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Using food to reduce stress: Effects of choosing meal components and preparing a meal

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ABSTRACT

Many people experience stress as a part of their daily lives. Chronic stress can have an impact on physical and mental health. Since food and eating are generally associated with positive moods, we explored how aspects of meal preparation can relieve stress and improve measures related to mood.

Our main objectives were to determine whether choosing meal components and/or preparing a meal would improve measures related to mood and reduce stress.

Participants came individually to our lab at dinner time. We measured stress (salivary cortisol, heart rate and blood pressure) and took measures related to mood on arrival. We then induced stress (Trier Social Stress Task) and took measures related to stress and mood again. Each participant was assigned to one of four experimental conditions. In the *prepare-choice* condition participants prepared a meal (pasta + sauce + inclusions) and had control over selection of meal components. In the *prepare-no-choice* condition participants prepared their meal, but had no control over the menu. In the *choice-no-prepare* condition participants had control over the menu, but the meal was prepared by someone else. In the *no-prepare-no-choice* condition participants were provided with a meal prepared by someone else. Food preference questionnaires conducted before the stress induction ensured that all participants received foods they liked.

Having no choice produced greater reductions in the mood-related measures of anxiety and anger compared with the choice condition. Systolic blood pressure was reduced more in the no choice than in the choice condition after the meal. Preparing versus not preparing had little effect on measures related to stress and mood.

People may find choosing to be a depleting task on their limited psychological resources; hence, choosing can add to their general stress. Not faced with choosing, one avoids this unnecessary stress. Consuming a meal without the burden of choosing has potential as a stress-reduction strategy.

Introduction

Importance of the food-mood relationship

Eating behaviors, stress, and negative mood[1] all affect physical and mental health, but their interactions are complex and not well defined. Similar to unhealthy eating behaviors, negative mood and chronic stress can lead to anxiety, depression, diabetes, and cardiovascular disease (Dickerson & Kemeny, 2004; Kandiah, Yake, Jones, & Meyer, 2006). The process of choosing what food to eat can involve both physiological (i.e., hunger) and psychological (i.e., emotional) influences (Desmet & Schifferstein, 2008), and once eaten, those foods can affect our mood (King & Meiselman, 2010). If these relationships can be better understood, people may be able to make healthier food decisions that lead to a healthier physical and emotional state.

Effect of food on mood

Foods can elicit an emotional response when eaten, which is typically positive, but it is unclear why this response occurs. In recent years, the elicitation of emotions in response to food consumption

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[1] Although there are clear distinctions in terms of psychological constructs, the words 'mood' and 'emotion' are often used synonymously in the literature. For the remainder of this paper, the words 'mood' and 'emotion' will be used interchangeably.

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has been explored using several methods in many different contexts (Cardello et al., 2012; Desmet & Schifferstein, 2008; Gibson, 2006; King, Meiselman, & Carr, 2010). The majority of emotions found to be associated with foods are positive, including 25 out of 39 words in King & Meiselman (2010) EsSense™ Profile (three words are negative, and the remaining 11 are unclassified). Desmet and Schifferstein (2008) similarly found that positive emotions were experienced at a higher intensity than negative emotions in response to tasting both snack-type and meal-type foods.

Appetite levels could affect these emotional responses People are typically alert and irritable when hungry, and calm and sleepy when full (Gibson, 2006). Intrinsic qualities of a food, such as the inherent pleasantness of a sweet product, may affect emotional responses (Steiner, 1974). Macht, Gerer, and Ellgring (2003) suggested that emotional responses could also be due to the psychological aspects of food and eating, such as guilt after eating high calorie foods. Other hypotheses support this psychologically-elicited view, including the role of cognitive expectations and prior associations, whereby memories and past experiences with foods can influence what our emotional response will be (Cardello et al., 2012; Mojet & Köster, 2002; Walsh & Kiviniemi, 2013; Wansink, Payne, & North, 2007).

Effect of food on stress

In addition to prompting a positive emotional response, the consumption of food may also alleviate both psychological and physiological stress. Martin et al. (2009) found that consumption of 40 g dark chocolate per day for two weeks decreased urinary cortisol (an indicator of physiological stress levels) in participants with chronic stress. In another study on chocolate, just three days of dark chocolate consumption resulted in decreased levels of psychological stress captured by self-reported anxiety and depression (Lua & Wong, 2011). Finally, Pecoraro, Reyes, Gomez, Bhargava, and Dallman (2004) saw a decrease in stress hormone levels after consumption (by rats) of palatable, calorie-dense food during periods of stress. Therefore, food consumption may impact stress both physically and psychologically.

Choice

Too many choices and/or too many options per choice may cause increased stress and negative mood. Schwartz (2004) calls this the 'Paradox of Choice' as adding explicit choice to a situation may unknowingly increase stress and negative mood. Repeated acts of choosing deplete the resources needed for self-control (Vohs et al., 2008), which could further increase stress and negative mood. Experiencing stress itself can also deplete resources (Baumeister, Bratslavsky, Muraven, & Tice, 1998), further enhancing feelings of stress and negative mood. Too many options may make choice unappealing because although it can be enjoyable, choice can also be overwhelmingly frustrating (Iyengar & Lepper, 2000; Schwartz et al., 2002). When there are too many options, the added burden of weighing all the possibilities and making the 'best' choice can increase dissatisfaction with the final result (Schwartz et al., 2002). In other words, there will always be the underlying thought of regret that the consumer failed in their quest to find the best option. Indeed, Iyengar and Lepper (2000) found that greater dissatisfaction is experienced when the same option is chosen from an extensive set (24–30 options) than from a set with limited options (six). The more choices available, the greater the chance the consumer chooses the 'wrong' one, magnifying feelings of stress and negative mood.

