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Visceral States Call for Visceral Measures: Verbal Overshadowing of Hunger Ratings Across Assessment Modalities

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Abstract

We introduce a nonverbal “visceral” measure of hunger (i.e., squeezing a handheld dynamometer) and provide the first evidence of verbal overshadowing effects in this visceral domain. We presented 106 participants with popcorn and recorded their hunger levels in one of three conditions: (1) first report hunger using a traditional self-report rating scale (i.e., verbal measure) and then indicate hunger by squeezing a dynamometer (i.e., nonverbal measure), (2) first indicate hunger nonverbally and then indicate hunger verbally, or (3) indicate hunger only nonverbally. As hypothesized, nonverbal measures of hunger predicted subsequent eating behavior when they were uncontaminated by verbal measures—either because they preceded verbal measures of hunger or because they were the sole measure of hunger. Moreover, nonverbal measures of hunger were a better predictor of eating behavior than verbal measures. Implications of the study for communicating embodied experiences in a way that escapes the confines of symbolic representations are discussed.

Keywords

visceral states; hunger; cue exposure; eating behavior; verbal overshadowing

There are some experiences that are inherently difficult to put into words, and articulating these nonverbal experiences can impair performance (Schooler, 2002, 2011). A well-documented example of this effect has been shown in the context of visual memories. Specifically, Schooler and Engstler-Schooler (1990) found that verbalizing memory for faces significantly reduced subsequent memory for these faces, an effect that has been widely replicated across independent laboratories (see Alogna et al., 2014, for the registered

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replication report). The disruptive effect of asking individuals to translate nonverbal experiences into words with verbal description (Schooler & Engstler-Schooler, 1990) or simple verbal labels (Brown, Brandimonte, Wickham, Bosco, & Schooler, 2014) has been termed *verbal overshadowing*, and it has been shown using a variety of nonverbal stimuli, such as shapes, tastes, and sounds (for reviews, see Chin & Schooler, 2008; Schooler 2002). When individuals attempt to verbally describe or label these inherently nonverbal experiences, the resulting representations fail to do justice to the original experience (Schooler, 2002).

In the case of describing one's feelings about nonverbal experiences (e.g., the taste of jam), verbal overshadowing effects are thought to occur because verbalization causes individuals to focus on verbally relevant information and to "lose touch" with their actual hedonic feelings (Schooler, 2002; Wilson & Schooler, 1991). Indeed, studies have shown that self-report assessments of emotions can disrupt the experience of the emotion itself (e.g., Schooler, Ariely, & Loewenstein, 2003). For instance, participants who labeled an emotionally evocative image showed disrupted affective responses in the amygdala and other limbic regions that would otherwise occur in the presence of negative emotional images (Lieberman et al., 2007), and participants assigned to rate their emotional experience of anger on an analogue scale exhibited physiological responses distinct from the responses of those who did not report (Kassam & Mendes, 2013). Importantly, this latter study suggests that verbal overshadowing effects may not be limited to verbal descriptions or verbal labels of underlying hedonic states but may also be observed when individuals are asked to reduce their feelings to numerical representations on self-report rating scales with verbal anchors (referred to hereafter as verbal measures). Thus, translating one's feelings into numbers on verbal measures may, like other symbolic renderings of nonverbal experiences, disrupt the experience of the emotion and distance people from the underlying state.

Motivational (visceral) states, such as hunger, thirst, drug craving, and sexual arousal (see Loewenstein, 1996; Nordgren & Chou, 2011), are inherently nonverbal experiences that may be particularly vulnerable to verbal overshadowing effects (Schooler et al., 2003). Importantly, however, prior verbal overshadowing studies have neither investigated the impact of translating visceral drive states to numerical representations on verbal measures nor compared the relative reactivity of verbal versus nonverbal assessments. A handheld dynamometer that records grip strength may be an especially useful tool to measure visceral states in a nonverbal way. Prior studies have used handgrip devices to measure strength after resource depletion (e.g., Muraven, Tice, & Baumeister, 1998), negative and positive feedback given to children (Bugental, Lewis, Lin, Lyon, & Kopeikin, 1999), and subliminal processes (e.g., Aarts, Custers, & Marien, 2008; Pessiglione et al., 2007). Their use to express the experience of visceral drive states may be particularly illuminating, though, because these devices allow participants to express the intensity of their feelings in a sensitive, dynamic, and nonverbal way. In the alcohol literature, for example, nonverbal performance measures (i.e., tasks assessing automatic alcohol action tendencies) have significantly predicted hazardous drinking (Kersbergen, Woud, & Field, 2015).

Dynamometer recordings, which are nonverbal and arguably more viscerally relevant (i.e., less subject to the limitations of language), may also offer a more direct and less reactive

assessment of visceral drive states and may be a better predictor of actual behavior than verbal measures. Indeed, measures capable of capturing the intrinsic dynamics of other feeling states (e.g., ambivalence in social judgments) have revealed important insights that may go undetected when using traditional, static verbal measures (Vallacher, Nowak, & Kaufman, 1994). Allowing participants to express their feelings nonverbally with a dynamometer may overcome the problems associated with verbal measures by permitting a dynamic, nonverbal assessment technique. Thus, the nonverbal dynamometer measure may be a more sensitive and valid predictor of actual behaviors than verbal measures.

