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Testing a Metacognitive Regulation Approach for Judgment of Satiation: Might Hunger and Fullness not be the Polar Opposites of the Same Dimension?

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Keywords
Metacognition, eating behaviour, dietary control, satiation, hunger, fullness

Abstract
Despite the existence of several cognitive influences, metacognitive factors on eating and satiation still remain unclear. Therefore, we investigated a relatively recent metacognitive regulation approach and its measurement method in a lab-experiment. Participants (*N*=216) were shown photografs of varying portions of common lunch foods (selected after a separate study, *N*=94) and asked to make predicted judgments of satiation (JOS) for each via considering their actual hunger levels and whilst imagining other bodily states (e.g., extremely hungry and completely full). Differences calculated between observed-JOS and their reference scores -those presumed to yield accurate matches for the cases- produced either deviances or none at all (discordant- or concordant-JOS). Hungry-group yielded significantly lower concordant-JOS percentage than full-group regardless of portion size, indicating a clearer cognitive tendency to lose control over consumption when being hungry than satiated. Critically, full-group could *not* imagine extreme hunger as hungry-group whereas hungry-group imagined complete fullness just as full-group did, suggesting that whilst hunger was not an obstacle to imagine fullness, fullness hindered the ability to imagine hunger. These findings suggest that hunger and fullness might *not* be the polar opposites on the very same dimension, which would, for instance, reveal a need to revisit the treatments of eating disorders accordingly.

Doyma Kararında Bir Üstbilişsel Düzenleme Yaklaşımın Test Edilmesi: Açlık ve Tokluk Aynı Boyutun Zıt Kutupları Olmayabilir mi?

Anahtar kelimeler
Üstbiliş, yeme davranışı, diyet kontrolü, doyma, açlık, tokluk

Öz
Çeşitli bilişsel etkilerin bulunmasına rağmen, yemek yemeyi ve doymayı etkileyen etkileyen üstbilişsel faktörler halen açık değildir. Bu nedenle, 216 katılımcının yaygın olarak tüketilen çeşitli öğle yemeklerinin (94 katılımcı ile ayrı bir çalışmada belirlenen) farklı porsiyonlarının fotoğraflarını gördükleri ve katılımcıların gerçek açlık durumlarını düşünerek ve farklı bedensel durumlarını da hayal ederek (ör., çok aç ve tıka basa tok) her bir porsiyon için tahmini doyma kararlarını (DK) belirttikleri bir laboratuvar deneyinde, görece yakın zamanda önerilen bir üstbilişsel düzenleme yaklaşımını ve buna ait ölçme yöntemini inceledik. Gözlenen DK'lar ve bunların -durum için uygun şekilde eşleşme sağladığı beklenen- referans skorları arasında hesaplanan fark, ortaya bir sapma çıkarmış ya da hiçbir sapma çıkarmamıştır (sırasıyla, uyumsuz- ve uyumlu-DK). Açlığın tokluğa göre tüketimde daha belirgin bir bilişsel kontrol kaybına neden olduğunu belirtir şekilde, aç-grup tok-gruba göre porsiyon büyüklüğü fark etmeksizin anlamlı şekilde daha fazla uyumsuz-DK yüzdesine sahip olmuştur. Kritik olarak ise, açlığın, tokluğu hayal etmede bir engel değilken, tokluğun açlığı hayal etmede bilişsel bir engel olduğunu işaret ederek, tok-grup aç-grup gibi çok aç olma durumunu hayal ede*mez*ken, aç-grup tok-grup gibi tıka basa tok olma durumunu hayal edebilmiştir. Bu son bulgu, açlık ve tokluğun tam da aynı boyutun birer zıt uçları ol*ma*yabileceğine işaret etmektedir; ki bu da, örneğin, yeme problemlerinin tedavilerinin, buna göre yeniden gözden geçirilmesi gerekliğini ortaya çıkarır görünmektedir.

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Making a judgment on the expected or actual satiation level of consuming a particular food is neither a trivial nor an arbitrary one. Quite the contrary, judgments of satiation can readily indicate how one's eating regulation is governed (e.g., Brunstrom et al., 2011; Galak et al., 2014; Green & Blundell, 1996; Higgs, 2008). A recently growing line of research, however, has revealed that the decisions given on the satiation level for a particular food involve cognitive and metacognitive influences (see e.g., Higgs, 2005; Redden, 2015; Robinson et al., 2013; & Guzel, 2015 for an extensive review and dissussion), as good as -or even beyond- the interpretation of the related bodily signals (e.g., see Brunstrom et al. 2011 for the 'expected satieties'; also see Brunstrom, et al., 2008).

Various cognitive and metacognitive factors affect one's satiation. For instance, it has been shown that the food consumed while engaging with distractive activities (e.g., watching TV, driving car) leads to consuming higher amounts of food as well as reducing the vividness of the consumption compared to the food consumed without such distractions (Higgs & Woodward, 2009; see also e.g., Higgs, 2005). Further, *mere imagination of satiation* has been shown to result in a very real sensation of satiation that is comparable to actual satiation (Morewedge et al., 2010) and even "imagining consuming food itself" was evinced to reduce actual consumption (Larson et al., 2014). Besides cognitive factors, Redden and Galak (2013), studied the effect of metacognitive knowledge on satiation and they challenged the traditional view of satiation, i.e., the physiological view. They found the inference one makes on past consumption(s) is a substantial factor when assessing satiation. They argued that it is in fact *not* the actual amount consumed affecting satiation, but is the subjective sense of how much one has previously consumed. Additionally, the findings gathered from several neurological conditions converge onto that account. For instance, patients with memory dysfunctions (e.g., amnesia, H. M. disease, etc.) have been shown to engage in repetitive consumption of high amount of food even after a quite recent food intake due to the inability to recall such activities effectively (Rozin et al., 1998).