On the other hand, common consensus is that people enjoy freedom of choice. Liking and consumption tend to increase when people choose their food (Cardello et al., 2012). While this increase in liking could presumably improve mood and stress, limited evidence suggests that this actually happens. When the participants of Garg and Lerner (2013) were given a choice of reward (chocolates vs. a ballpoint pen, with the idea that this would be an easy choice and most people would choose the chocolates) after induction of sad mood, sadness was reduced more than if the participants were just presented with chocolates as a gift. The work of Garg and Lerner (2013) and Iyengar and Lepper (2000) showed that simple choices, such as those with few options and/or trivial consequences, may result in less negative consequences for mood and stress. The detrimental effects of too many choices, however, especially when distressed, may outweigh the benefits of having the freedom to choose.

Food preparation

The alleviation of stress and improvement of mood are likely outcomes of food preparation, although limited evidence suggests that food preparation itself can be stressful. Benson, Beary, and Carol (1974) suggested that activities involving mindless, repetitive tasks elicit a relaxation response. Food preparation, which entails such tasks as chopping vegetables and repeated stirring, may fit well into this category. Food preparation may also result in improved mood when it is done out of a sense of duty (i.e., to feed the family) or to please others (Daniels, Glorieux, Minnen, & van Tienoven, 2012). Building on this, Costa (2013) found that people ascribe strong, positive feelings towards cooking hot meals at home, whereas they feel guilty (along with other negative emotions) when they do not cook at home. Food preparation allows for a certain amount of autonomy and control. Control in general is related to well-being and life satisfaction (Tangney, Baumeister, & Boone, 2004). Knowing the ingredients and processes that go into one's meal may be an easy way to exercise control and reap the psychological benefits. On the other hand, food preparation can be stressful, especially when hunger, distractions, and time constraints come into play (Daniels et al., 2012). In the case of mood improvement and stress relief, the advantages of preparing food may, under many circumstances, outweigh its detriments.

Objectives and hypotheses

The main objective of this study was to explore whether choice of meal ingredients (vs. no choice) and/or preparation of a meal (vs. someone else preparing) influence the stress-reducing and mood-lifting effects of food and eating.

Given the stressful consequences inherent to making choices, we expected choosing ingredients to have detrimental effects on mood and stress. We specifically hypothesized that if people did not choose their meal ingredients, they would show a greater improvement in measures related to mood and larger reduction in stress after eating than if they did choose their meal ingredients.

Given the positive consequences from preparing food, we expected preparing food to produce improvements in mood and stress. We specifically hypothesized that if people prepared the meal themselves, they would show a greater improvement in measures related to mood and larger reduction in stress after eating than if someone else prepared the meal for them.

Materials and methods

Participants

One hundred eighteen participants (36% male, mean age = 28, SD age = 11, range = 18–63) were recruited via email listserv and posted flyers. They were screened for availability and liking of meal

ingredients (Table 1). To be invited to participate in the study, each potential participant had to rate the pasta, at least one of the sauces, at least two of the inclusions, and at least one of the seasonings six or higher on a nine-point liking scale (Peryam & Pilgrim, 1957). We chose this cut-off point because it indicated that the participant liked the food as it was above the midpoint of the 9-point scale, and six corresponded to 'like slightly'. Exclusion criteria included those with food allergies or sensitivities; use of antidepressants, steroid medications, or tobacco; and pregnancy, as these can affect cortisol levels. Participants were compensated $20 for their participation. Participants were asked to avoid caffeine, alcohol, smoking, strenuous exercise, and eating for three hours prior to their appointment. The study protocol was approved by the Institutional Review Board of the university, and all participants gave informed consent prior to the study.

Study design

The study had a two-factor between-participants design: *Choice* (participants did or did not get to choose the ingredients in their pasta meal) and *Prepare* (participants either prepared the meal themselves, or the experimenter prepared it for them). This design resulted in four treatment groups: *Choice/Prepare, No Choice/Prepare, Choice/No Prepare,* and *No Choice/No Prepare*. Participants were scheduled individually for one test session lasting 1.5–2 h. The study was conducted between 4:00 pm and 8:30 pm on weekday evenings. The four treatments were randomly assigned to each of four time slots per day, and participants were randomly scheduled to a slot according to their availability.

Participant visit protocol

A schematic of the study protocol is shown in Fig. 1. When participants arrived at the site, they were greeted by an experimenter who would guide them through the study. To attenuate any experimenter effects, the experimenter was unaware of the theoretical constructs, the predictions of the study, or the outcomes of interest. As well, the experimenter read from a script to control for the content of instructions, and any interaction with the participant during food choice and preparation was limited to the degree required to execute the manipulation.

After signing the consent form, the participant was guided to the meal preparation area. The experimenter described what would happen later in the study when it was time for the meal. This was done to familiarize the participant with the setting, so as to minimize any additional stress invoked by new surroundings and uncertain tasks. Then the participant and experimenter sat at a table with a computer. A blood pressure cuff was attached to the participant's non-dominant arm (so he/she could easily work the computer mouse with the dominant hand). A practice blood pressure measurement and saliva sample (for cortisol measurement) were taken. At this point, the experimenter left the room for 20 min (habituation period), during which time the participant answered computerized questionnaires.

After 20 min, the experimenter returned and obtained baseline blood pressure/heart rate measurements and a saliva sample. Next, the participant completed a questionnaire containing mood-related words (see "Questionnaires") to get baseline measurements. Instructions were then given for the stress task.