Psychologists have long used food cue exposure studies to develop models of disordered eating relating to conditions such as obesity and diabetes (e.g., Fedoroff, Polivy, & Herman, 1997; Ferriday & Brunstrom, 2011; Gearhardt et al., 2011; Sobik, Hutchison, & Craighead, 2005; Werthmann et al., 2011). Foundational to this type of cue exposure research is the need to measure potential mediators, such as hunger (e.g., Fedoroff, Polivy, & Herman, 2003; Ferriday & Brunstrom, 2008; Nederkoorn, Smulders, & Jansen, 2000), of the link between food cue exposure and overeating. Thus, the current study had two primary goals: (1) to support the validity of a novel and nonverbal “visceral” measure of hunger (i.e., squeezing a handheld dynamometer to indicate hunger level) in predicting actual eating behavior and (2) to provide an initial test of verbal overshadowing effects in a visceral domain using both verbal and nonverbal measures.

To accomplish these goals, participants were randomly assigned to one of three experimental conditions that varied according to how they reported their hunger levels before and after the presentation of an in vivo food cue (freshly popped popcorn). Participants in the Verbal First condition first reported their hunger level using a verbal measure and then indicated their hunger level nonverbally by squeezing a dynamometer; participants in the Nonverbal First condition first indicated their hunger level nonverbally and then reported their hunger verbally; participants in the Nonverbal Only condition indicated their hunger level only nonverbally.¹ We hypothesized that nonverbal measures of hunger during food cue exposure would predict subsequent eating behavior when they were uncontaminated by verbal measures—either because they preceded verbal measures (in the Nonverbal First condition) or because they were the sole measure of hunger (in the Nonverbal Only condition). We did not expect nonverbal measures in the Verbal First condition to predict eating behavior, because we predicted that these measures would be contaminated by verbal overshadowing effects. In other words, we hypothesized that asking participants to translate their feelings of hunger into verbal reports would lead them to “lose touch” with their feelings and would interfere with the subsequently administered nonverbal measure of hunger to predict actual eating behavior. We also hypothesized that our visceral and non-verbal measure of hunger, presumably less subject to the limitations of language processing, would be a better predictor of eating than would verbal measures.

¹This third condition served as a control to confirm that non-verbal recordings were similar across the Nonverbal First and Nonverbal Only conditions at both pre- and post-cue, thereby ruling out the possibility of carryover effects of the pre-cue verbal assessment on the post-cue nonverbal recordings.

Method

Participants and Design

Male and female participants ($N=106$) were recruited through local fliers inviting inquiries from those willing to refrain from eating for at least 4 hours before a study session. To ensure adequate power in investigating a new effect, we chose a sample size comparable to or larger than those used in previous research on verbal overshadowing effects (e.g., Brown et al., 2014; Lane & Schooler, 2004; Schooler & Engstler-Schooler, 1990). We planned for $N=35$ per condition, but one additional participant was scheduled and was therefore run, resulting in the final N . Data collection stopped after 106 participants were tested. Participants were required to be 18 to 40 years of age, native English speakers, willing to abstain from eating or drinking (except for water) for at least 4 hours before the study session, in good general health, and free from food allergies. In addition, participants had to report that they liked popcorn (as indicated by at least a “5” on a scale ranging from 1 [*I don't like this food at all*] to 10 [*this is one of my favorite foods*]). Participants were randomly assigned to one of three study conditions that varied how they were asked to report their hunger during an in vivo food cue presentation paradigm (described in more detail below). A random number list created by random-list generator software was used to assign participants to conditions. As noted above, participants in the Verbal First condition ($N=36$) first reported their hunger level using a verbal measure and then indicated it nonverbally by squeezing a dynamometer; participants in the Nonverbal First condition ($N=35$) first indicated their hunger level nonverbally and then reported it verbally; participants in the Nonverbal Only condition ($N=35$) indicated their hunger level only nonverbally. All participants then watched a 5-minute video of food advertisements and indicated their hunger level nonverbally by squeezing the dynamometer as they watched.² Finally, participants were given the opportunity to eat as little or as much of the popcorn as they liked.

Materials and Procedure

Interested participants who contacted the Behavioral Health Research Lab answered screening questions to ensure that they met eligibility criteria. Eligible participants were then asked for their consent to fast for at least 4 hours before their study session. Participants were told that saliva samples would be obtained to ensure that they had conformed to the fasting instructions.