Since any scientific investigation requires a theoretical perspective for the phenomenon at hand, available eating regulation models that suggest possible mechanisms behind satiation judgments should herein be mentioned. Researchers utilized "externality model" (Schachter, 1971), "boundary model of eating" (Herman & Polivy, 1984), "goal-conflict model of eating behaviour" (Stroebe et al., 2013), and many others in order to lead their works on eating. Nonetheless, the primary target of these models is restricted to explain the development and maintenance of obesity or overweight only and so they do not offer a comprehensive conceptualization for eating behaviour that can be applicable to both normal and problematic eating behaviours equally well. Additionally, these models do not make a clear reference to any metacognitive processes in eating regulation even though some models, such as goal-conflict model, may be considered as metacognitive in nature (see Guzel, 2015 for a discussion). A relatively recent working model on eating behaviour, titled as "metacognitive regulation of eating behaviour" (Guzel, 2015), may herein be a viable option to delineate a global conceptualization for eating regulation and to quantify judgments of satiation (JOS) in eating (see e.g., Figure 1). Being an application of Nelson and Narens' metacognitive framework (1994) into the context of eating behaviour, the model offers a metacognitive regulatory mechanism that can be applied to normal as well as abnormal eating behaviours and patterns. Specifically, it considers a flow of information between "eating-and-hunger-related knowledge" (object-level) and "metacognitive knowledge and expectations on eating" (meta-level) through a monitoring and a control process ("monitoring hunger" and "controlling food intake", respectively). The model basically entails the following:

> "The meta-level involves any meta-knowledge and expectation related to eating and hunger, such as knowledge about previous eating habits, expectations about foods' satiety and/or sensory stimulations, etc. This level … is presumed to affect the food intake by controlling the amount as well as the type of food so as to satisfy present hunger level monitored. The result of such regulation, then, can be observed in terms of such as undereating, overeating (discordant JOS), or suitably controlled food intake matching to what hunger level monitored necessitates (concordant JOS) such as by starting, continuing, or ceasing eating. If JOS is explicitly observed and actual food intake is measured it is an observation of JOS-actual. On the other hand, if one makes a prediction on the amount of food imagined or presented, it refers to the observation of JOS-predicted." (Guzel, 2015, p. 934).

Following the above-mentioned working model and its calculation method, we investigated "predicted judgments of satiation" (JOS-predicted) that are made for common lunch foods in a laboratory experiment. Participants were asked to make predictions (i.e., judgments) about the presented foods' satiation with respect to their study-time reported hunger levels. The experiment tested the proposed model as a preliminary investigation and, it retained two main research questions. First, is it the state of hunger or fullness that is conducive to a better cognitive control over predicted JOS? Second, are the states of hunger and fullness simply the polar opposites of a single continuum? As we are aware, none of these questions have been answered from an explicitly metacognitive perspective so far. Murray and Vickers (2009), however, have asked the second question directly and gave a plausible response to that based on a consumer survey. They reported that the typical hunger was described with more biological concepts such as "stomach growls", "emptiness", "loss of energy", etc. whereas the typical fullness was described with more psychological representations such as "satisfaction", "contentment", "focused", etc. They concluded that these descriptions imply that hunger and fullness might not be the polar opposites of a single continuum, rather they might be different constructs. Therefore, the present experiment aimed to reveal whether this counter-intuitive conclusion of Murray and Vickers, which challenges the tacit assumption held so far that these bodily states (hunger vs. fullness) are seemingly polar opposites of the very same construct, could be converged on via quantitative evidence.

Overview of the experiment

We investigated JOS-predicted for common lunch foods in a laboratory experiment and utilised the measurement technique of Guzel (2015) to quantify the type and the degree of such judgments. The experiment involved the following procedure that allowed us to calculate JOS-predicted. Participants who rated their study-time hunger levels first were presented with various portions of foods on a computer screen and were asked to rate their predicted JOS for each portion (e.g., "Considering your hunger level you have just rated, what would you predict your satiation level would be if you have eaten the whole food presented?"). They made these predictions by imagining various other hunger states as well, such as imagining "extremely hungry", "neither hungry nor full", and "completely satiated" separately even if they had rated their study-time hunger levels with one of those bodily states already.

To reach at the rationale on the quantification method of the JOS that was used in the present experiment, first the model's basic predictions should be highlighted. For instance, as one gets hungrier, the portion sizes should proportionately be larger so as to attain -or predict- complete satiation. That is, the higher one's hunger level is, the larger the portions should be to predict or actually gain a full satiation. On the other hand, as one is fuller in the stomach, the portions to be consumed (on which JOS is predicted) should be gradually smaller in order to gain complete satiation. Following this rationale, the calculation method is based on measuring the deviations of the "JOS-observed" scores (i.e., those given by the participants) from the "JOS-matched" ones that are generated as reference scores to imply expectedly perfect matches for any given 'hunger level, portion size, and JOS level' combination. Based on a linearity assumption, for instance, Figure 1 depicts possible "JOS-matched scores" that are generated for each hunger level-portion size-JOS combination where the ratings of each scale (i.e., hunger level, JOS, portion size) vary on "nine-point" interval scale. In short, the calculation subtracts each JOS-observed score of the participant from its very own reference score (i.e., JOS-matched) depicted in Figure 1.