The stress task closely followed the protocol of the Trier Social Stress Task (TSST) outlined by Kirschbaum, Pirke, and Helhammer (1993). The experimenter told the participants that they would have five minutes to prepare a speech. They were told to pretend they were a job applicant interviewing for a position in a company. They were asked to explain why they would be the perfect candidate for the job. They were given paper and pen to take notes, but were told that they could not use the notes during the speech. The experimenter indicated that two people would come in to evaluate the speech, and then the experimenter left the room. This TSST approach has been widely used in laboratory settings to reliably induce both physiological and psychological stress. We should note that we slightly modified the original task in the following ways: the experimenter was unaware of the treatment group; the speech was not videotaped; the speech was shorted from 10 min to 5 min, and the arithmetic task began at a different number each minute.

When the five minutes had passed, two people (one male, one female; hereafter referred to as confederates) in white lab coats and holding clipboards entered. They asked the participant to stand up and deliver the speech into a microphone. The confederates told the participant that the speech would be recorded and a 'voice frequency analysis' would be done on the recording. (The speech was not actually recorded.) One of the confederates was introduced as being specially trained to monitor nonverbal behavior. This confederate would be taking notes throughout the task. The participant was then told to begin the speech. The participant was required to speak for the entire five minutes. Specific verbal

Table 1
Meal components.

Ingredient	Type	Manufacturer	Address	Portion (g)
Pasta	Rotini	Creamette®	Allentown, PA	224*
Olive oil	Extra-virgin	Pompeian®	Baltimore, MD	3.4**
Salt	Iodized	Roundy's®	Milwaukee, WI	4.5***
Sauces				
Alfredo sauce	Four Cheese	Roundy's®	Milwaukee, WI	150
Marinara sauce	Traditional	Prego®	Camden, NJ	150
Inclusions				
Green chilies	Canned, diced, fire-roasted	Ortega®	Parsippany, NJ	15
Sun-dried tomatoes	Julienne cut, with extra virgin olive oil and Italian herbs	Bella Sun Luci®	Chico, CA	20
Olives	Kalamata, pitted, whole	Mezzetta®	American Canyon, CA	20
Mushrooms	Canned, stems & pieces	Roundy's®	Milwaukee, WI	25
Seasonings				
Parmesan cheese	Grated	Roundy's®	Milwaukee, WI	7
Basil	Dried	McCormick®	Sparks, MD	<1
Black pepper	Dried	Roundy's®	Milwaukee, WI	<1

* Cooked: This amount is approximately two servings (based on the Nutrition Facts panel on the pasta box).
** Tossed with cooked pasta (13.5 g/4 servings).
*** Added to pasta cooking water (18 g/4 servings).

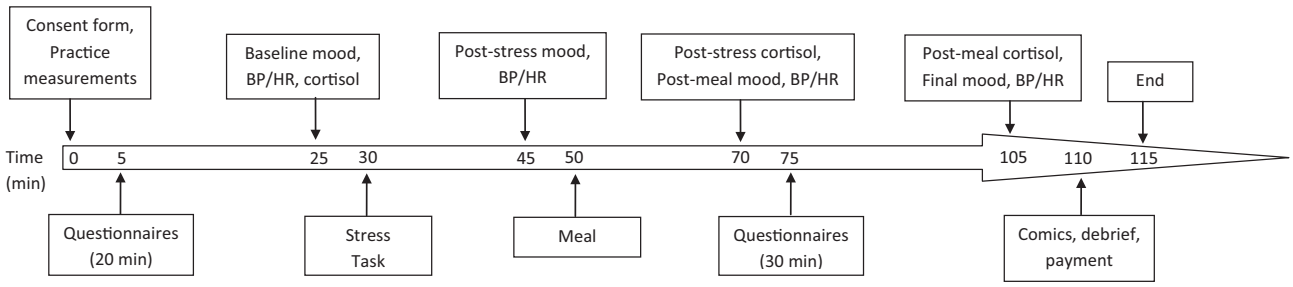

Fig. 1. Experimental Protocol.

prompts were used if the participant stopped speaking before the time was up.

After the speech, the participant had to perform a counting task. The participant was asked to start at 1022 and count back by 13 s to zero. In reality, the task was timed for five minutes and the participant did not have to count back to zero. After each minute, the confederate instructed the participant to begin at a different number. Each time a mistake was made, the participant had to start over. Throughout the stress task, the confederates remained stoic and stern faced.

When the 15-min stress task was finished, the confederates left the room and made a subjective rating of how good the participant was at the stress task (hereafter referred to as 'TSST Score'), from 1 = Very Bad to 5 = Very Good. A participant who was 'Very Bad' at the TSST, for example, appeared very uncomfortable during the speech and was not able to make it past one or two subtractions on the mental arithmetic task. A 'Very Good' participant was able to speak easily for the entire five minute speech and complete 15–20 correct subtractions during the math task. Therefore, a participant who was 'Very Good' at the TSST presumably did not become as stressed as a 'Very Bad' participant.

After the stress task ended, the experimenter returned and immediately took post-stress blood pressure and heart rate measurements. Then the participant completed post-stress measures related to mood. The experimenter then gave the participant a menu sheet. The sheet was either already filled out (for participants in the *No Choice* groups), or the participant was instructed to fill it out (*Choice* groups). The specific wording for each treatment group was as follows:

> *Choice/Prepare*: "Fill out this menu sheet. You get to choose one sauce, 3 inclusions, and 1 topping for your pasta. Whichever ones you want, it's up to you! Then we will go over there, and you will get to cook it yourself!"
> *No Choice/Prepare*: "Look at this menu sheet. You have been assigned to eat a pasta dish with these specific ingredients. You don't get to choose. Then we will go over there, and you will get to cook it yourself!"
> *Choice/No Prepare*: "Fill out this menu sheet. You get to choose one sauce, 3 inclusions, and 1 topping for your pasta. Whichever ones you want, it's up to you! Then we will go over there, and I will cook it for you."
> *No Choice/No Prepare*: "Look at this menu sheet. You have been assigned to eat a pasta dish with these specific ingredients. You don't get to choose. Then we will go over there, and I will cook it for you."

