*Review*

# The Positive Valence Systems Scale: Development and Validation

Assessment
2020, Vol. 27(5) 1045–1069

DOI: 10.1177/1073191119869836
journals.sagepub.com/home/asm
SAGE

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## Abstract

We present the Positive Valence Systems Scale (PVSS), a measure of the National Institute of Mental Health's Research Domain Criteria Positive Valence Systems domain. An initial long form of the scale (45 items) providing a broad assessment of the domain was distilled into a short form (21 items) measuring responses to a wide range of rewards (Food, Physical Touch, Outdoors, Positive Feedback, Social Interactions, Hobbies, and Goals). Across three diverse samples, the PVSS-21 demonstrated strong internal consistency, retest reliability, and factorial validity. It was more strongly related to reward than punishment sensitivity, positive than negative affect, and depression than anxiety. PVSS-21 scores discriminated depressed from nondepressed individuals and predicted anhedonia severity even when controlling for depression status. Hobbies emerged as the strongest predictor of clinical outcomes and the best differentiator of depressed and nondepressed individuals. Results highlight the potential of the PVSS for advancing understanding of reward-related abnormalities in depression and other disorders.

## Keywords

Research Domain Criteria, Positive Valence Systems, depression, reward, anxiety

Individuals have long been recognized to differ in their pursuit of, and reactions to, rewarding experiences (Clark & Watson, 1991; Costa & McCrae, 1992; Gray, 1994). In recent years, there has been an upsurge of interest in the implications of these differences for psychopathology. Abnormally *low* interest or pleasure in rewarding activities, often referred to as anhedonia, is a core symptom of depression (Ferster, 1973), and a feature of disorders like schizophrenia (Der-Avakian & Markou, 2012) and anorexia (Kaye, Fudge, & Paulus, 2009). Conversely, abnormally *high* sensitivity to rewarding stimuli is found in conditions like bipolar disorder (Gruber, Johnson, Oveis, & Keltner, 2008) and addictions (Dawe & Loxton, 2004).

Recognizing the importance of altered responding to reward in psychopathology, the National Institute of Mental Health (NIMH) included a Positive Valence Systems (PVS) domain in its Research Domain Criteria (RDoC) project, a framework for representing mental disorders based on broad domains of functioning (Insel et al., 2010). The PVS was originally proposed in 2011 (NIMH, 2011b) and was updated in 2018 (NIMH, 2018) to reflect emerging research findings. Constructs retained across the two versions include desire for rewards (Reward Valuation), expectations regarding the probability of attaining rewards (Reward Expectancy, or "reward probability"), willingness to expend effort to attain rewards (Effort Valuation), anticipation of future rewards (Reward Anticipation), immediate (Initial Responsiveness) and sustained (Reward Satiation, or "sustained responsiveness") responses to rewards, and constructs related to reward learning.

The constructs included in the PVS domain were identified and defined via expert consensus based on extant theory and research (NIMH, 2018, 2011b). Although the constructs are thought to map onto particular neural circuits (Liu, Hairston, Schrier, & Fan, 2011), little research has examined the extent to which they are differentiable. The available studies have focused on neurobiological differences between the motivation to pursue a reward (involving dopamine signaling in the neurostriatal circuit) and the pleasure experienced when a reward is attained (involving endogenous opioids), primarily in nonclinical samples (Nusslock & Alloy, 2017; Treadway & Zald, 2011). We are unaware of research examining the differentiability of other PVS constructs. As neurobiological studies rarely measure more than one or two PVS constructs, nor report associations between

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them, the differentiability of these constructs even at the neural level remains unresolved.

Additionally, each PVS construct can be observed in the context of different rewards, and research has shown that responses may vary by reward type (Shankman et al., 2014). For example, responses to social rewards, like feelings of closeness to a loved one, may be disrupted to a greater degree in depression than responses to physical rewards, like food (Forbes & Dahl, 2012). Additionally, responses to primary rewards (i.e., food and sex) and secondary rewards (e.g., engaging in a hobby) may be distinguishable (Rizvi, Pizzagalli, Sproule, & Kennedy, 2016). These findings underscore the value of assessing PVS constructs in relation to a variety of reward types. Several overarching categories of rewards have been identified, including social (Forbes & Dahl, 2012), physical (Chapman, Chapman, & Raulin, 1976; Zhang, Harris, Split, Troiani, & Olson, 2016), and recreational (Johnson, Fulford, & Carver, 2012; Ryba & Hopko, 2012) rewards; however, the extent to which reward types are differentiable has not yet been established.