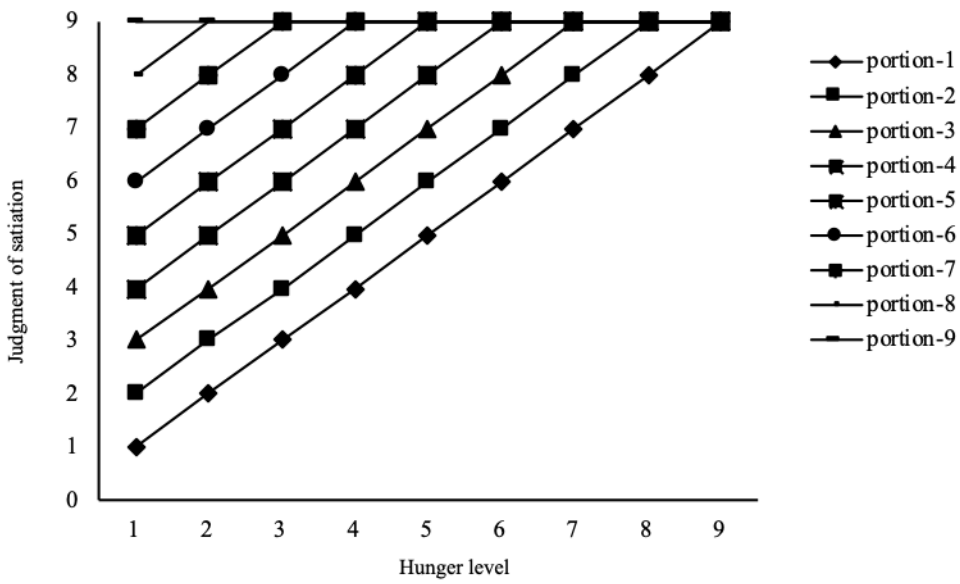

Figure 1. All possible judgement of satiation scores (1="not at all"; 5="averagely satiated"; 9="completely satiated") presumed to yield accurate matches with respect to each combination of the subjective (i.e., reported) hunger levels (1="completely hungry"; 5="neither hungry nor full"; 9="completely full") and portion sizes ranging between 1 (portion-1: the smallest portion) and 9 (portion-9: the largest portion) (Guzel, 2015, p. 938).

For instance, consider that one makes a predicted judgment for a medium portion (portion-5) with a JOS level that implies "completely full" (i.e., "9") when she/he rates their reported hunger level with anchor "1" (i.e., "as hungry as a wolf"); see Figure 1. Therefore, the deviation value for this observed prediction is "- 4". That is, "JOS-observed – JOS-matched=5 - 9=-4". This deviation score ("-4"), as a result, yields both the type of the observed judgment (i.e., an undereating judgment) as well as the degree of it (4 interval point deviation from the matching one). It is an undereating prediction since it was expected that when one is hungry (hunger level= "1") then they should report a prediction of a medium level JOS (JOS level= "5") for this medium-sized portion; however, this case predicts a higher level of satiation (JOS-observed= "9") if they consumed the whole food presented. As a result, this case is far above what it is expected (i.e., JOS-matched). To summarize, the sign of any deviance calculated ("-" or "+") depicts whether the observed judgment produces either an undereating or an overeating prediction ('-' & '+' signs, respectively). Should there be no deviations at all (i.e., JOS-predicted – JOS-matched= '0'), then the observed judgment implies a perfect control. It is also inferred that the more the observed scores disperse further away from the JOS-matched ones (e.g., as the value of the subtraction increases), the higher the degree of such discordant predictions; see Figure 1 (also see Guzel, 2015 for detailed review of the model and the suggested method).

The experiment used a 3(group: hungry, neither hungry nor full, full) x 3(portion size category: small, medium, large) x 2(how judgments made: based on reported vs. imagined bodily states) mixed factorial design where group variable was between, and portion size category and how judgments were made were within subject variables. The dependent variable was the degree of JOS types, concordant and discordant (i.e., undereating & overeating predictions). Two hypotheses were tested in this experiment. Firstly, the group of participants who report their study-time bodily state as hungry (hungry-group) was expected to have a lower concordance (i.e., % of "0" deviations out of the total number of observations) than those who report their study-time bodily state as full in the stomach (full-group). We predicted this in the light of existing evidence. For instance, it has been shown that food deprivation results in impairments in inhibitory control and processing food-related cues, which in turn, results in poorer performance on mental tasks (e.g., Loeber et al., 2013). Evidence revealing that the starvation diets generally end up with failure also seems compatible with this hypothesis (see e.g., Polivy & Herman, 1985; Stirling & Yeomans, 2004; Stroebe et al., 2013; Veltkamp et al., 2008). Secondly, providing Murray and Vickers' (2009) conclusion is valid, then imagining extreme hunger and complete fullness would result in different patterns when hungry and full-groups are compared in terms of their imagination abilities (i.e., generating mental representations of being in different bodily states). In other words, imagining "extreme fullness" would result in dissimilar JOS patterns between hungry and fullgroups if representation of hunger requires more biological signals (note that unlike full group of participants, hungry group should expectedly have such signals already). On the contrary, imagining "complete fullness" would yield comparable JOS patterns regardless of the participants' reported bodily states, providing that imagining fullness would require evoking the related psychological mental representations instead of biologically related ones and so, the present bodily signals already existing for hungry-group might not be an obstacle to imagining fullness as successfully as the full-group would.

