formally mediate the relationship between odor imagery ability and BMI.
(H5) Self-reported, psychophysical, and neural measures of odor imagery ability will predict cue-potentiated feeding and weight gain.
(H6) If better odor imagery ability leads to greater cue-potentiated feeding and weight gain by strengthening FCR, then FCR will formally mediate the relationships between odor imagery ability and cue-potentiated feeding or weight gain.

3) Describe the key dependent variable(s) specifying how they will be measured.
1. Self-reported imagery ability: Participants will complete the Vividness of Olfactory Imagery Questionnaire (VOIQ; Gilbert et al., 1997), the Vividness of Visual Imagery Questionnaire (VVIQ; Marks, 1973), and a modified Vividness of Food Imagery Questionnaire (VFIQ; Patel et al., 2015).
2. Psychophysical measure of odor imagery ability: We will use a validated detection task of odor imagery ability (Djordjevic et al., 2004). Using two odors (rose and cookie), participants will image the smell of one odor while detecting either the same odor (matched trials) or the other odor (mismatched trials) at peri-threshold level. The interference effect (psychophysical measure of odor imagery ability) is calculated by subtracting detection accuracy (% trials correct) in mismatched trials from that in matched trials.
3. Neural measure of odor imagery ability: The BOLD signal will be measured in an event-related design with 6 trial types: smell rose, cookie, or odorless; and imagine rose, cookie, or odorless. We will then implement searchlight multivariate pattern analyses (MVPA) to classify fMRI neural activity patterns while smelling vs imaging odors.
4. Adiposity measures: We will quantify participant body weight and height using a digital scale and stadiometer to calculate BMI, obtain body fat % with bioelectric impedance, and take waist circumference with a tape measure at baseline and 1-year follow-up.
5. FCR measures:
   (a) Cue-induced craving: We will take the average rated craving (on a VAS) in response to 90 palatable food images (Boswell et al., 2018).
   (b) Brain response to food cues: We will assess ventral striatal (VS) response in the contrasts food>nonfood or food>clean air with family-wise error small-volume correction (FWE-SVC) for multiple comparisons in a functional VS mask (e.g., from Bartra et al., 2013).
6. Cue-potentiated feeding: Participants will complete a validated bogus taste test (Robinson et al., 2017), and we will quantify total grams of cookie consumed.

4) How many and which conditions will participants be assigned to?
There will be only one condition. We will recruit participants into two BMI groups: healthy weight (BMI < 25 kg/m2) and overweight/obesity (BMI ≥ 25 kg/m2) in a manner to minimize differences in demographic measures (e.g., age, sex, socioeconomic status, education) between them.

5) Specify exactly which analyses you will conduct to examine the main question/hypothesis.
(H1-H2) We will perform bivariate correlations between the interference effect (psychophysical measure of odor imagery ability), VOIQ score, and BMI. We will also regress decoding accuracy (neural measure of odor imagery ability) against VOIQ score or BMI using software such as Statistical Parametric Mapping (SPM). We will small volume correct (SVC) for voxels in anatomical masks of olfactory regions (e.g., piriform, amygdala, and orbitofrontal cortex). We will consider sex, age, odor ratings, and hunger as covariates.
(H3) First, we will regress cue-induced craving against the interference effect. Second, we will regress brain response to food cues against the interference effect in SPM using SVC in a VS mask. Finally, we will regress cue-induced craving scores and brain response to food cues (mean betas extracted from the VS mask) against decoding accuracy in SPM and perform SVC in anatomical masks of olfactory regions.
(H4) We will use formal mediation analyses to test if FCR mediates the association between odor imagery ability (VOIQ score, interference effect, or decoding accuracy) and BMI.
(H5) We will perform separate multiple linear regressions for cue-potentiated feeding and weight gain (or changes in BMI or body fat %) at 12 months. All questionnaire, odor imagery, FCR, and adiposity measures will serve as potential predictors.
(H6) We will use formal mediation analyses to test if FCR mediates the associations between odor imagery ability (VOIQ score, interference effect, or decoding accuracy) and changes in adiposity or cue-potentiated feeding.
6) Describe exactly how outliers will be defined and handled, and your precise rule(s) for excluding observations.
Subjects may be excluded if they show abnormal baseline olfactory function (e.g., in the hyposmia or anosmia ranges). For the fMRI scan, participants with excess movement in the scanner may be excluded from the analyses. We will use the FSL motion outliers tool (with default thresholding) to detect timepoints with large motion to remove or use as regressors at the first level in our GLMs. Subjects may be further excluded if they do not follow task instructions (i.e., sniffing when instructed to do so). Finally, subjects may be excluded prior to scanning if they specifically dislike any of our test odors.

To define outliers for all other variables, we will use the ‘outliers’ package available in R studio or the ‘outliers’ function in Matlab or SPSS. These will detect extreme observations from the mean (set to 2 or 3 standard deviations) and remove them from our analyses. Within bivariate correlations or regressions, we will also check for multivariate outliers (>4*mean cook’s distance) and remove them if they modify the nature of the results.

7) How many observations will be collected or what will determine sample size? No need to justify decision, but be precise about exactly how the number will be determined.
Sample size will be determined a priori with 3 main considerations in mind:
1. Replicating the interference effect (d=0.722) for the validated psychophysical task of odor imagery ability (Djordjevic et al., 2004).
2. Confirming the association between self-reported odor imagery ability and BMI (r=0.42) from our lab’s previous study (Patel et al., 2015).
3. Identifying the effect size for predicting long-term eating and weight changes from odor imagery ability, based on the variance in these metrics explained by FCR (r=0.43) from a prior meta-analysis (Boswell and Kober, 2016).

8) Anything else you would like to pre-register? (e.g., secondary analyses, variables collected for exploratory purposes, unusual analyses planned?)
1. Data collection: Thus far, we have collected some pilot data from 15 subjects for the behavioral components and 10 subjects for the scans. These participants have not completed the full study and their data has only been used thus far to inform basic study design (e.g., to test our fMRI acquisition parameters).
2. Additional questionnaires: The International Physical Activity Questionnaire (IPAQ; Hagströmer et al., 2006), Dietary Fat and Free Sugar Short Questionnaires (DFS; Francis and Stevenson, 2013), and Reward-Based Eating Drive Scale (RED; Epel et al., 2014). We may use these questionnaires as covariates in our analyses and test for their relationships with odor imagery ability and BMI.
3. Alternatives: If unable to identify a neural measure of odor imagery with MVPA, we would instead use connectome-based predictive modeling (CPM). If odor imagery is unrelated to BMI, we will test if it accounts for variance in body fat % or waist circumference. We will further test if effects are specific to the food vs nonfood odor and test for associations between VFIQ score and our FCR measures. Finally, we may test a different metric of intake at the 1-year follow-up, such as ad libitum consumption (e.g., of chips, pizza, etc.).