Participants arrived for the study sessions between 1:00 p.m. and 6:00 p.m. Immediately on arrival to the lab, participants were asked to report the last time they had eaten or drunk anything except for water (all participants reported fasting for at least 4 hours before their session). They then received more information about the study procedures and provided written informed consent. Participants were told that the purpose of the study was to investigate alternative ways to measure how someone is feeling. They were informed that

²In addition to the two primary goals described above, an ancillary goal of the study was to examine the validity of the dynamometer as a continuous measure of hunger (when verbal measures are especially cumbersome). We hypothesized that dynamometer recordings during the video presentation would predict subsequent eating behavior in all three experimental conditions, providing further support of the validity of the dynamometer for assessing continuous motivational experiences.

they might be asked to indicate how hungry they were feeling by rating their hunger on a 0 to 100 rating scale and/or by indicating their hunger level by squeezing a handheld dynamometer with their dominant hand. We used a commercially available dynamometer (Vernier Software & Technology, accuracy ± 0.6 N, operational range 0–600 N, grip size 50 mm \times 25 mm). The force of a person's grip (N) was transmitted by USB to a computer, where it was recorded by Logger Pro data collection and analysis software. The experimenter explained the dynamometer by stating the following:

This dynamometer measures two things—how forcefully you squeeze it and how long you squeeze it. So, it measures both force and time. You can squeeze this as forcefully as you like and for as long as you like to show us how hungry you're feeling at various times throughout the experiment. More time and more force indicate more hunger—so if you are feeling very hungry you will squeeze this device harder and for a longer amount of time. If you're not feeling very hungry, you could show us that too by squeezing less hard and for a shorter amount of time.

[Note: Area under the curve, which accounts for both force and time, was calculated and used in all dynamometer analyses.] The experimenter then demonstrated how to use the dynamometer, including how to calibrate it to zero before each reading (which required participants to hold the dynamometer in a neutral, upright position for approximately 3 seconds). After this demonstration, the experimenter left the room to conduct the cue exposure manipulation via intercom.

Popcorn Cue Exposure Paradigm—Participants were asked via intercom to report a pre-cue exposure hunger rating. For the nonverbal measure, participants were instructed to wrap their hand around the dynamometer and squeeze in order to show how hungry they were feeling “right now at this very moment.” For the verbal measure, participants were asked to report their hunger level using a rating scale ranging from 0 (*not hungry at all*) to 100 (*the most intense hunger I have ever felt*), referring to how they were feeling “right now at this very moment” (Morris & Dolan, 2001). Over the intercom, the experimenter asked participants in the Verbal First condition to fill out the verbal hunger form and then to indicate their hunger nonverbally using the dynamometer. Participants in the Nonverbal First condition were asked to indicate their hunger nonverbally using the dynamometer and then to rate their hunger using the verbal form. Participants in the Nonverbal Only condition were asked to indicate their hunger only nonverbally using the dynamometer. A tray containing a plastic cover was then placed on the desk in front of participants. They were told not to touch the tray until they were told to do so. After approximately 10 seconds, they were instructed, via intercom, to pick up the cover on the tray and to set it to the side. Participants found a bowl of freshly popped popcorn (Pop Secret 100 Calorie Pop, butter flavor, 1 ounce) under the cover. After 5 seconds, participants were instructed to again rate their hunger (i.e., post-cue exposure) using the same procedure described above for the pre-cue exposure rating. That is, participants in the Verbal First condition first reported their hunger level verbally and then indicated it nonverbally; participants in the Nonverbal First condition first indicated their hunger level nonverbally and then reported it verbally; participants in the Nonverbal Only condition indicated their hunger only nonverbally. As noted above, area under the curve was calculated for each participant's pre-cue and post-cue dynamometer

recording. Due to technical difficulties, data were unavailable for one participant's pre-cue exposure recording (in the Nonverbal Only condition) and one participant's post-cue exposure recording (in the Nonverbal First condition).

Hunger Rating During the Video—Immediately after the cue exposure paradigm, the experimenter reentered the room and placed the cover back over the bowl of popcorn. Participants were asked to watch a silent, 5-minute video that included a mix of food commercial clips and nature scenes (available on request from the first author). The video contained 3 minutes of food clips, presented in segments of 26 to 48 seconds, which showed a variety of different foods (e.g., pasta, bagels, pizza, dessert, etc.). The clips were derived from food commercials downloaded from YouTube. Portions of these commercials were included in the final video if they met the following criteria: good video quality, no brand names, no sexual content, no alcohol or smoking, no faces (hands were acceptable), and no mention of dieting or reduced calories. Each food segment was flanked by 20-second clips of nature imagery (2 minutes in total), depicting deserts, forests, and mountain landscapes. Participants were instructed to hold the dynamometer during the video and to squeeze with varying amounts of force in order to show their hunger level as they watched. The experimenter then left the room and recorded the force of the participant's squeeze during the video. As noted above, area under the curve was calculated for each participant's commercial video period. Data were not recorded for two participants due to experimenter error. When the video finished, all study participants used the verbal form to report their hunger.