The purpose of this specific wording was to strengthen the *Choice/No Choice* and *Prepare/No Prepare* manipulations. Next, the participant was guided to the meal preparation area. For the *No Prepare* groups, the experimenter prepared the pasta and then left the room. For the *Prepare* groups, the participants were handed an instruction sheet and the experimenter left the room. The participant sat back down at the table with the pasta and was given ten minutes to eat.

At the end of the eating period, the experimenter returned and removed the plate from in front of the participant. Another saliva sample was taken (post-stress), as well as blood pressure/heart rate measurements (post-meal). The participant then began answering questionnaires again (including the post-meal measures related to mood). The experimenter then left the room for 30 min.

When the 30 min elapsed, the experimenter returned and took final blood pressure/heart rate measurements and the post-meal saliva sample. After that, the participant filled out the final measures related to mood. Finally, the participant read through a set of comic strips and rated how funny they were. This was done to ensure that any residual stress after the meal was gone by the time they left. Then the participant was debriefed and introduced to the two confederates who had administered the stress task. Lastly, the participant was paid and thanked for coming.

Meal

The meal consisted of a hot pasta dish prepared on site and a glass of water. The participants in the *No Choice* groups were given a subset of the ingredients that they had rated six or higher on the liking scales during the prescreening process. For these participants, menu sheets were filled out in advance by the experimenter. Participants in the *Choice* groups filled out their own menu sheets as described above in "Participant visit protocol". Each participant's meal consisted of one of two sauces, two or three of four possible vegetable inclusions, and one of three seasonings. However, all ingredient choices were presented at the meal preparation area to reinforce the fact that the *No Choice* participants were missing out on the other ingredients. See Table 1 for ingredients and portion sizes. Meal ingredients were pre-portioned and set out prior to the start of the study. Labels were placed behind each ingredient so each participant was exposed to the names of all the ingredients. Pasta was precooked according to the package directions with the addition of 18 g salt to the cooking water. Cooked pasta was tossed with 13.5 g olive oil, portioned, and refrigerated until needed. Cooked pasta was held refrigerated for no longer than 24 h.

When it was time for the meal (right after the stress task), the experimenter brought the participant over to the meal preparation area. The experimenter removed the ingredients that the participant was not going to eat and placed them on a tray. For the *No Prepare* groups, the experimenter then added the selected ingredients to the bowl of pasta, stirred it, and microwaved it for two minutes. When it was heated, the experimenter poured it onto a plate. For the *Prepare* groups, the experimenter gave the participant an instruction sheet and asked if there were any questions about the meal preparation. The experimenter then left the room, taking the tray of extra ingredients. The participant was instructed to

prepare the meal by adding the appropriate ingredients to the bowl of pasta, stirring, microwaving for two minutes, and then pouring it onto a plate. All participants sat down to eat and were not required to finish the entire pasta dish.

All meal ingredients were weighed prior to the start of the study. Leftover pasta was weighed at the end to calculate how much of each ingredient was eaten.

Questionnaires

The questionnaire used to assess mood variables used the Profile of Mood States (POMS) (McNair, Lorr, & Droppleman, 1971) as a starting point. The questionnaire consisted of 24 mood-related words (15 from the original POMS scale), divided into five broader categories (*anxiety, anger, fatigue, positivity, and sadness*) derived from a factor analysis (Table 2; "Data analysis"). Words expressing threat ('threatened', 'intimidated', 'pressured') and self-consciousness ('self-conscious', 'embarrassed', 'awkward') were added for this experiment to measure emotions specifically elicited by the TSST (which specifically elicits self-evaluative threat), and other adjectives from the full POMS scale were eliminated for lack of relationship to the TSST and concerns about the total length of the questionnaire for repeated administrations. Words expressing calmness ('calm', 'content', 'satisfied') were also added as additional positive emotions. Participants were asked to rate the extent to which they were experiencing each mood-related word on a seven-point scale (1 = not at all, 7 = extremely). The questionnaire was administered four times during the study: baseline, post-stress, post-meal, and final (Fig. 1).

The rest of the questionnaires were inventories of personality characteristics and scales of individual differences (see Table 3 for full list). Participants completed these questionnaires during the 20 min habituation period and the 30 min post-meal period. These waiting periods were included to allow for the lag time in detecting cortisol changes in saliva. Enough questionnaires were included to fill the time, but not all participants finished all of them. The goal was to keep the participants occupied during these waiting periods, but not induce positive or negative mood. Possibly these personality measurements could have affected stress and mood-related measures, so they were also potential covariates in our analyses. All questionnaires regarding eating behaviors were reserved for the post-meal period so as to minimize the effect of increased awareness of these behaviors while the participant was eating.

After the meal, participants were asked to rate liking of the food ingredients they ate, as well as their overall enjoyment of the meal. They also answered questions about how well they liked choosing the ingredients, if they thought they were in control of the preparation/choice of ingredients, how difficult it was to prepare, and if they felt they were really cooking (as opposed to just mixing and microwaving). General questions also included how much the participants enjoyed cooking in everyday life, and how many hours per week they spent cooking. Hunger measures were obtained at the start of the study, after the meal, and at the very end of the study by asking the participants to "Rate the amount of food you desire" and "Rate the amount of food you could eat" on a scale from 0 (none) to 100 (greatest possible amount).

Blood pressure and heart rate

Blood pressure cuffs (Omron Healthcare®, Lake Forest, IL) were worn by participants throughout the study. Blood pressure and heart rate measurements were made in duplicate at four times: baseline, post-stress, post-meal, and final. Blood pressure and heart rate measurements determined the extent of activation of the sympathetic-adrenomedullary (SAM) axis, a physiological stress response pathway (Creswell et al., 2005).