Method

Participants

Two-hundred-and-sixteen undergraduate students of a private university in Izmir were recruited for the experiment in exchange for course credits. Four participants did not wish to report their ages; therefore, mean replacement technique was applied to these cases in calculating the mean age of the sample. The descriptive statistics showed a fairly normal distribution in terms of participants' reported hunger level (M=5.16, SD=1.73, Sk=.08, β^{2}=-.31). Hunger level was not experimentally manipulated by, for instance, depriving participants for food intake for a particular duration of time. Therefore, the participants were clustered into three hunger-level groups after the data was collected on the basis of their study-time actual hunger levels: hungry-, neither-hungry-nor-full, and full-groups. A 9-point interval scale was used to assess hunger levels of the participants. The hungry group consisted of those who rated their hunger levels as below 5 (i.e., 1="kurt gibi açım [as hungry as a wolf]", 2= "çok açım [very hungry]", 3="açım [hungry]", 4="biraz açım [slightly hungry]"). Ratings above the medium level of 5 were clustered into the full group (i.e., 6="biraz tokum [slightly full]"; 7="tokum [full]", 8="çok tokum [so much full]", & 9="tıka basa tokum [as full as a tick]"). Therefore, neither-hungry-nor-full group involved those who rated their study time hunger level only with the medium anchor "5" (i.e., "neither hungry nor full") (n=44; M=5.00). Table 1 displays the participant characteristics in each group.

Table 1
Participant Characteristics (N=216) in Each Study-Time-Hunger-Level Categories (i.e., groups: hungry, neither hungry nor full, full) (note that: 1="as hungry as a wolf", 9="completely full in stomach")

Groups	Gender(f/m*)	Age	BMI**	Reported hunger
Hungry	45/43	20.3 (1.70)	21.86 (3.44)	3.52 (0.86)
Normal***	20/24	22.12 (3.36)	22.12 (3.36)	5.00 (0.00)
Full	46/38	20.70 (5.39)	23.46 (4.40)	6.98 (0.89)

Note. * f/m=female/male. **BMI= body mass index. *** The participants who reported their study time hunger level on a 9-point Likert type as "neither-hungry nor full (5)" only. Standard deviations are shown in parentheses.

Measurements

Presentation material: A relatively medium-scale survey was conducted to determine which food items were to be presented. Our project team listed 32 common Turkish lunch foods that were expected to vary in terms of liking. In two parallel classroom sessions, 94 undergraduate students (69 females, 25 males; Age: M=20.28, SD=1.19) rated each of the foods on a five-point likert-scale in terms of how much they like them (1="not at all", 5="a lot"). Based on their mean scores, nine of the foods were selected to be the presentation material, and those foods, which were later tagged as "food-1", "food-2", and so on, constructed three food categories: "the most-liked", "the averagely-liked", and "the least-liked" foods (M=4.53, SD=0.77; M=3.74, SD=1.1; M=2.49, SD=1.37, respectively). Table 2 displays the food list and the selected foods.

Table 2
The liking levels of the foods listed in the pilot study (N=94) and those selected for the actual study

No	Foods	*M*	*Mdn.*	*S*
1	kereviz yemeği (*celery*)	2,06	2,00	1,26
2	kapuska (*cabbage stew*)	2,16	2,00	1,25
3	karnabahar yemeği (*cauliflower*)*	2,63	3,00	1,34
4	pırasa yemeği (*leek*)*	2,78	3,00	1,50
5	arnavut cigeri (*spiced mutton liver*)	2,89	3,00	1,53
6	kabak yemeği (*courgette*) *	2,97	3,00	1,42
7	bamya yemeği (*okra*)	3,10	3,00	1,41
8	ıspanak yemeği (*spinach*)	3,24	3,00	1,25
9	musakka(*mousaka*)	3,49	4,00	1,37
10	kuru fasulye (*white beans*)**	3,60	4,00	1,22
11	omlet (*omelettes*)	3,78	4,00	1,01
12	pilav (*pilaf/rice*)**	3,81	4,00	1,10
13	kolböreği (*rolled pastry*)**	3,82	4,00	0,97
14	taze fasulye yemeği (*green beans*)	3,90	4,00	1,11
15	tavuklu salata (*Caesar salad*)	3,94	4,00	1,04
16	patates salatası (*potato salad*)	4,11	4,00	0,91
17	ızgara balık (*grilled fish*)	4,12	5,00	1,21
18	bezelye yemeği (*peas*)	4,12	4,00	3,20
19	çiğ köfte (*steak tartar a la turca*)	4,13	4,00	0,99
20	kuru fasulye & pilav (*white beans with rice*)	4,16	4,00	0,86
21	gözleme (*Turkish pancake*)	4,18	4,00	0,84
22	su böreği (*water heurek*)	4,19	4,00	0,83
23	kısır (*bulgur salad*)	4,26	5,00	1,08
24	pizza (*pizza*)	4,26	5,00	1,02
25	pide (*pita with minced meat*)	4,31	4,50	0,84
26	makarna (*pasta*)	4,35	4,00	0,67
27	mantı (*Turkish ravioli*)	4,35	5,00	0,98
28	ızgara tavuk (*grilled chicken*)	4,36	5,00	0,99
29	lahmacun (*thin pizza with spicy meat*)	4,41	5,00	0,89
30	yaprak sarması (*stuffed vine leaves*)***	4,54	5,00	0,79
31	patates kızartması (*French fries*)***	4,60	5,00	0,72
32	ızgara köfte (*grilled meatball*)***	4,63	5,00	0,72

Note. * The least liked foods category. ** Averagely liked foods category. *** The most liked foods category.