Eating Behavior—The experimenter then reentered the room with an 8 oz. bottle of water and asked the participants to wait quietly for 10 minutes while the experimenter set up the next study task in the other room. The experimenter stated, "The last part of the study doesn't require you to be hungry—so feel free to eat some of the popcorn while you're waiting if you like." The experimenter then took the cover off of the popcorn, set the water on the desk, exited the room, and left the participant alone with the popcorn for 10 minutes. At the conclusion of the 10-minute period, the experimenter reentered the room, gave the participants a final set of questionnaires that included demographic questions and self-reported height and weight, took the popcorn out of the room, and recorded the popcorn's final weight. Eating behavior was defined as the difference between the initial and final weight of the popcorn. After participants completed this final set of questionnaires, the experimenter debriefed, paid (\$15), and dismissed the participant.

Data Analysis

The dynamometer data were nonnormal with large skewness and kurtosis values; thus, log transformations were used in all analyses. The skewness and kurtosis values of the transformed variables were between -1.0 and 1.0 .

To determine if there was evidence of verbal overshadowing, we tested whether condition moderated the association between dynamometer (i.e., nonverbal) recordings during popcorn exposure and eating behavior, such that nonverbal recordings in the Nonverbal First condition and the Nonverbal Only condition would predict popcorn consumption but that

nonverbal recordings in the Verbal First condition would not. To test this, we created a complete, orthogonal set of contrast codes comparing (1) the Verbal First condition versus both of the other two conditions (i.e., Nonverbal First and Nonverbal Only) and (2) the Nonverbal First condition versus the Nonverbal Only condition. A linear regression model was then used to predict popcorn consumption from the interaction between the two condition contrast codes and post-cue exposure nonverbal recordings, with the following covariates entered into the model: gender, age, condition contrast codes, post-cue exposure non-verbal recordings, and pre-cue exposure nonverbal recordings. A model was also run excluding all covariates other than the two contrast codes and their interactions with the nonverbal recordings to ensure that the basic results were robust and properly interpreted. Finally, to determine the effect size of the verbal overshadowing effect, a model was run including only the key interaction between Contrast 1 (i.e., Verbal First vs. Nonverbal First and Nonverbal Only) and nonverbal recordings. Nonverbal recordings were centered at their mean to aid in the interpretation of results, including when they were added to interaction terms with the condition contrasts. Where analyses indicated a significant moderation effect, we examined simple contrasts by plotting the regression lines by study condition along with 95% confidence intervals (CIs).

Finally, we tested whether “uncontaminated” nonverbal recordings of hunger predicted popcorn consumption better than hunger reported on the verbal form in a within-subject design using participants from the Nonverbal First condition. We first examined the correlations between both hunger assessments (i.e., verbal and nonverbal) during popcorn exposure and popcorn consumption, and then we used Steiger’s *z* test to determine if the strength of these associations differed across the assessment technique. Participants in the Verbal First condition were excluded from these analyses because we expected their nonverbal recordings to be contaminated by verbal overshadowing effects (see prediction above).

Results

Preliminary Analyses

The three experimental conditions did not differ in gender distribution (47% male, 53% female), ethnicity (41.5% White, 8.5% African American, 3.8% Hispanic, 26.4% Asian American, and 19.8% mixed/other), the number of fasting hours ($M = 6.8$, $SD = 4.4$), body mass index (BMI [kg/m^2 ; $M = 24.89$, $SD = 4.5$), or rating of popcorn liking ($M = 6.8$, $SD = 1.6$) (all p s $> .30$). Age, however, was significantly different across groups, $F(2, 103) = 5.2$, $p = .007$, with Verbal First participants being older ($M = 23.8$, $SD = 6.8$) than both Nonverbal First ($M = 21.1$, $SD = 2.7$) and Nonverbal Only ($M = 20.6$, $SD = 2.5$) participants. Participants did not differ in age between the Nonverbal First and Nonverbal Only conditions. Thus, age was entered as a covariate in all analyses. In addition, preliminary analyses indicated that nonverbal recordings of hunger differed across genders, with males having larger area under the curve values than females for all three hunger ratings (both p s $< .001$ for ratings made at pre-cue and post-cue exposure, and $p = .049$ for the video rating). Thus, gender was also entered as a covariate in all analyses.

Table 1 shows descriptive statistics for pre-cue and post-cue exposure hunger assessments, nonverbal recordings during the video, hunger reported on the verbal form after the video, and the amount of popcorn consumed across the three experimental conditions. Pre-cue and post-cue exposure nonverbal recordings did not differ across conditions (both p s = .110). The difference between the Verbal First and Nonverbal First conditions on pre-cue verbal hunger was significant, $F(1, 67) = 5.2, p = .026$, but post-cue verbal hunger did not differ between these conditions, $F(1, 67) = 2.8, p = .097$. There were also no differences across experimental conditions on nonverbal recordings during the video ($p > .250$), hunger reported on the verbal form after the video ($p = .095$), or in the amount of popcorn consumed ($p = .061$). Importantly, condition assignment and pre-cue exposure verbal reports and nonverbal recordings were controlled for in the key regression analyses to test study predictions (presented below). As expected, the in vivo cue exposure manipulation significantly increased hunger ratings from pre- to post-cue exposure for both the nonverbal, $F(1, 69) = 43.7, p < .001$, and verbal measures, $F(2, 101) = 29.3, p < .001$.