The RDoC initiative has drawn considerable attention and is already influencing research through its impact on grant funding (Cuthbert, 2015) and publication (Morris, Vaidyanathan, & Cuthbert, 2015). In response, there has been growing demand for measures that provide reliable and valid assessments of RDoC constructs (Watson, Stanton, & Clark, 2017). However, despite strong interest in RDoC in general and the PVS in particular, there is currently no measure that comprehensively assesses the PVS domain. Table 1 lists the self-report scales that were expressly designed or are commonly used to assess reward-related processes, and details the constructs and reward types assessed by each scale. We did not include constructs related to reward learning, as these constructs are defined entirely by their behavioral outputs and are therefore less amenable to assessment by self-report.

As Table 1 shows, none of the available scales measure all relevant PVS constructs. In fact, Reward Satiation is not measured by any scale. Most scales assess fewer than half of the constructs. Additionally, the Behavioral Activation Scale (BAS) and Reinforcement Sensitivity Theory of Personality Questionnaire assess general attitudes toward rewards rather than responses to particular stimuli. Two newer scales—the Motivation and Pleasure Scale–Self-report (MAP-SR) and the Dimensional Anhedonia Rating Scale (DARS)—assess a larger number of PVS constructs and responses to particular stimuli. The MAP-SR, however, was derived from an interview measuring negative symptoms of schizophrenia, and is limited by its use of global items that require individuals to evaluate their responsiveness across reward types (e.g., "In the past week, what is the most pleasure you experienced from hobbies, recreation, or from work?"). While the scale assesses several PVS constructs, the items do not clearly differentiate them, and the score combines responses to rewards over the past week with expected responses during the upcoming few weeks. Finally, the scale is limited to social and recreational rewards and was developed in a small sample of individuals with schizophrenia.

The DARS includes assessment of physical rewards. However, many items are nonspecific and difficult to map onto a single PVS construct (e.g., "I would actively participate in these social activities"). Moreover, the DARS requires individuals to nominate their own rewards for each category, complicating comparisons between individuals with and without clinical disorders, whose chosen activities may differ in their rewarding properties. Although the authors did not compare the types of activities nominated by depressed versus nondepressed individuals, they noted that participants commonly expressed difficulty coming up with rewards to rate (Rizvi et al., 2015). Last, the DARS instructs individuals to respond based on how they are feeling "right now." This time frame may not adequately represent individuals' recent experiences, particularly if they are completing the assessment in an atypical environment (e.g., a lab or clinic), and may not capture reward responding over a clinically significant amount of time.

Behavioral PVS measures have also been developed and are gaining in popularity. Although they serve an important role, they are unlikely to displace self-report scales. One reason is that most behavioral tasks assess only one PVS construct. For example, the Effort Expenditure for Rewards Task (Treadway, Buckholtz, Schwartzman, Lambert, & Zald, 2009) measures individuals' willingness to exert effort for rewards. Other tasks measure multiple PVS constructs without distinguishing between them. For example, tasks assessing response bias for rewards (Pizzagalli, Iosifescu, Hallett, Ratner, & Fava, 2008) conflate overall sensitivity to reward with the ability to learn reward contingencies. Although behavioral tasks provide measures of PVS constructs free of some of the biases associated with self-report measures, it is time-consuming and expensive to assess each construct with a separate measure. Moreover, behavioral tasks have not yet been validated for many relevant constructs, and the vast majority of available tasks only measure individuals' responsiveness to small monetary rewards (NIMH, 2016; Rizvi et al., 2016), leaving open questions about generalizability to other reward types. Finally, although behavioral assessments are well suited to measuring constructs defined by their behavioral outcomes (e.g., reward learning), most PVS constructs concern individuals' subjective experiences of stimuli as rewarding. These cognitive and emotional reactions are not readily observable and may be assessed most appropriately via self-report.

To address these gaps, we developed the Positive Valence Systems Scale (PVSS). Grounded in the RDoC PVS domain, this self-report scale assesses all relevant PVS constructs, excluding explicitly behavioral constructs related to reward

**Table 1.** Existing Self-Report Measures of Positive Valence Processes.

| Scales | Positive Valence Systems Domain | | | | | | |
|---|---|---|---|---|---|---|---|
| | Overall Motivation | Reward Valuation | Reward Expectancy | Effort Valuation | Reward Anticipation | Initial Responsiveness | Reward Satiation |
| Generalized Reward Expectancy Scale (Ball & Zuckerman, 1990) | | | x | | | | |
| Sensitivity to Reward Questionnaire (Torrubia, Avila, Moltó, & Caseras, 2001) | | x | | | | | |
| Fawcett–Clark Pleasure Scale (Fawcett, Clark, Scheftner, & Gibbons, 1983) | | | | | | x | |
| Snaith–Hamilton Pleasure Scale (Snaith et al., 1995) | | | | | | x | |
| Chapman Anhedonia Scales (Chapman et al., 1976) | x | | | | | x | |
| Specific Loss of Interest and Pleasure Scale (Winer, Veilleux, & Ginger, 2014) | x | | | | | x | |
| Temporal Experience of Pleasure Scale (Gard, Gard, Kring, & John, 2006) | | | | | x | x | |
| Anticipatory and Consummatory Interpersonal Pleasure Scale (Gooding & Pflum, 2014) | | | | | x | x | |
| Rewarding Events Inventory (Hughes et al., 2017) | | | | x | x | | |
| Behavioral Activation Scale (Carver & White, 1994) | x | x | | x | | x | |
| Reinforcement Sensitivity Theory of Personality Questionnaire (Corr & Cooper, 2016) | x | x | | x | | x | |
| Motivation and Pleasure Scale–Self-report (Llerena et al., 2013) | x | x | | x | x | x | |
| Dimensional Anhedonia Rating Scale (Rizvi et al., 2015) | x | x | | x | | x | |