After a catering company cooked the foods traditionally, nine portions of each food were prepared and their photos were shot (i.e., 9 [food type] x 9 [portion size]). The photos were taken by a Fujifilm FinePix S1500 10 MP digital camera in a home environment. The angle and the distance of the camera were arranged in a way that the view was as from the eyes of an average-height person who is about to have lunch on a kitchen table. The foods were dished on a white, standard-size lunch plate that is placed on a black anti-reflecting background. The plates were accompanied with a fork on the left and a knife over a folded napkin on the right, and with a water-filled medium size tumbler at the top right of the plates. The portions were created by using a standard medium-size serving spoon and the smallest portion ("portion-1") contained one serving-spoon of the food to be captured and "portion-2" contained two spoons of the food, and so on. Whilst creating the portions starting from portion-1 to portion-9 and then taking the photos at this gradually increasing portion size, each added serving was placed right next to the previous one without leaving any noticeable distance in between. Since how appealing the food looks might be a confounding factor, none of the photos were retouched by any photo correction technique.

Demographic Questions Form**:** The form consisted of demographic questions, i.e., age, gender, and socioeconomic status, and also involved the items measuring the level of satisfaction that participants have on their current body shape, weight, and several body parts (i.e., face, arms, legs, hips, and waist). Participants rated these items (e.g., "I am satisfied with my current weight") on a five-point Likert-type scale (1="not at all", 5="a lot").

Data Collection Procedure

The Ethics Board of Scientific Research approved the study prior to data collection. Participants signed a written informed consent form before the experiment and they took part in the study voluntarily. They were given 3-point course credits for their participation. Each participant was tested individually in a quiet and dim-lit psychology laboratory.

Participants were first measured in terms of their weight in kilograms and height in centimetres. This procedure allowed us to measure their body mass indexes (BMI). The experimental phase started right after they filled in the demographic form on the test table. The photos were presented on a 21-inch iMac computer, which also recorded the responses electronically. Necessary scripts were written on Java Runtime Environment software program. The program selected a photo randomly from the photo pool, which involved 81 food photos in total (9 [food type] x 9 [portion size]), then, it presented this photo in the first order (say, portion-3 of food-8). It continued selecting any remaining food type (e.g., food-6) and a remaining portion size randomly (e.g., portion-5). Then, it presented this photo in the second order (in this example it is "portion-5 of food-6"). The program showed the last unselected food and last remaining portion size in the ninth order. The program ensured that each participant responded to totally nine food photos in a completely randomized order, and none of the photos contained the same food and the same portion size twice throughout each testing session.

During the experimental phase, each participant rated their hunger level on a nine-point likert-scale (1="extremely hungry"; 9="completely full") just before giving JOS ratings. Then, they saw the food photos on the computer screen sequentially and were asked to respond to the following question for each food: "Considering the hunger level you have just reported (e.g., "very hungry [2]"), how much do you think you would feel satiated if you had eaten the whole food presented?" (1="not at all"; 9="completely"). This question was rated three more times for each photo where participants made judgments via imagining other hunger states, i.e., "extremely hungry", "neither hungry nor full", and "completely full". The additional instruction was as follows: "Imagine that you were "extremely hungry (1)", how much do you think you would feel satiated if you have eaten the whole food presented?". Each participant responded to these additional questions even if they had already reported their study-time hunger level with one of these levels (i.e., "1", "5", or "9"). They also reported how much they like the presented food on a nine-point Likert-type scale (1="not at all"; 9="a lot"). Right after they completed their responses to the last food, the participants rated their hunger levels once more, just like they did in the beginning of the experiment. Participants were then taken to the section of the laboratory where they filled in the demographic questions form upon their arrival. They were given a written debriefing form and their possible queries were responded before they left the laboratory. Being a self-paced one, the study lasted between 40–60 minutes to complete.

Results

Since the primary interest of the study focuses on the hunger and full bodily states mainly and for brevity in the analyses, the following analyses were run between only hungry-group and full-group excluding neither hungry nor full (i.e., normal) group and excluding the medium-size portion category (please see footnote 1 for the multivariate analysis of covariance [MANCOVA] results where all available groups were compared on the dependant variables analysed in the following sections).