Saliva samples and cortisol analysis

Four saliva samples were taken from each participant: a practice sample, and then one each at baseline, post-stress, and post-meal. Samples were collected with an oral swab, or 'salivette' (Salimetrics, State College, PA). Changes in cortisol can be detected in saliva 20–40 min after changes in stress level. Therefore, the

Table 2
Words in mood questionnaire (adapted from the Profile of Mood States; McNair et al., 1971).

Category*	Emotion words
Anxiety	Anxious Awkward Discouraged Embarrassed Intimidated On edge Pressured Self-conscious Uneasy
Anger	Angry Annoyed Resentful Threatened
Fatigue	Exhausted Fatigued Worn out
Positivity	Calm Cheerful Content Lively Satisfied
Sadness	Hopeless Sad
uncategorized**	Vigorous

* Categories are based on Principal Components Analysis (see "Data analysis").
** 'Vigorous' loaded below 0.5 on all of the factors and was not included in data analysis.

Table 3
Individual difference questionnaires.

Questionnaire	Source
Sensation Seeking Scale	Arnett (1994)
Internal vs. External Locus of Control	Rotter (1966)
Maximizing vs. Satisficing	Schwartz et al. (2002)
Perceived Stress Scale	Cohen, Kamarck, and Mermelstein (1983)
Sensation Seeking Scale	Zuckerman, Kolin, Price, and Zoob (1964)
Personal Need for Structure	Neuberg and Newsom (1993)
Eating Self-Efficacy	Glynn and Ruderman (1986)
Self-Control Scale	Tangney et al. (2004)
Variety Seeking Scale (VARSEEK)	Van Trijp, Lähteenmäki, and Tuorila (1992)
Three Factor Eating Questionnaire (Factors 1 & 2)	Stunkard and Messick (1985)
Self-Esteem Scale	Rosenberg (1965)
Life Orientation (Optimism) Scale	Scheier, Carver, and Bridges (1994)
Restrained Eating Scale	Polivy, Herman, and Warsh (1978)
Optimum Stimulation Level	Raju (1980)
Boredom Proneness Scale	Farmer and Sundber (1986)
Dutch Eating Behavior Questionnaire (external and restrained eating subscales)	Van Strien, Frijters, Bergers, and Defares (1986)

Table 4
Changes in stress and mood responses from before to after the stress task. Least squares means for each factor level are given (standard errors in parentheses). 'Yes' under the 'Choice' heading indicates Choice group and 'No' indicates No Choice group. 'Yes' under the 'Prepare' heading indicates Prepare group and 'No' indicates No Prepare group. Positive means indicate increases in a response and negative means indicate a decrease. *F*-statistics and *p*-values are for 2 × 2 ANOVAs for each *response* and factor.

Responses	Choice				Prepare			
	Yes	No	*F*	*p*	Yes	No	*F*	*p*
Anxiety[a]	1.0 (0.2)	1.8 (0.2)	8.6	0.00	1.3 (0.2)	1.4 (0.2)	0.0	0.85
Anger	0.6 (0.2)	1.2 (0.2)	5.5	0.02	0.8 (0.2)	0.9 (0.2)	0.1	0.78
Fatigue	0.2 (0.2)	0.3 (0.2)	0.2	0.66	0.2 (0.2)	0.2 (0.2)	0.0	0.88
Positivity	−1.0 (0.1)	−1.4 (0.1)	4.1	0.05	−1.1 (0.1)	−1.3 (0.1)	0.5	0.47
Sadness	0.1 (0.1)	0.3 (0.1)	1.7	0.20	0.1 (0.1)	0.4 (0.1)	3.1	0.08
Systolic BP (mmHg)	9.1 (1.2)	11.3 (1.2)	1.7	0.20	9.6 (1.2)	10.7 (1.2)	0.4	0.53
Diastolic BP (mmHg)	6.3 (0.9)	6.5 (0.9)	0.0	0.86	5.9 (0.9)	7.0 (0.9)	0.7	0.40
Heart rate (bpm)	0.3 (1.0)	2.3 (1.0)	1.8	0.18	0.3 (1.0)	2.2 (1.0)	1.7	0.20
Cortisol (μg/dL)	0.1 (0.04)	0.2 (0.04)	0.0	0.91	0.1 (0.04)	0.2 (0.04)	1.5	0.23

[a] Mood words were rated on a 7-point scale, from 1 = not at all to 7 = extremely.

baseline sample was taken after a 20 min habituation period. The post-stress sample was taken immediately after the meal (35 min post stress-induction). The post-meal sample was taken 30 min after the meal was finished. Samples were immediately frozen until a sufficient number were ready for analysis. Cortisol was detected via a salivary cortisol enzyme immunoassay kit (Salimetrics, State College, PA). Each sample was assayed in duplicate. Elevated cortisol is an indication of physiological stress, specifically activation of the hypothalamic–pituitary–adrenal (HPA) axis (Creswell et al., 2005).

Data analysis

All data were analyzed using SAS® version 9.3 (SAS Institute Inc., Cary, NC, USA) using a significance level of $\alpha = 0.05$. A factor analysis was done on the changes in measures related to mood (from baseline to post-stress and from post-stress to post-meal). The factor analysis revealed five factors using a criterion of the Eigenvalue exceeding one (see Table 2 for word groupings). Subsequently these factors were computed from each participant's data at each time point as the average of the scores of each emotion word in the factor. The emotion word 'vigorous' did not load onto any factor, and so was dropped from subsequent analyses. Duplicate systolic and diastolic blood pressure and heart rate measurements were averaged at each time point for each participant. Averages of the cortisol content of the two saliva aliquots at each time point were calculated for each participant. All subsequent analyses were done using the five mood-related factors (*anxiety, anger, fatigue, positivity, and sadness*), blood pressure (systolic and diastolic), heart rate, and cortisol as dependent variables, hereafter referred to as *responses*.