| Scales | Reward Category | | | |
|---|---|---|---|---|
| | Primary Rewards | Social Rewards | Physical Rewards | Recreational Rewards |
| Generalized Reward Expectancy Scale (Ball & Zuckerman, 1990) | | | x | x |
| Sensitivity to Reward Questionnaire (Torrubia et al., 2001) | x | x | x | x |
| Fawcett–Clark Pleasure Scale (Fawcett et al., 1983) | x | x | x | x |
| Snaith–Hamilton Pleasure Scale (Snaith et al., 1995) | x | x | x | x |
| Chapman Anhedonia Scales (Chapman et al., 1976) | x | x | x | x |
| Specific Loss of Interest and Pleasure Scale (Winer et al., 2014) | | x | | x |
| Temporal Experience of Pleasure Scale (Gard et al., 2006) | x | | x | x |
| Anticipatory and Consummatory Interpersonal Pleasure Scale (Gooding & Pflum, 2014) | | x | | |
| Rewarding Events Inventory (Hughes et al., 2017) | x | x | x | x |
| Behavioral Activation Scale (Carver & White, 1994) | | | | x |
| Reinforcement Sensitivity Theory of Personality Questionnaire (Corr & Cooper, 2016) | | | | x |
| Motivation and Pleasure Scale–Self-report (Llerena et al., 2013) | | x | | x |
| Dimensional Anhedonia Rating Scale (Rizvi et al., 2015) | x | x | x | x |

*Note*. Overall Motivation is not a construct in the Positive Valence Systems domain, but was included here to identify scales that provide a broad assessment of motivation rather than assessing specific subconstructs. Primary rewards are defined as rewards related to food or sex.

learning. The PVSS assesses these constructs in the context of social, physical, and recreational rewards, including both primary and secondary rewards. The comprehensive assessment offered by the PVSS offers several advantages over existing measures. First, it provides a "big picture" view of individuals' PVS functioning instead of a partial snapshot of their responses to a restricted range of stimuli, which may not accurately represent their experiences. Second, it

circumvents the need to administer several different scales and combine their results—a method that, given the scales available, would likely still privilege certain PVS constructs or reward types. Third, it can facilitate further study and refinement of the PVS framework itself, which has received little systematic evaluation despite its influence in the field (Olino, McMakin, & Forbes, 2018). Finally, it can be used to investigate PVS functioning in healthy and clinical populations, enhancing connections between basic and applied research and advancing understanding of positive valence constructs as transdiagnostic processes.

We first developed a long version of the PVSS (45 items) for which items were selected to represent a strong overall factor of reward responding. Study 1 describes the development of the PVSS-45 in a selected community sample (Sample 1) and its validation in an unselected student sample (Sample 2). We report the scale's internal consistency and convergent and discriminant validity. We then developed a short version of the PVSS (21 items) for which the items that loaded strongly on the overall factor were further refined to represent the reward-specific subfactors that emerged in Samples 1 and 2. Given the close relationship between positive valence processes and depression, with loss of interest or pleasure in rewards representing one of two cardinal symptoms of major depressive disorder (MDD), we also administered the PVSS to individuals with and without MDD (Sample 3). Study 2 describes the development of the PVSS-21 and presents evidence for its reliability and validity in the three aforementioned samples, including its retest reliability, ability to discriminate depressed from nondepressed individuals, and incremental validity for predicting symptom and functional outcomes over and above existing measures. Finally, in Study 3, we provide further evidence for the reliability and validity of the PVSS-21 by testing only these 21 items in a new, unselected community sample (Sample 4).

## Study 1: The PVSS-45

### *Initial Development of the PVSS*

We generated items for the PVSS based on the definition of each reward construct provided in the RDoC Workshop proceedings and the available literature. Items referenced commonly experienced positive stimuli that were expected to be applicable regardless of respondents' socioeconomic status, given generalizability concerns associated with culturally specific items (Leventhal, Chasson, Tapia, Miller, & Pettit, 2006). Each PVS construct was measured by items assessing the primary rewards of food and sex, as well as secondary rewards in social, physical, and recreational domains. Given our interest in measuring state levels of PVS that may fluctuate over time, particularly in clinical samples, and the requirement that loss of interest or pleasure in rewards last 2 weeks to qualify for an MDD diagnosis (American Psychiatric Association, 2013), individuals were asked to rate their responses over the previous 2 weeks.