Concordant JOS

An independent samples t-test analysis was conducted to test the effect of "reported hunger level" on concordant-JOS percentage of no divergent observations out of the total number of judgments. Results revealed that hungry-group yielded significantly lower percentage of concordant-JOS scores (M=25.95%, SD=15.71) compared to full-group (M=44.88%, SD=25.66, t(136,35)=-5.800, p<.001). A further analysis was conducted between groups with respect to the portion size as well. Portions were categorised into two: small vs. large portions. The small-portions category involved the portion 1, 2, and 3, and the larger-portions category was composed of portion 7, 8, and 9. The results also showed the full-group yielded higher percentage of concordant judgments for both small and large portions compared to hungry-group ($M_{small=}$27.38%, SD=25.43; $M_{small=}$14.02%, SD=25.63, respectively; t(170)= 3.431, p<.01; M_{large}=57.94%, SD=36.99; $M_{large=}$45.46%, SD=34.72, respectively; t(170)=2.279, p<.05); see Figure 2. This result confirmed the expectation that a lower cognitive control over food intake seems to emerge amongst those who were hungry rather than those who were full and this was observed regardless of the portion size. Further t-test analyses revealed that the hungry and full groups did not differ from each other in terms of concordant-JOS either when they imagined being "extremely hungry" (M=18.05%, SD=12.06; M=16.66%, SD=12.01, respectively) or when they imagined being "completely full" and made their JOS accordingly (M=65.90%, SD=31.01; M=69.71%, SD=31.25, respectively).

The above-mentioned pattern may seem contradictory to the expectation that hunger and fullness might be different constructs. However, a deeper analysis let the supporting evidence come to surface. That is, "providing any difference in imagination ability exists between the groups", full-group should have lower concordant-JOS than hungry-group particularly for "smaller portions" than for "larger portions" due to the following possibility. Full-group might have given higher JOS ratings (i.e., they think they could satiate better)

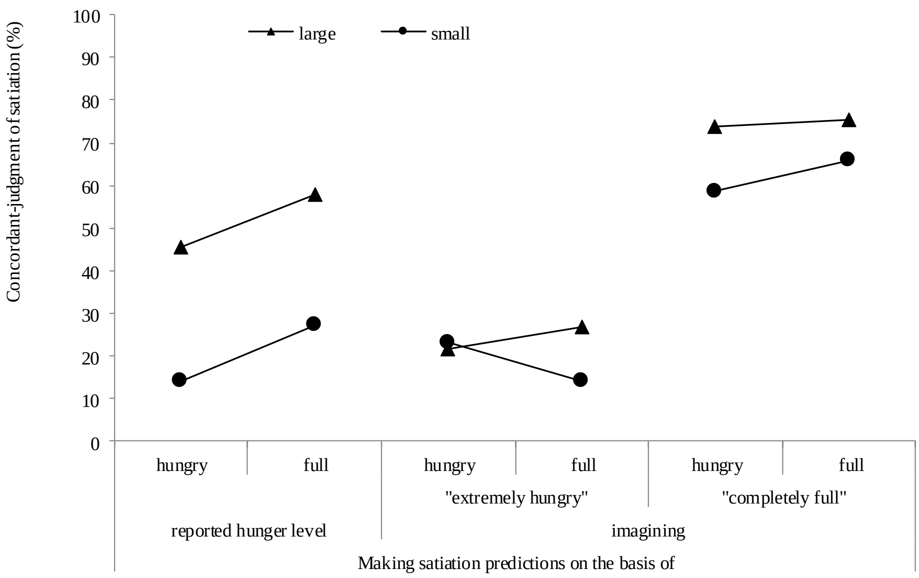

Figure 2. Means of predicted concordant-JOS scores that are gathered with respect to portion size categories (small vs. large) when the groups (hungry vs. full-groups) made their judgments in terms of their actual hunger level and when they imagined various hunger levels (extremely hungry vs completely full).

than hungry-group regardless of the portion sizes if they were still considering their actual bodily state (i.e., full in stomach) despite that they were asked to imagine extreme hunger. In other words, if full-group could not have imagined "extreme hunger" as successfully as the hungry-group, then they must have reported their JOS most likely based on their study-time bodily state so that they must have judged even the small portions with higher satiation ratings compared to hungry-group. To reveal whether this expectation was valid, concordant-JOS scores that were obtained for small and large-portion categories were compared between groups. When "extreme hunger" was imagined, full-group was found to have significantly lower percentage of concordant-JOS for small portions (M=11.45%, SD=22.39) than hungry-group (23.11%; $t(170)=-2.764$, $p=.006$), but not for large portions (M=21.59%, SD=24.26; M=26.98, SD=26.11, respectively). Additionally, the groups did not differ in terms of concordant-JOS for any portion size categories when "complete fullness" was imagined. The reason behind such patterns was that full-group had significantly higher ratings (i.e., predicting better satiation) only for small portions compared to the hungry-group when "extreme hunger" was imagined ($t(170)= 4.738$, $p<.001$). When "complete fullness" was imagined, however, JOS ratings differed between groups for neither small nor large portions. These further analyses showed that those who were full could *not* imagine "extreme hunger" as those who reported being hungry, particularly for small portions whereas hungry participants could imagine "complete fullness" just like full participants did no matter what the size of the portions were.

Discordant JOS

Undereating judgments

Separate independent sample t-tests were run to test the effect of hunger level on undereating scores. The results revealed that, when actual (i.e., reported) hunger level was considered, full-group had a lower level of undereating predictions (M=-1.41, SD=.49) compared to hungry-group (M=-2.19, SD=.92, t(111,98)=-

5.868, p<.001). This result seems valid since the calculation method inevitably results in gradually higher degree of undereating predictions (rather than overeating ones) as the reported hunger level is rated away from the state of being completely full in the stomach (see Figure 1). When extreme hunger was imagined, hungry-group yielded lower level of undereating predictions than full-group (M=-2.68, SD=.93; M=-3.02, SD=.88, respectively, t(160)=-2.438, p < .01). This evidence was in line with the expectation that when individuals are full and asked to imagine extreme hunger, they would yield significantly different undereating scores compared to those who reported being full due to predicting better satiation -particularly for small portions- even though they were asked to imagine extreme hunger. Lastly, note that the calculation method cannot yield any undereating scores when participants are asked to imagine complete fullness (see Figure 3).