Table 2 shows correlations between the nonverbal and verbal measures across experimental conditions. None of the correlations differed across conditions (all p values for Fisher's z -tests were greater than .10). Across assessment periods, the nonverbal and verbal measures were positively correlated.

Do Nonverbal and Verbal Measures Predict Eating Behavior?

As predicted, a series of linear regression analyses demonstrated that nonverbal recordings of hunger at all three time points predicted the amount of popcorn consumed during the follow-up period in the expected direction (i.e., increased area under the curve values predicted more popcorn consumed) after controlling for condition assignment (contrast coded), age, and gender (pre-cue nonverbal recording: $b = .17, t[99] = 2.36, p = .020, 95\% \text{ CI } [.02, .32], \beta = .25$; post-cue nonverbal recording: $b = .19, t[99] = 2.64, p = .010, 95\% \text{ CI } [.04, .33], \beta = .27$; video nonverbal recording: $b = .28, t[98] = 3.31, p < .001, 95\% \text{ CI } [.11, .45], \beta = .32$). In contrast, verbal reports at pre-cue exposure, $b = .00, t(66) = 0.18, p > .85, 95\% \text{ CI } [-.01, .01], \beta = .02$, and post-cue exposure, $b = .00, t(66) = 0.26, p > .75, 95\% \text{ CI } [-.01, .01], \beta = .03$, were not related to the amount of popcorn consumed, but verbal reports of hunger after watching the video were related to popcorn consumption, $b = .01, t(100) = 2.29, p = .024, 95\% \text{ CI } [.00, .01], \beta = .22$. Results were unchanged when gender was removed as a covariate in these analyses and when BMI was added as an additional covariate.

Is There Evidence of Verbal Overshadowing?

Table 3 shows the results from a linear regression analysis predicting popcorn consumption from the following predictors: gender, age, the two orthogonal contrasts comparing conditions, pre-cue and post-cue exposure nonverbal recordings, and the interactions between the contrast codes and post-cue exposure nonverbal recordings. Most relevant to the present study, the interaction between Contrast 1 (i.e., Verbal First vs. Nonverbal First and Nonverbal Only) and nonverbal recordings was significant ($p < .001$), whereas the interaction between Contrast 2 (i.e., Nonverbal First vs. Nonverbal Only) and nonverbal recordings was not ($p = .58$). This indicates that, as predicted, Contrast 1 moderated the

association between nonverbal recordings and popcorn consumption. A plot of the slopes by condition and associated 95% CIs (see Figure 1) confirmed the presence of verbal-overshadowing effects. In the Verbal First condition, the 95% CIs indicate a nonsignificant slope of nonverbal recordings predicting popcorn consumption (i.e., nonverbal recordings made after verbal reports of hunger were unrelated to popcorn consumption). Furthermore, as expected, uncontaminated nonverbal recordings made before verbal reports of hunger (i.e., in the Nonverbal First condition) and as the sole measure of hunger (i.e., in the Nonverbal Only condition) significantly predicted popcorn consumption. Finally, the 95% CIs of the Nonverbal Only condition always included the point estimates of the Nonverbal First condition (i.e., popcorn consumption was predicted equally well by nonverbal recordings in both of these conditions). Results were unchanged when also controlling for pre-cue verbal reports and BMI and when removing all covariates from the model other than the two contrast codes and their interactions with dynamometer recordings.³ To determine an effect size for the verbal overshadowing effect, we also ran a regression model including only the key interaction between Contrast 1 (i.e., Verbal First vs. Nonverbal First and Nonverbal Only) and nonverbal recordings, which produced the following results: $b = .25$, $t(103) = 2.93$, $p = .004$, 95% CI [.08, .42], $\beta = .28$. (Further support for the difference between contaminated and uncontaminated nonverbal recordings of hunger was observed when examining the effects of cue exposure. Specifically, a 2×2 repeated measures ANOVA (analysis of variance) with condition [contaminated vs. uncontaminated] as a between-subjects variable and time [pre-cue exposure and post-cue exposure nonverbal recordings] as a repeated variable revealed a significant condition by time interaction, $F(1, 102) = 5.9$, $p = .017$. Participants in the uncontaminated conditions [i.e., those in the Nonverbal First and Nonverbal Only conditions] reported a significantly greater increase from pre-cue exposure hunger to post-cue exposure hunger than participants in the contaminated condition [i.e., Verbal First]).

Do Nonverbal Measures of Hunger Predict Eating Behavior Better Than Verbal Measures of Hunger?