Three experts on reward processing in depression rated the face validity of each item and commented on each item and the scale overall. After adding items suggested by these experts and editing or deleting items flagged as problematic or assigned low face validity ratings, the PVSS included 9 to 13 items for each PVS construct (74 items total). Based on initial pilot testing with 15 unselected adults that included extensive in-person debriefings, we clarified the PVSS's instructions, expanded the response scale, and made several changes to encourage individuals to attend to the differences between PVS constructs. These changes included underlining the words in each item that differentiated the constructs and directing individuals to pay attention to these differences (see Supplemental Item 2, available online).

Given high item ratings across participants and our desire to avoid ceiling effects, we generated a "high difficulty" and "low difficulty" version of each item (e.g., "I *went out of my way* to admire the beauty around me" vs. "I *made an effort* to notice beauty around me"). We randomly selected one item from each pair to create two alternate forms of the scale. In a second pilot study,[1] we tested each form in a separate group of 25 unselected adults. We chose the best-performing item from each pair by examining the item's distribution (wider distributions and means below 7 out of 9 were preferred), item-total correlations, correlations with convergent and discriminant measures, and reports of higher frequencies of encountering the reward. These features were considered holistically, with particular attention paid to features indicating large differences between items. When both items in a pair performed poorly, both were eliminated. As items focusing on sex were encountered infrequently by participants, had low item-total correlations, and demonstrated inconsistent correlations with other measures in both pilot studies, these were eliminated from the scale, although items assessing other physical contact (e.g., receiving a hug) were retained. To ensure that each PVS construct was evaluated for primary as well as secondary rewards, we included at least one item referencing food or drink for each construct. This resulted in a pool of 61 items, including 7 to 12 items per PVS construct, that was tested in Sample 1. For a full list of pilot-tested items, see Supplemental Item 1 (available online).

### *Method*

*Quality Assurance.* Data collection for Samples 1 and 2 was conducted online. We ensured the validity of our data by (a) excluding participants who failed to respond accurately to objectively verifiable questions, (b) including the same questionnaire twice and excluding participants whose discrepant responses to the two versions emerged as outliers in

**Table 2.** Demographic Characteristics by Sample.

| Demographic characteristics | Sample 1 ($n$ = 356) | Sample 2 ($n$ = 358) | Sample 2 follow-up ($n$ = 59) | Sample 3 ($n$ = 76) | Sample 4 ($n$ = 266) |
|---|---|---|---|---|---|
| Age | 36.96 (10.94) | 19.96 (1.82) | 19.90 (2.16) | 32.73 (12.96) | 36.84 (10.82) |
| Female, % | 50.6 | 56.1 | 61.0 | 61.8 | 41.4 |
| Race, % | | | | | |
| Caucasian | 87.4 | 60.6 | 55.9 | 48.7 | 80.8 |
| African American | 3.9 | 7.0 | 10.2 | 32.9 | 9.8 |
| Asian | 4.2 | 24.6 | 27.1 | 11.8 | 6.8 |
| Multiracial | 3.4 | 6.4 | 6.8 | NA | 2.2 |
| Other | 1.1 | 1.4 | 0.0 | 6.6 | 0.4 |
| Ethnicity, % | | | | | |
| Hispanic/Latino | 3.1 | 8.4 | 11.9 | 1.5 | 3.8 |

*Note.* *M* (*SD*) are presented for dimensional variables; all other values represent percentages. In Study 3, multiracial participants were included in the "Other" category.

the distribution of responses, and (c) excluding participants who completed a majority of the surveys at a pace faster than one third of the median response time (Goodman, Cryder, & Cheema, 2013; Huang, Curran, Keeney, Poposki, & DeShon, 2012; Meade & Craig, 2012). Participants with invalid data (26 from Sample 1 and 18 from Sample 2) were excluded from analyses.

### *Participants*

*Sample 1*. This community sample included 356 participants recruited through Amazon Mechanical Turk (MTurk). All participants completed the PVSS and a measure of depression, and 167 of these participants also completed a battery of convergent and discriminant self-report measures. To enhance data quality and ensure English-language fluency, we restricted participation to experienced individuals (those who had completed over 5,000 assignments) with high reputations (over 95% approval ratings) living in the United States, and paid participants between $6 and $9 per hour, depending on how long it took them to complete the study (Litman, Robinson, & Rosenzweig, 2015; Peer, Vosgerau, & Acquisti, 2014).

Given our primary interest in measuring positive valence processes within the context of depression and our desire to base item selection on a sample with an adequate range of symptoms, we selected participants based on their current level of depression. Participants completed a validated and widely used screening measure for depression, the Patient Health Questionnaire (PHQ-9). Previously established cutoffs were used to enroll participants with minimal ($n$ = 125), mild ($n$ = 117), and moderate ($n$ = 114) symptoms of depression (Kroenke, Spitzer, & Williams, 2001; see Table 2 for sample characteristics).