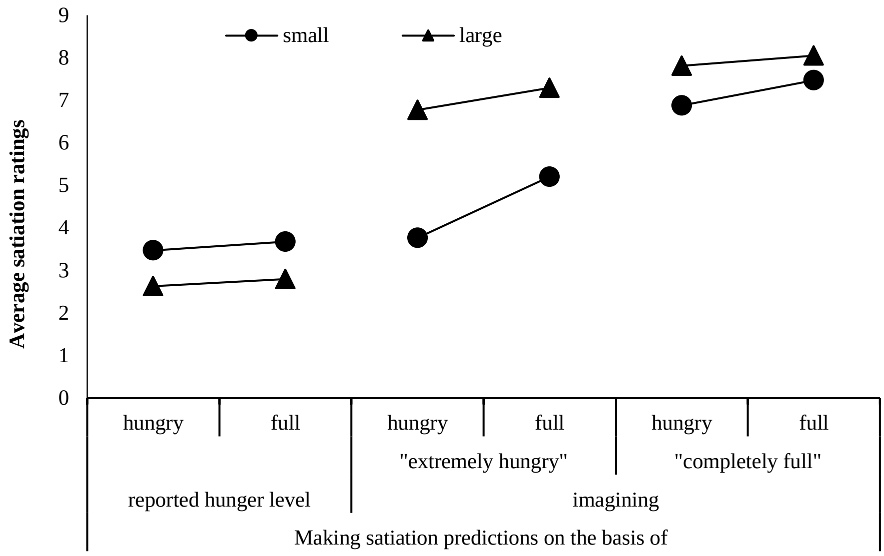

Figure 3. Means of reported satiation ratings (1="not at all", 9="completely satiated") with respect to portion size categories (small vs. large) when the groups (hungry vs. full) made their judgments considering their reported hunger level and whilst imagining various bodily states (extremely hungry vs. completely full).

Overeating judgments

After comparing the scores of reported hunger states, no differences were found between hungry-group and full-group of participants in their overeating judgements (M=1.41, SD=1.12; M=1.46, SD=1.39, respectively, t<1). Additionally, the groups did not differ from each other when the states of "extreme hunger" was imagined (M=2.52, SD=1.19; M=2.46, SD=1.02, respectively, t<1), and when "complete fullness" was imagined (M=4.52, SD=2.32; M=4.02, SD=2.21, respectively, $t(126)$=1.255, p>.05). The obtained patterns might seem contrary to the expectation; however, finding different overeating scores in full-group when they imagined "extreme hunger" compared to, for instance, hungry-group is "not" plausible providing that the groups had already differed in terms of undereating scores when imagination was enforced (see the results obtained for undereating predictions).

Overall, the results on discordant-JOS scores, particularly those of the undereating patterns, also imply that there emerges a variation on imagination ability between those who reported being hungry and those who reported being full when they are asked to imagine extreme hunger. Conversely, it seems plausible for hungry individuals to imagine complete fullness just like those who are already full.[3]

Discussion

Bearing the expectation that the findings could answer some critical questions on eating behaviour, we tested the metacognitive regulation approach of Guzel (2015) in a laboratory experiment and quantified the types and degrees of "predicted judgments of satiation" for common lunch foods amongst different hunger states. First, the results revealed that being hungry rather than full seems to have an adverse effect on having a good command over making predictions about satiation. This conclusion, indexed with a lower percentage of concordant-JOS scores in hungry than full-group, seems compatible with the previous works. For instance, it has been evinced that hunger, but not fullness, induces an approach bias and it is a state that is much associated with response inhibition in humans (e.g., Loeber et al., 2013; also see e.g., Seibt et al., 2007; Veltkamp et al., 2008 for the effects of food deprivation or thristiness on behavior). Also, the research on food deprivation showed that hunger results in poorer performance on various mental tasks as compared to being full (e.g., Loeber et al., 2012). Though this finding seems compatible with previous evidence, one might, approach it with caution. For instance, a plausible response bias (e.g., rating any portion size as completely satiatory) might be advantageous for those who report themselves as completely full whereas those hungrier participants should arrange their JOS with respect to each portion in order to yield a concordant score. However, the probability of yielding the same percentage of concordant-JOS is exactly same for every single participant who rates their bodily states with any of the hunger levels (e.g., see Figure 1). Despite that, full-group of participants in the present study ended up with obtaining higher percentage for concordant-JOS scores although they had the same probability of not obtaining so (please also note that a possible response bias advantage can be valid 'only' for those who report their hunger level with the highest level of fullness [i.e., 9="completely full"]). Therefore, further research is needed to reveal whether any response bias emerges with respect to varying degrees of hunger. Whilst interpreting the results of these prospective experiments, however, it should be considered that responding with higher JOS ratings for full-groups is in fact what it is already expected. Therefore, the future research may answer this query via showing, for instance, whether a sample of chronic dieters or restricted eaters differs substantially from a sample of normal eaters in terms of this possible bias. In other words, providing that a sample of restricted eaters who report their states as already full rates significantly higher number of any portions with the highest JOS rating available than the group of normal eaters who report being full and asked to make judgments accordingly, then, this pattern would "not" imply a response bias rather it would mean a healthy judging amongst the normal eaters, just like those observed in the present experiment.