To determine whether stress and negative mood-related measures increased across all participants after the stress task (i.e., did the stress induction work?) and then decreased after the meal, one-sided t-tests on post-stress minus baseline differences and post-meal minus post-stress differences in *responses* were performed.

A 2 (*Choice* vs. *No Choice*) × 2 (*Prepare* vs. *No Prepare*) analysis of variance (ANOVA; PROC GLM in SAS) was done with baseline *responses* as the dependent variables to determine if there were differences in stress or in measures related to mood among treatment groups at baseline. The same ANOVA model was used with post-stress minus baseline *responses* as dependent variables to determine if stress and measures related to negative mood changed uniformly across the four treatment groups.

To test both the hypothesis that not choosing meal ingredients results in greater reduction of stress/measures related to negative mood than choosing and the hypothesis that preparing a meal results in greater reduction of stress/measures related to negative mood than not preparing, we performed 2 × 2 ANOVA using the differences between post-meal and post-stress values of the *responses* as dependent variables. Statistical significance for these was determined using one-tailed tests matching the direction of our hypotheses. Performing the analysis on the change in *responses* allowed us to take into account the differences in stress levels after the TSST. Potential covariates (i.e., age, gender, and personality scales) were also analyzed, but none reached statistical significance (all *p*-values > 0.05). Thus, we do not discuss them further. As well, the covariates did not differ between any of the experimental conditions (all pairwise *p*-values > 0.05), indicating our randomization appeared successful.

Results

The factor analysis of the mood-related measures revealed five factors with Eigenvalues greater than one (Table 2). Cronbach's alphas calculated for each factor showed good consistency (*anxiety*, $\alpha = 0.94$; *anger*, $\alpha = 0.88$; *fatigue*, $\alpha = 0.87$; *positivity*, $\alpha = 0.77$; *sadness*, $\alpha = 0.84$). Importantly, we noted that the *anxiety* factor encompassed self-conscious and threatening emotions as well as anxious emotions.

A check of baseline mood-related measures and stress *responses*[2] found only one initial difference according to treatment. Those in the *Prepare* groups had lower baseline heart rates ($M = 66$ bpm, SE = 1.3) than those in the *No Prepare* groups ($M = 70$ bpm, SE = 1.3) ($t = -2.19$, $p < 0.05$). All other responses showed no significant differences in baseline *responses* according to treatment group (data not shown). No interaction effects between *Choice* and *Prepare* were apparent at baseline.

The stress induction task was effective at inducing stress and increasing negative measures related to mood (Supplemental Table 3). Anxiety, anger, fatigue, and sadness, as well as systolic and diastolic blood pressure and cortisol all increased after the TSST (all *p*-values < 0.05). Positivity rating decreased after the TSST ($p < 0.001$). Heart rate was not affected by the TSST.

Post-meal *responses* indicated that stress and negative measures related to mood had decreased (Supplemental Table 3). *Anxiety*, *anger*, *fatigue*, and *sadness*, as well as systolic and diastolic blood pressure and cortisol decreased after the meal (all *p*-values < 0.01). *Positivity* rating increased after the meal ($p < 0.001$). Heart rate did not change significantly.

Although there were no differences in experimental protocol before the meal, those in the *No Choice* groups experienced greater stress increases and deterioration in measures related to mood after the TSST than those in the *Choice* groups. *Anxiety* and *anger*

[2] Means for all treatment groups for all responses at all time points can be found in Supplemental Table 1.

Table 5
Changes in stress and mood responses from after the stress test to after the meal. Least squares means for each factor level are given (standard errors in parentheses). 'Yes' under the 'Choice' heading indicates Choice group and 'No' indicates No Choice group. 'Yes' under the 'Prepare' heading indicates Prepare group and 'No' indicates No Prepare group. Positive means indicate increases in a response and negative means indicate a decrease. *F*-statistics and *p*-values (one-sided) are for 2 × 2 ANOVAs for each *response* and factor.

Responses	Choice				Prepare			
	Yes	No	*F*	*p*	Yes	No	*F*	*p*
Anxiety[a]	−1.0 (0.1)	−1.5 (0.1)	7.0	0.00	−1.3 (0.1)	−1.3 (0.1)	0.0	0.50
Anger	−0.4 (0.1)	−0.9 (0.1)	6.6	0.01	−0.6 (0.1)	−0.6 (0.1)	0.1	0.41
Fatigue	−0.4 (0.1)	−0.4 (0.1)	0.0	0.42	−0.3 (0.1)	−0.5 (0.1)	0.9	0.18
Positivity	0.4 (0.1)	0.6 (0.1)	1.2	0.14	0.6 (0.1)	0.4 (0.1)	0.9	0.18
Sadness	−0.2 (0.1)	−0.4 (0.1)	2.0	0.08	−0.2 (0.1)	−0.4 (0.1)	1.4	0.12
Systolic BP (mmHg)	−3.3 (1.0)	−7.1 (1.0)	7.0	0.00	−4.0 (1.0)	−6.4 (1.0)	2.8	0.05
Diastolic BP (mmHg)	−1.2 (0.8)	−1.6 (0.7)	0.2	0.35	−0.7 (0.7)	−2.1 (0.8)	1.8	0.09
Heart rate (bpm)	2.4 (1.0)	0.0 (1.0)	2.9	0.05	2.7 (1.0)	−0.3 (1.0)	4.3	0.02
Cortisol (μg/dL)	−0.1 (0.03)	−0.1 (0.03)	0.5	0.24	−0.1 (0.03)	−0.1 (0.03)	0.9	0.17

[a] Mood words were rated on a 7-point scale, from 1 = not at all to 7 = extremely.

increased more after the TSST for those in the *No Choice* groups versus the *Choice* groups (Table 4). *Positivity* ratings decreased more for those in the *No Choice* groups versus the *Choice* groups. No differences in stress increase or deterioration in measures related to mood were observed between those who prepared the meal and those who did not prepare the meal. No significant interaction effects were seen between the *Choice* and *Prepare* factors (data not shown).