As noted above, these analyses focused on within-subject comparisons in the Nonverbal First condition, since verbal overshadowing effects were present in the Verbal First condition. Verbal reports of hunger during cue exposure were not related to popcorn consumption ($r = .16$, $p = .37$), but hunger levels expressed nonverbally with the dynamometer at this same time point were significantly associated with popcorn consumption ($r = .54$, $p < .001$). A Steiger's z -test showed that these correlational values were significantly different from one another (z -score = -2.75 , $p = .003$). Results were similar when controlling for gender, age, BMI, and pre-cue exposure nonverbal recordings. Moreover, nonverbal recordings continued to predict popcorn consumption even after controlling for verbal reports of hunger (partial $r = .56$, $p < .001$), indicating that the non-

³We ran a similar linear regression analysis testing whether the results remained the same when using pre-cue exposure non-verbal recordings in the interaction terms, rather than post-cue nonverbal recordings. The interaction between Contrast 1 (i.e., Verbal First vs. Nonverbal First and Nonverbal Only) and pre-cue nonverbal recordings remained significant, albeit less so, $b = .27$, $t(97) = 3.01$, $p < .01$, 95% CI [.09, .44], $\beta = .28$, and the interaction between Contrast 2 (i.e., Nonverbal First vs. Nonverbal Only) and pre-cue nonverbal recordings remained nonsignificant, $b = .03$, $t(97) = 0.20$, $p = .84$, 95% CI [-.30, .37], $\beta = .02$. Results for all of the other predictor variables in Table 3 also remained the same.

verbal measure was accounting for unique variance in hunger ratings. As expected, the relationship between nonverbal recordings and popcorn consumption was similar in the Nonverbal Only condition ($r = .53, p < .001$) when compared to the Nonverbal First condition. To confirm that verbal reports of hunger in the Nonverbal First condition were not biased because they followed nonverbal recordings, we also examined the relationship between verbal reports of hunger and popcorn consumption in the Verbal First condition. Verbal reports of hunger were not predictive of popcorn consumption in this condition either ($r = -.04, p = .80$), indicating that squeezing the dynamometer first did not contaminate the verbal reports.

Discussion

The present study used an in vivo food cue exposure manipulation to provide support for the validity of a novel visceral and nonverbal measure of hunger (i.e., squeezing a handheld dynamometer). In addition, using both verbal (i.e., rating scales with verbal anchors) and nonverbal measures of hunger, this study is the first to demonstrate verbal overshadowing effects of visceral states. Specifically, nonverbal recordings of hunger significantly predicted subsequent eating behavior only when these recordings were uncontaminated by verbal reports, suggesting that verbal reports may have caused individuals to “lose touch” with how they were feeling. Also consistent with this idea, we found particularly robust effects of the cue exposure manipulation on nonverbal recordings of hunger when these recordings were uncontaminated by verbal reports. The nonverbal measure provided a sensitive assessment at pre- and post-cue exposure, as well as during a continuous video manipulation of hunger when verbal measures can be especially unwieldy. Moreover, a within-subject comparison of the predictive utility of verbal versus nonverbal measures demonstrated the superiority of the non-verbal recordings in predicting actual behavior. Taken together, findings show that verbal overshadowing effects interfere with the ability to assess visceral states using verbal measures and that a novel dynamometer measure, which is less reliant on language, provides a highly effective assessment technique for these nonverbal visceral states.

The present findings have important methodological and theoretical implications. From a methodological perspective, it is essential for psychologists interested in visceral states to collect sensitive and valid measurements of these internal drives. While verbal reports are fairly easy to collect and display a high degree of face validity, they have been shown to disrupt the experience of emotions (e.g., Kassam & Mendes, 2013; Lieberman et al., 2007), and requiring participants to complete them can at times impair performance (Schooler, 2002). Consistent with the verbal overshadowing literature, our results argue for the utility of nonverbal assessment techniques to measure visceral states. In fact, the often weak relationship between visceral states such as drug craving and actual drug use behavior (Wray, Gass, & Tiffany, 2013) may be explained in part by limitations in how craving is measured (Griffin & Sayette, 2008; Sayette et al., 2000). Future research should test the validity of the dynamometer measure in other populations and in assessing other drive states, such as drug craving, emotions, and physical pain. Indeed, one small prior study ($n = 15$; Wilkie, Lovejoy, Dodd, & Tesler, 1990) showed initial promise for the use of a finger dynamometer in assessing pain intensity in older individuals unable to use traditional pain scales. While these investigators did not relate the finger dynamometer measure to actual

behavior, they did find that the dynamometer was moderately correlated with traditional self-report rating scales of pain intensity (Wilkie et al., 1990).

From a theoretical perspective, our findings illustrate the limits of symbolic systems such as numbers and language for representing visceral experiences. The fact that people's behavior was better predicted by their handgrip squeeze than standard verbal measures, and that engaging in the latter actually disrupted the former, indicates that people can have difficulty translating their inner experiences into symbols. It is particularly intriguing that nonverbal dynamometer recordings circumvented the limitations of standard verbal measures. In recent years, it has become increasingly clear that many mental constructs are represented in an embodied manner (Schubert & Semin, 2009). The handgrip technology appears to offer great promise for communicating embodied experiences in a way that escapes the confines of symbolic representations.