*Sample 2*. To test the reliability and validity of the PVSS across sample types, we recruited unselected college students for our second sample. Given widespread use of undergraduate samples in personality and clinical studies, this strategy also permitted us to evaluate the characteristics of the PVSS in the context in which it is most likely to be used.

The sample included 358 participants recruited via a Psychology Department website, of whom 253 also completed convergent and discriminant measures. Participants were not screened, so the final sample included more participants with minimal ($n$ = 174) and mild ($n$ = 133) than moderate ($n$ = 50) depression symptoms. Participants were younger and more racially diverse than those in Sample 1 (Table 2). We offered participants the chance to complete a follow-up study until all slots were filled. This subsample ($n$ = 59) completed the PVSS again 2 weeks later. Participants were compensated with course credit.

### *Measures*

*The Positive Valence Systems Scale, 45 items (PVSS-45)*. The PVSS-45 (see Supplemental Item 2, available online) measures responding to positive social, physical, and recreational stimuli. In addition to the RDoC PVS constructs already described, the PVSS-45 includes a construct listed in the 2011, but not the 2018, version of the domain (Action Selection).[2] Thus, the PVSS-45 measures seven constructs:[3] Reward Valuation, desire for the reward (e.g., "I *wanted* to spend time with people I know"); Reward Expectancy, expectations regarding the likelihood of experiencing the reward (e.g., "I *expected* to master the tasks I undertook"); Effort Valuation, willingness to exert effort for the reward (e.g., "I *invested time* in my friendships"); Reward Anticipation, anticipation for the reward (e.g., "I really *looked forward* to watching a movie I heard might be good"); Action Selection, choosing to pursue the reward among other possible courses of action (e.g., "I made time to pursue my hobbies *even when* it was inconvenient"); Initial Responsiveness, immediate responses to the reward (e.g., "I *was delighted* to

catch a breath of fresh air outdoors"); and Reward Satiation, long-term responses to the reward (e.g., "I felt satisfied and relaxed *for a long time* after a good meal").

Responses are rated on a 9-point scale ranging from *extremely untrue of me* to *extremely true of me*. The response scale was expanded during pilot testing to avoid ceiling effects in nonclinical samples. Participants indicate the extent to which the statements describe their responses over the previous 2 weeks. If a statement describes a situation they have not experienced over the previous 2 weeks, they are asked to rate how they would have responded if they had experienced the situation during this time. Participants are asked to pay attention to the underlined words in each item, which reference the PVS construct assessed.

*PVSS frequencies ratings*. To check how commonly the rewards described in the PVSS were experienced, we asked participants to indicate whether they had the opportunity to experience each reward over the previous 2 weeks. These dichotomous ratings were made after participants completed the PVSS. Items were phrased differently depending on the PVSS construct from which they were derived. For example, the PVSS item "I *invested time* in my friendships" (Effort Valuation) was replaced with "I had the opportunity to invest time in my friendships." The item "I *was delighted* to catch a breath of fresh air outdoors" (Initial Responsiveness) was replaced with "I caught a breath of fresh air outdoors." We calculated the proportion of participants who reported experiencing each situation over the previous 2 weeks, and used this as an index of the extent to which participants perceived the rewards described in the PVSS as available to them in their daily lives.

*Measures for validity testing*. The measures described below have all shown evidence of reliability and validity in community and student samples. Due to time constraints, Sample 2 participants completed a subset of the measures completed by Sample 1 (Table 5). Sample 2 measures included one validation scale for each PVS construct, where available, along with measures for testing convergent and discriminant validity. Cronbach's alpha coefficients are listed below for the sample in which each measure was administered.

*Convergent measures*. *Reward processing.* To test convergent validity, we included a measure assessing each PVS construct to the extent that such measures were available at the time of data collection. We measured overall motivation with the full BAS, Reward Valuation with the BAS Reward Responsiveness subscale, and Effort Valuation with the BAS Drive subscale (Carver & White, 1994; Jorm et al., 1998). The BAS (Sample [S] 1 $\alpha = .89$, S2 $\alpha = .80$) measures individual differences in the sensitivity of the behavioral system proposed to regulate motivation for rewards. BAS subscales include Reward Responsiveness, measuring interest in rewards (S1: $\alpha = .83$, S2: $\alpha = .69$); Drive, measuring persistent pursuit of desired goals (S1: $\alpha = .88$, S2: $\alpha = .78$); and Fun Seeking, measuring willingness to approach a potentially rewarding event on the spur of the moment (S1: $\alpha = .81$, S2: $\alpha = .68$).