Preparing a meal versus not preparing a meal had little effect on reducing stress or improving measures related to mood. Heart rate increased more for those in the *Prepare* groups than in the *No Prepare* groups after the meal (Table 5). Systolic blood pressure decreased more for those in the *No Prepare* groups versus the *Prepare* groups. *Prepare* versus *No Prepare* had no effect on the other *responses*.

In agreement with our hypothesis, those in the *No Choice* groups showed a greater decrease in *anxiety, anger*, and systolic blood pressure after the meal than those in the *Choice* groups (Table 5). After the meal, heart rate increased more for those in the *Choice* versus the *No Choice* groups. *Choice* versus *No Choice* had no effect on the other *responses*.

Discussion

The No Choice groups reacted more strongly to the TSST

Stress and measures related to negative mood would have been predicted to have increased similarly for all groups of participants, but in the context of this study the *No Choice* groups reacted more strongly to the TSST than the *Choice* groups. Those in the *No Choice* groups had greater increases in *anxiety* and *anger* and greater decreases in *positivity* after the TSST (Table 4) than did the *Choice* groups. The experimental protocol was the same for all participants through the end of the TSST. The manipulated differences occurred only during the meal portion of the study. However, at the very beginning of the experiment, participants were briefed on what would happen during the meal. This was done to prevent possible stress increases from worry about preparing a meal in an unfamiliar setting. Verbal cues were subtle, but there was a difference between what was said to the *Choice* groups versus what was said to the *No Choice* groups. Those in the *Choice* groups heard: "You will fill out a menu where you get to choose the ingredients for your pasta," and those in the *No Choice* groups heard: "You will receive a list of ingredients that you will need to add to your pasta." It is possible that these differences in wording were enough to induce the 'choice' manipulation before it was intended and allow for the *No Choice* groups to be more susceptible to stress increases because they felt they would not be in control of their meal choices. This potential susceptibility was possibly reflected by TSST scores. We observed a trend for those in the *Choice* groups ($M = 2.4$, SE = 0.17) to perform better (i.e., score higher) than those in the *No Choice* groups ($M = 2.2$, SE = 0.17; $F = 1.49$, $p = 0.22$). We could reasonably expect that performing better on the TSST would result in a smaller stress increase. *Anxiety, anger*, and *sadness* increased less after the stress task if the participant had a higher TSST score (Supplemental Table 2).

No cortisol differences observed among factor levels

Differences in salivary cortisol levels between the *Choice* and *Prepare* factors were not observed in this experiment, possibly because of high inter-individual variability. Cortisol levels vary widely from person to person, both in baseline values and response to stress (Kirschbaum & Hellhammer, 1994). We tried to control for this by excluding smokers, pregnant women, and users of certain drugs, but genetics also contribute greatly to cortisol reactivity (Kirschbaum & Hellhammer, 1994). High variability may have masked detectable differences in salivary cortisol among factor levels after the meal. Given the observed variability of post-meal minus post-stress cortisol (overall $M = -0.11$ μg/dL, SD = 0.18, $n = 96$), a difference in means of 0.07 should have been detectable with 95% power. Our test was not sensitive enough to detect the small differences we actually observed (around 0.03).

Timing of sample collection may also have affected measured cortisol levels. Post-stress saliva samples were taken approximately 35 min after the start of the TSST. This is within the range of the cortisol peak time of 20–40 min post stress onset (Dickerson & Kemeny, 2004), although others have demonstrated the peak to be closer to the 20 min time point (Creswell et al., 2005). Our measurement may have been during the decline of post-stress cortisol, which could have resulted in smaller differences between post-meal and post-stress samples and a decreased ability to detect separations between factor levels.

Different types of laboratory stress tasks elicit different types of stress. When a stress task involves social-evaluative threat and is uncontrollable, such as in the TSST, the hypothalamic–pituitary–adrenal (HPA) axis is preferentially activated (Creswell et al., 2005). If, however, the threat is controllable or seen as a challenge that can be met, sympathetic-adrenomedullary (SAM) axis is preferentially activated over HPA (Creswell et al., 2005). Possibly the TSST may not have been challenging enough for some participants, and as a result, the HPA axis was not activated enough to elicit a *strong* cortisol response. Our data, however, did not show that this was the case. In a meta-analysis by Dickerson and Kemeny (2004), the average effect size[3] for a psychosocial stressor (such as the TSST) was 0.92; for our study it was 1.21. Therefore, it appears that our

[3] Effect size is defined as *d*: $d = \frac{Mean_{poststress} - Mean_{baseline}}{SD_{baseline}}$.

stress induction was effective and the HPA axis was activated, as evidenced by high cortisol levels after the TSST.