Second yet more critically, the results revealed that there emerges a difference in imagination ability of hunger and fullness depending on the reported bodily state of the individual. As was concluded by Murray and Vickers (2009), typical hunger seems to be more of a biological construct whereas typical fullness seems to be linked to a psychological representation so that these states may not be tapping into the very same construct. Based on the predicted JOS patterns, we also suspect that fullness and hunger might not be the two

[3] A one-way MANCOVA, where the independent variable was hunger-state categories (i.e., groups: hungry, neither hungry nor full, and full groups) and body mass index (BMI) was controlled for, was also conducted on the following dependent variables (DVs): concordant and discordant judgments (under- and overeating predictions) made when participants considered their actual study-time hunger levels and imagined other bodily states (extremely hungry, neither hungry nor full, and completely full). Concomitant to the findings reported in the text, the results revealed significant effects of the group variable only on the following DVs: concordant and undereating judgments that made when actual hunger state was considered ($F(2, 64)=5.618$, $p=.005$, $\eta^2=.15$; $F(2,64)=6,171$, $p=.004$, $\eta^2=.16$, respectively). Post-hoc comparisons showed full-group obtained higher concordant JOS percentage ($M=52.6$, $SE=3.3$) than hungry- and neither hungry nor full groups, where the latest two had comparable percentages ($M=39.2$, $SE=2.6$ & $M=39.5$, $SE=3.3$, respectively). Again, full-group had significantly a lower degree of under-eating predictions ($M=-1.42$, $SE=.18$) than the hungry-group ($M=-2.23$, $SE=.20$) when neither hungry nor full group ($M=-1.84$, $SE=.24$) did not differ from any other group.

extremes of a single continuum. This implication, which is fairly counter-intuitive, comes about as a preliminary quantitative evidence that converges with the conclusion of Murray and Vickers (2009). The participants who were full in the present study could not imagine extreme hunger as those who reported being hungry due to the possibility that this mental representation (i.e., hunger) plausibly requires sensing a relevant biological signal to evoke a better imagination of this sensation. Conversely, the state of hunger does not seem to be a critical obstacle to imagine complete fullness as successfully as those who are already full, most probably due to the nature of its mental representation. Further, the patterns emerged in the current experiment are compatible with many previous findings that suggest, for instance, the mere imagination of satiation results in a very real satiation sensation that is not substantially different than actual satiation (Larson et al., 2014). Even imagining consuming food results in a heightened feeling of satiation (Morewedge et al., 2010), and the actual amount one has consumed does 'not' turn out to be a critical factor affecting satiation rather it is the subjective sense of how much has been consumed (Redden & Galak, 2013).

One might, however, wonder whether the difference found in the imagination ability of hunger and fullness might have emerged simply due to the possibility that the groups might have differed in terms of several participant characteristics. The groups, for instance, differed in terms of body mass index (BMI; $t(170)=2.676$, $p<.01$), although they were all within the normal range of BMI scores (according to the criteria set by World Health Organization). Full-group had significantly higher BMI scores (M=23.47, SD=4.40) than hungry-group (M=21.86, SD=3.44). We, on the contrary, do not consider this BMI difference as a critical factor to influence imagination ability, and we even interpret this incomparability as something that renders the findings on the imagination ability patterns more entrenched (also note that results revealed the same patterns when BMI was controlled for; see footnote 1). That is, had there been no such difficulty in imagining extreme hunger amongst full-group, conceivably the participants who were full must have had "even lower" JOS ratings whilst imagining extreme hunger since they had higher BMI scores than hungry-group so that reasonably necessitate larger portions for satiation. The results, however, revealed exactly the opposite, which render the implication even more sound: Although they had higher BMI scores, full-group judged small portions with better satiation ratings than hungry group (despite that they presumably would need larger portions for a better satiation) let alone yielding lower or even comparable JOS ratings just like hungry group did.

Of the quantification method, we suggest that the prospective research may consider whether similar results would be gathered when the scales vary between different intervals other than a 9-point one. It should, however, be considered that a 2-point scaling, for instance, eliminates the linearity assumption and renders hunger state, portion size, and JOS level be ordinal scales (i.e., 'hungry' vs. 'full', 'small' vs 'large' portions, and 'not at all satiation' vs. 'complete satiation') so that it loses the ability to quantify the 'degree' of discordant JOS scores and reveals only the direction of judgments categorically, such as it is either an under or an overeating prediction.

To summarize, we believe that conceptualizing eating behaviour and judgment of satiation from a metacognition perspective seems to be a prolific research venue. It may potentially drive and answer various research questions particularly for problematic eating behaviours when any prospective manipulations are made with respect to the cases at interest, such as chronic dieters, those diagnosed with anorexia, bulimia, or orthorexia nervosas, night eating, or obesity. Future research may also reveal, for instance, which factors are critical to account for under and/or over-eating predictions, or lay out some intervention methods that may eliminate or reduce those discordant predictions. Also, the treatment approaches for eating problems that assume hunger and fullness belong to the same contrast and they are the two ends of a single continuum might need to be revisited.

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