We also measured Reward Valuation with the Sensitivity to Reward scale of the Sensitivity to Punishment and Sensitivity to Reward Questionnaire (SPSRQ; Torrubia et al., 2001). The Sensitivity to Reward scale (S1: $\alpha = .85$) measures desire for social, physical, and recreational rewards. We measured Reward Expectancy with the Generalized Reward Expectancy Scale, a subscale of the Generalized Reward and Punishment Expectancy Scales (GRAPES; Ball & Zuckerman, 1990; Gomez & Gomez, 2005), which assesses expectations for experiencing positive events (S1: $\alpha = .84$, S2: $\alpha = .69$). We measured Reward Anticipation with the Temporal Experience of Pleasure Scale (TEPS; Gard et al., 2006) Anticipatory Pleasure subscale, which assesses pleasure experienced during anticipation of rewards (S1: $\alpha = .84$, S2: $\alpha = .77$). Initial Responsiveness was measured with the TEPS Consummatory Pleasure subscale, which assesses pleasure experienced on attaining rewards (S1: $\alpha = .76$, S2: $\alpha = .67$), and with the Snaith–Hamilton Pleasure Scale (SHAPS; Snaith et al., 1995; S1 $\alpha = .91$). As no scales measuring Reward Satiation or Action Selection were available, no measures of those constructs were included.

*Positive emotionality*. Positive emotionality, or the tendency to experience positive emotions like happiness, energy, and confidence, is the broad personality trait most strongly associated with responsiveness to positive stimuli (Watson & Naragon-Gainey, 2010). As positive emotionality is commonly assessed with measures of positive affect (assessing positive emotions) or extraversion (assessing positive emotions as well as sociability, ascendance, and excitement seeking), we included both types of measures (Naragon-Gainey & Watson, 2014). This strategy also enabled us to measure positive emotionality as a state (i.e., using a specific time frame) and a trait (i.e., without reference to a specific time frame).

Positive affect over the "past few weeks" was measured with the Positive Affect subscale of the Positive and Negative Affect Schedule (PANAS; Crawford & Henry, 2004; Watson, Clark, & Tellegen, 1988; S1 $\alpha = .92$, S2 $\alpha = .90$). These previously validated instructions were selected to correspond most closely to the time period covered by the PVSS. Extraversion was measured with the Big Five Inventory (BFI) Extraversion subscale (John & Srivastava, 1999; S1 $\alpha = .91$, S2 $\alpha = .88$).

*Mood symptoms*. We measured overall depression symptoms over the previous 2 weeks using the PHQ-9 (Kroenke et al., 2001; S1 $\alpha = .91$, S2 $\alpha = .88$). Anhedonic depression symptoms, in particular, were measured with the Mood and

Anxiety Symptom Questionnaire (MASQ) Anhedonic Depression subscale (Watson et al., 1995; S1 $\alpha = .97$, S2 $\alpha = .93$). As in previous studies (e.g., Kashdan, Zvolensky, & McLeish, 2008), only the Anhedonic Depression and Anxious Arousal MASQ subscales were administered. Hypomania was assessed with the Hypomanic Personality Scale–Short form (HPS-20; Meads & Bentall, 2008), which assesses personality traits consistent with symptoms of hypomania (S1: $\alpha = .85$).

*Contact with rewarding stimuli*. We used the reward probability index (RPI; Carvalho et al., 2011) to measure participants' access to rewards in their everyday environment. The RPI consists of the Reward Probability subscale, measuring individuals' likelihood of encountering rewards (S1: $\alpha = .92$), and the Environmental Suppressors subscale, measuring environmental constraints on accessing rewarding stimuli (S1: $\alpha = .90$).

*Social/occupational impairment*. The Social Functioning Questionnaire (SFQ; Tyrer et al., 2005) was used to measure social and occupational impairment. The SFQ asks individuals to rate their level of functional impairment over the previous 2 weeks, with higher scores indicating greater impairment (S1: $\alpha = .83$).

*Discriminant measures*. *Punishment sensitivity.* Sensitivity to punishment, or behavioral inhibition, is the behavioral system hypothesized to control responses to aversive stimuli. It is proposed to be orthogonal to reward sensitivity, or behavioral approach (Torrubia et al., 2001), although studies typically find these constructs to be correlated (Campbell-Sills, Liverant, & Brown, 2004). To evaluate the PVSS' discriminant validity, we used two measures of punishment sensitivity: the Behavioral Inhibition Scale (BIS; Carver & White, 1994; S1 $\alpha = .89$, S2 $\alpha = .76$) and the GRAPES Generalized Punishment Expectancy subscale (Gomez & Gomez, 2005; S1 $\alpha = .76$, S2 $\alpha = .65$).