Cortisol directly affects appetite and food-related brain activity, which may have blurred differences in the effects of choosing and preparing a meal on cortisol levels after eating. Consumption of high-carbohydrate foods may increase HPA-axis activity (indicated by elevated cortisol levels) (Lemmens, Martens, Born, Martens, & Westerterp-Plantenga, 2011). The pasta meal in this study may have had this effect, resulting in post-meal cortisol levels that were higher than they would have been had the meal been lower in carbohydrates. Percent carbohydrate intake was calculated based on each participant's pasta dish composition (from nutrition labels of each ingredient), taking into account amounts of each ingredient added and total amount of food consumed. In fact, cortisol change after the meal was negatively correlated with percent carbohydrate intake (Pearson correlation coefficient = −0.21, $p = 0.04$), indicating that the higher a participant's meal was in carbohydrates, the greater was the participant's cortisol decrease. Increased cortisol during stress can also cause increased food intake (Martens, Rutters, Lemmens, Born, & Westerterp-Plantenga, 2010). However, this was not seen in the present study, as cortisol increase after the TSST was not significantly correlated with food intake (Pearson correlation coefficient = −0.14, $p = 0.18$).

Not choosing resulted in greater improvement in mood-related measures and stress reduction

The greater reduction in systolic blood pressure (SBP), *anxiety*, and *anger* for those in the *No Choice* groups versus the *Choice* groups may have occurred because, for those in the *Choice* groups, the act of choosing became more daunting after being stressed via the TSST. Stress can deplete the self-regulatory resources necessary to deliberate and make informed choices (Baumeister et al., 1998). When resources are depleted and choices need to be made, preference increases for the option requiring the simplest mental processing (Pocheptsova, Amir, Dhar, & Baumeister, 2009). This leads to increased dissatisfaction with the final choice (Schwartz et al., 2002), which could be the reason for higher negative emotion ratings in the *Choice* groups. Plausibly, the lack of thought the participants had to put into their meal if they did not have to choose made it easier to relax, enjoy their meal, and ease their stress.

Another reason that not choosing had a greater effect on reducing stress and improving measures related to mood than choosing may have been because all of the participants received a meal that they liked. 'Likers' have more positive emotional responses to a food than 'non-likers' (King & Meiselman, 2010). In our study, if participants did not get to choose their ingredients, the choice was made for them based on previous liking ratings of the ingredients. 'Overall enjoyment', while generally high for all participants, did not differ between *Choice* ($M = 72$ out of 100, SE = 2.67) and *No Choice* ($M = 66$, SE = 2.67) groups ($F = 2.68$, $p = 0.1$), although the trend was for those in the *Choice* groups to enjoy their meal more. This effect was also seen in a study by De Graaf et al. (2005), in which higher liking ratings were made for foods tasted in the laboratory if participants were allowed to choose which foods to sample than if they were simply given the same foods to taste. In the present experiment, none of the changes in stress or measures related to mood were significantly correlated with 'overall enjoyment' rating. We may have seen a greater stress-lowering effect of *Choice* in this experiment if the *No Choice* groups received a meal they did not like or felt neutral about. In that case, choosing should result in greater satisfaction with the meal if they chose something they like, and if so, greater would be the chance that choosing would result in stress reduction.

Meal preparation had little effect on stress and measures related to mood

Whether or not the participants prepared their own meal did not have an effect on their stress levels following the meal. Possibly the amount of preparing done by the participants was not enough to elicit many differences. Since the meal preparation consisted only of mixing items together and microwaving, participants may not have felt they were really 'cooking'. Indeed, when those in the *Prepare* groups were asked to respond to the statement "I felt like I was really cooking" (from 0 to 100, 0 being 'Strongly Disagree' and 100 being 'Strongly Agree'), the mean response was only 26. It is also possible that the effect of food preparation on stress relief and improvement in mood-related measures is affected by how much one enjoys cooking. When we included participants' responses to the question, "In general, how much do you enjoy cooking/preparing food?" (rated 0–100, 0 being 'Dislike Extremely' and 100 being 'Like Extremely') as a covariate in our 2 × 2 ANCOVA model, significance of the results did not change (for *anxiety* without "...enjoy cooking...", $F = 0.00$, $p = 0.83$; with "...enjoy cooking..." included as covariate, $F = 0.00$, $p = 0.94$). (The interaction between "...enjoy cooking..." and the *Prepare* factor was not significant).

We found that those who prepared their meal exhibited less of a decrease in 'self-conscious' ratings ($M = -1.5$, SE = 0.2) after the meal than those who did not prepare their meal ($M = -0.8$, SE = 0.2; $F = 7.0$, one-sided $p < 0.01$). Being asked to perform a cooking task in an unfamiliar environment as part of a study where one is being evaluated may have increased feelings of self-consciousness during the meal preparation period. We did not take mood-related measurements after the meal was prepared but before it was eaten. If feelings of self-consciousness increased during this period, our results make sense. *Not* preparing the meal would result in 'self-conscious' ratings being reduced further than when preparing the meal, because they would not have increased in the period between mood-related measurements.

Limitations

Several limitations to this study may have prevented us from seeing strong results. First of all, our 'meal' consisted of only one dish, and although it was large (providing approximately 1000 kilocalories if consumed in its entirety), participants may not have considered it a full meal. If we had provided more meal items, such as salad, beverage, and dessert, our participants may have been more satisfied with the meal. They also would have had to do more 'choosing' and 'preparing', which could have strengthened our manipulation. Secondly, the preparation of the pasta dish itself was not very extensive. Perhaps if we had included such steps as boiling the pasta and chopping vegetables, our *Prepare* manipulation would have been further strengthened. Finally, our mood questionnaire was only partially taken from a standardized and validated measure, the POMS. While many researchers take liberties with the adjectives used to measure mood, the modifications we made to the POMS may have resulted in non-standardized measures of specific mood constructs.

Conclusion

When the burden of choice is removed, food and eating relieve *anxiety* and *anger* and reduce systolic blood pressure more than when choice is involved. We found little evidence for an effect of preparing a meal on stress or measures related to negative mood.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.foodqual.2014.08.001

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