There are additional points worth considering. First, the exact mechanisms explaining the verbal overshadowing effects found in this study remain unclear. We suggest that the verbal measure may have caused participants to "lose touch" with their feelings (see also Schooler, 2002), rendering the subsequent nonverbal dynamometer measure less valid. Alternative interpretations exist, however. One possibility is that the verbal measure changed the underlying hunger state itself, such that the nonverbal measure that followed it was an accurate assessment of this now-modified state. Another possibility is that participants tried to match their subsequent hand squeeze to their verbal report and not to their internal feelings of hunger. Further research would be useful to try to tease apart these different possibilities. However, regardless of the exact mechanism, our findings extend studies demonstrating that verbal assessments of emotions can disrupt emotional experiences (e.g., Kassam & Mendes, 2013; Lieberman et al., 2007) to suggest that such disruptions reduce the predictive utility of these emotional states.

Second, we compared the nonverbal dynamometer measure with a verbal measure that included a single item assessing hunger rather than using a multi-item scale. One could argue that a multi-item measure of hunger would have been more reliable and thus a stronger predictor of eating behavior than the single-item measure used here. We chose to use a single-item measure for two reasons. First, single-item measures of visceral states such as hunger and craving are very common in the field, especially when cue exposure paradigms are utilized and there is a need for repeated and rapid reporting of visceral states (Sayette et al., 2000; Sayette, Griffin, & Sayers, 2010). Second, at least in the case of craving and pain, a growing body of evidence suggests that single-item scales perform just as well if not better than multi-item scales (Heckman et al., 2013; Jensen, 2003; Sayette, 2016; Tiffany & Wray, 2012). We thought it prudent to compare our novel visceral measure with traditional verbal measures as they appear in the literature. Nonetheless, future studies should determine whether the dynamometer has better predictive strength than other standard self-report assessments of emotions and visceral states (e.g., multi-item measures, visual analogue scales, joystick dials, Subjective Units of Distress scales).

Third, after the cue exposure paradigm, all participants were asked to indicate their hunger level using the nonverbal measure while watching a brief video of food advertisements.

Although speculative, this could have led participants to prioritize the nonverbal measure and to align their later eating behavior more with their earlier nonverbal recording than with their verbal report during cue exposure. It will be important to replicate our results using only the cue exposure paradigm without including the food video. Furthermore, although we measured hunger continuously during the video with the dynamometer, we created a summary score (i.e., total area under the curve) from this data rather than doing more fine-grained time analyses, which was beyond the scope of the current study. More sophisticated, time-linked analyses are indicated, as these would better speak to the incremental validity of using the dynamometer as a continuous measure of hunger over time than the analyses reported here.

Fifth, we did not include a Verbal Only condition and instead tested the relative predictive utility of the verbal versus nonverbal measure using a within-subjects design. Future research should be conducted to replicate our findings using a between-subjects design that includes both Verbal Only and Nonverbal Only conditions. Sixth, in line with recent calls for use of behavioral measures of drive states (e.g., Perkins, 2009), we used consummatory behavior (i.e., popcorn consumption) as our outcome measure rather than a physiological index of hunger. As such, it is important to note that any claims we make about the superior predictive utility of the nonverbal measure over traditional verbal assessments relate only to the correspondence between this measure and eating behavior. However, we believe that our outcome measure is particularly relevant to psychologists, given that much of the interest in hypothetical constructs like hunger and craving centers around their ability to predict consummatory behavior (Sayette & Creswell, in press). Still, future studies could attempt to relate dynamometer recordings to other response domains (e.g., physiological indices of hunger).

Finally, it is important to keep in mind that eating behavior can be determined by factors other than hunger (e.g., mood, boredom), and our rather ambiguous instructions to participants to “feel free to eat some of the popcorn” may have affected popcorn consumption for reasons unrelated to hunger. However, given random assignment to conditions, we would assume that these possible confounding factors would be equally distributed among conditions and be unlikely to affect the results reported here. Still, future studies could revise the instructions to more clearly instruct participants to eat the popcorn only if they feel hungry.

In conclusion, data from this study suggest that verbal overshadowing effects are evident when individuals attempt to represent their visceral states with verbal measures. Nonverbal dynamometer recordings of hunger significantly predicted subsequent eating behavior only when these ratings were uncontaminated by verbal assessments. Furthermore, uncontaminated nonverbal recordings were significantly more sensitive to the impact of an in vivo cue exposure manipulation than were contaminated recordings that followed verbal reports of hunger. Finally, the nonverbal measure was a better predictor of actual behavior than the verbal measure. This finding in particular highlights the distinctive utility of the nonverbal dynamometer measure to assess drive states related to important health behaviors. Clearly, additional research is warranted to establish (1) why dynamometers are superior to standard verbal rating scales in predicting hunger, (2) how verbal reports undermine this

advantage, and (3) whether this novel measurement approach also provides a superior index of other physically embodied experiences (e.g., drug craving, mood, motivation, pain). Although much remains to be discovered, these findings suggest that dynamometers may provide a more direct gauge of visceral states that avoids the distortion that can otherwise arise from translating nonverbal experiences into words or numbers.