*Negative emotionality.* Just as positive emotionality is the personality trait most associated with reward sensitivity, negative emotionality is the personality trait most associated with punishment sensitivity (Campbell-Sills et al., 2004). As a further test of discriminant validity, we included two negative emotionality measures, which typically correlate moderately with positive emotionality measures (Crawford & Henry, 2004). Paralleling our assessment of positive emotionality, we measured state levels of negative affect over the previous few weeks with the PANAS Negative Affect subscale (S1: $\alpha = .95$, S2: $\alpha = .87$), and trait levels of neuroticism—reflecting characteristically high levels of emotional distress—with the BFI Neuroticism subscale (S1: $\alpha = .93$, S2: $\alpha = .84$).

*Anxiety symptoms*. As positive valence processes are more strongly related to depression than to anxiety symptoms characterized by hyperarousal (Keogh & Reidy, 2000), we used the Anxious Arousal subscale of the MASQ as an additional test of discriminant validity (S1: $\alpha = .92$, S2: $\alpha = .89$). Given the PVSS's inclusion of social rewards, we wanted to ensure that responses to the scale were not driven by participants' social fears. To that end, we included the Brief Fear of Negative Evaluation Scale–Straightforward items (BFNE-S), a measure of individuals' fears of being evaluated by others (Carleton, Collimore, McCabe, & Antony, 2011; Rodebaugh et al., 2004; S1 $\alpha = .98$, S2 $\alpha = .94$).

*Positive personality traits*. We included measures of creativity, agreeableness, and conscientiousness to test the PVSS's ability to discriminate responsiveness to rewarding stimuli from other, theoretically unrelated personality traits sharing the same valence. Creativity was measured with the Creative Behavior Inventory–Short form (CBI-SF; Dollinger, 2003; Silvia, Wigert, Reiter-Palmon, & Kaufman, 2012), which assesses the frequency with which respondents engaged in creative behaviors as adolescents and adults (S1: $\alpha = .90$). Agreeableness (S1: $\alpha = .85$, S2: $\alpha = .76$) and conscientiousness (S1: $\alpha = .89$, S2: $\alpha = .85$) were both measured with the relevant BFI subscales.

*Social desirability*. To test whether PVSS scores were related to participants' desire for positive self-presentation, we included a 13-item version of the Marlowe–Crowne Social Desirability Scale (MCSD; Ballard, 1992; Loo & Thorpe, 2000). In the MCSD, individuals rate descriptions of themselves that are positive but unlikely to be accurate (S1: $\alpha = .82$).

## Results

*Preliminary Analyses.* Participants answered questions about the PVSS as a check on its clarity and relevance. Response scales ranged from 1 to 5. In both samples, participants rated the situations described in the PVSS as very clear (S1: $M = 4.81$, $SD = 0.42$; S2: $M = 4.37$, $SD = 0.68$) and quite a bit like the positive situations they encounter in their daily lives (S1: $M = 4.16$, $SD = 0.81$; S2: $M = 4.12$, $SD = 0.80$). They indicated that their ratings very closely reflected their typical responses to positive events in their daily lives (S1: $M = 4.59$, $SD = 0.65$; S2: $M = 4.32$, $SD = 0.69$) and that it was easy to imagine how they would have responded to situations that they did not experience in the previous 2 weeks (S1: $M = 4.31$, $SD = 0.81$; S2: $M = 3.99$, $SD = 0.88$). It took participants an average of less than 5 minutes to complete the PVSS-45 (S2: $M = 4.61$ minutes, $SD = 2.46$).

### Factor Analyses

*Sample 1*. As PVSS responses were relatively normally distributed (i.e., skewness and kurtosis under 1; Osborne & Costello, 2005), we performed an exploratory factor analysis (EFA) using maximum likelihood estimation with SPSS 24.0 (IBM Corp, 2016). We used oblique rotation

(direct oblimin) as we expected correlations between factors. The Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy (.95) exceeded the recommended value (Kaiser, 1960) and Bartlett's Test of Sphericity was significant ($p < .001$), indicating the adequacy of this sample for factor analysis.

This initial analysis produced a first factor accounting for 35% of the variance, with each subsequent factor accounting for no more than 5% of the variance. The scree plot also indicated the presence of one main factor (see Supplemental Figure 1, available online). Given evidence for a strong overall factor in which all PVS constructs and reward types were represented, we ran a follow-up EFA specifying the presence of one factor. To enhance the validity of the resulting scale, we eliminated items that loaded under .5, except for two Action Selection items whose removal would have resulted in incomplete representation of reward types for this construct (starred items in Table 3). Instead of eliminating these items, we reworded them to improve their future performance. We also eliminated redundant items by retaining the item with the highest factor loading.

This process resulted in an internally consistent ($\alpha = .95$) 45-item scale with at least six items per PVS construct. Each PVS construct was assessed with items referencing social, physical, and recreational rewards, including primary as well as secondary rewards. We ran a follow-up confirmatory factor analysis (CFA) in M*plus* 7.0 (Muthén & Muthén, 1998-2015; see Table 3 for loadings). Following current conventions (Hooper, Coughlan, & Mullen, 2008; Hu & Bentler, 1999), we considered several fit indices and used the following cutoffs to indicate good fit: root mean square error of approximation less than .10, standardized root mean square residual less than .08, and comparative fit index greater than .90. As shown in Table 4 (Model 1), this one-factor model had fit indices below conventional standards.