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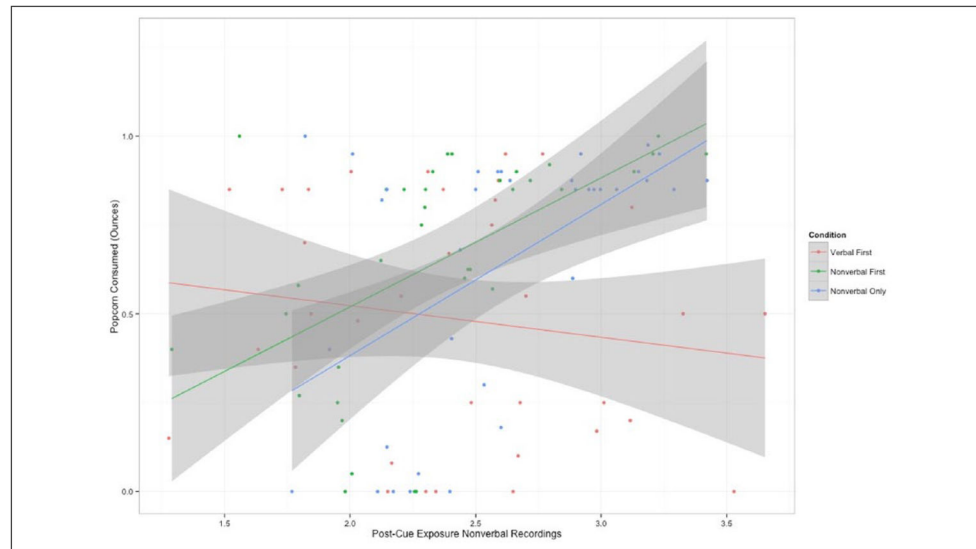


Figure 1. Plots of the individual observations and fitted regression lines with 95% confidence intervals (gray shading) by study condition.

Note. Regression lines do not extend beyond observed data in each condition. Log-transformed values are depicted for dynamometer (i.e., nonverbal) data. Inspection of box-plots and histograms revealed no outliers in either variable (i.e., post-cue exposure nonverbal recordings or popcorn consumption).

Table 1

Hunger Values and the Amount of Popcorn Consumed (*M*, *SD*) Across the Three Experimental Conditions.

Variable	Condition		
	Verbal first	Nonverbal first	Nonverbal only
Pre-cue nonverbal hunger	2.3 (0.54)	2.2 (0.44)	2.4 (0.47)
Post-cue nonverbal hunger	2.4 (0.57)	2.4 (0.48)	2.6 (0.46)
Pre-cue verbal hunger	63.1 (19.5) ^a	52.1 (19.2) ^b	—
Post-cue verbal hunger	68.5 (18.2)	60.4 (20.1)	—
Video nonverbal hunger	3.6 (0.31)	3.5 (0.31)	3.4 (0.51)
Postvideo verbal hunger	75.0 (3.2)	66.8 (3.2)	66.1 (3.3)
Popcorn consumed (ounces)	0.5 (0.33)	0.6 (0.32)	0.6 (0.36)

Note. Log-transformed values are depicted for nonverbal recordings. Participants in the Nonverbal Only condition were not asked to provide verbal reports. Superscripts denote significant differences between conditions.

Table 2

Correlations Between Nonverbal and Verbal Measures of Hunger Across the Experimental Conditions.

Variables	Condition		
	Verbal first	Nonverbal first	Nonverbal only
Pre-cue NV with Pre-cue V	.41 *	.51 **	—
Post-cue NV with Post-cue V	.38 *	.61 **	—
Video NV with Video V	.40 *	.56 **	.26

Note. NV = nonverbal; V = verbal. Log-transformed values are depicted for nonverbal data. Nonverbal Only participants were not asked to provide verbal reports.

* $p < .05$.

** $p < .01$.

Table 3Summary of Linear Regression Model for Variables Predicting Popcorn Consumption ($n = 104$).

Variable	β	b	95% CI	t
Intercept		.88	0.55, 1.2	5.37*
Gender	-.08	-.05	-0.18, 0.08	-0.81
Age	-.16	-.01	-0.04, 0.02	-1.77
Contrast 1	.21	.11	0.02, 0.20	2.36*
Contrast 2	-.10	-.08	-0.24, 0.08	-1.03
Pre-cue nonverbal recordings	.04	.03	-0.23, 0.29	0.26
Post-cue nonverbal recordings	.32	.21	-0.03, 0.47	1.72
Contrast 1 \times Post-cue nonverbal recordings	.38	.34	0.18, 0.51	4.17***
Contrast 2 \times post-cue nonverbal recordings	.05	.09	-0.23, 0.41	0.56

Note. Nonverbal variables were centered at their means. CI = confidence interval. Contrast 1 compares Verbal First versus Nonverbal First and Nonverbal Only. Contrast 2 compares Nonverbal First versus Nonverbal Only.

* $p < .05$.

*** $p < .001$.