*Sample 2*. The KMO (.92) and Bartlett's Test of Sphericity ($p < .001$) indicated that the sample was adequate for factor analysis. As a further test of factor structure, we performed an EFA on the PVSS-45 using maximum likelihood estimation with oblique rotation. The first factor accounted for 32% of the variance, with all remaining factors accounting for 4% of the variance or less; the scree plot confirmed the large contribution of the first factor (see Supplemental Figure 2, available online). A follow-up CFA specifying one factor (see Table 3 for loadings) showed that all items had loadings of .35 or above, including the two reworded items (total scale $\alpha = .96$). Despite these strong loadings, model fit indices again fell below conventional standards (Table 4, Model 2).

*Convergent and Discriminant Validity.* Correlations of the PVSS-45 with convergent and discriminant measures are shown in Table 5 (left columns). Given the similarity of the effect sizes for the PVSS-45 and the PVSS-21, we discuss validity results in Study 2.

### *Discussion*

In both a community sample selected for a range of depression scores and an unselected student sample, participants judged the PVSS to be clear, relevant to their experiences, and easy to complete. We found evidence of a strong overall factor and the final items were chosen to load highly on this factor. The PVSS-45 is internally consistent, and each PVS construct is represented by both primary and secondary rewards in physical, social, and recreational domains. While there was no support for the differentiability of the PVS constructs, these face valid groups of items can be administered separately by researchers interested in assessing only a subset of PVS constructs. The PVSS-45 demonstrated convergent, discriminant, and incremental validity; descriptions of these analyses were excluded to conserve space but are available on request from the corresponding author.

## Study 2: The PVSS-21

### *Development of the PVSS-21*

Despite advantages of the PVSS-45 as a comprehensive measure of reward responding, the inadequate fit of the data to a one-factor model indicated the need to account for additional item heterogeneity. To provide further clarification, we ran a parallel analysis in Sample 1 using the PVSS-45 items. We used the comparative data procedure, which compares data sets generated from the observed correlation matrix with known factorial structures to the actual data to determine the number of factors to retain (Ruscio & Roche, 2012). This approach indicated that we should retain nine factors.

As we had the opportunity to utilize both the selected community and the unselected student samples to determine the presence of additional factors, we ran models in both samples using bifactor exploratory structural equation modeling (ESEM) in M*plus*. Bifactor ESEM, used with the bi-geomin rotation, allows for the specification of a general factor as well as correlated subfactors within the EFA framework (Jennrich & Bentler, 2012). Given the results of the parallel analysis, we ran models specifying 1 to 9 subfactors in both samples. In all models, the subfactors reflected specific reward types. The most consistent subfactors to emerge across samples related to food, physical touch, the outdoors, and positive feedback. Additional factors that emerged in both samples related to hobbies, social interactions, and goals.

We reran CFAs in both samples specifying one overall factor and these seven reward-specific subfactors (Table 4, Models 3 and 4). All 45 items were analyzed, so the number

**Table 3.** Confirmatory Factor Analysis Loadings for the Positive Valence Systems Scale, 45 Items (PVSS-45).

| Item | Sample 1 | Sample 2 |
|---|---|---|
| Reward Valuation | | |
| I *had the desire* to feel part of a group or community | .52 | .41 |
| I *craved* a delicious food | .52 | .43 |
| I *wanted* to spend time doing productive activities | .56 | .35 |
| I *wanted* to spend time with people I know | .70 | .60 |
| I *wanted* to participate in a fun activity with friends | .71 | .69 |
| I *wanted* to accomplish goals I set for myself | .55 | .51 |
| Reward Expectancy | | |
| I *expected* to master the tasks I undertook | .59 | .47 |
| I *expected* to hear positive comments about my work | .61 | .53 |
| I *expected* to enjoy a brief moment outdoors | .52 | .46 |
| I *expected* to be received warmly by people I met | .66 | .62 |
| I *expected* to enjoy being hugged by someone I love | .66 | .58 |
| I *expected* to enjoy my meals | .63 | .59 |
| Effort Valuation | | |
| I *invested time* in my friendships | .65 | .64 |
| I *actively pursued* activities I thought would be fun | .70 | .74 |
| I *worked hard* to earn positive feedback on my projects | .65 | .59 |
| I *went out of my way* to admire the beauty around me | .60 | .48 |
| I *put energy* into activities I enjoy | .72 | .65 |
| I *went out of my way* to find a food I enjoy | .55 | .54 |
| Reward Anticipation | | |
| I really *looked forward* to watching a movie I heard might be good | .51 | .41 |
| I *looked forward* to hugging someone I felt close to | .57 | .58 |
| I *looked forward* to an upcoming meal | .56 | .59 |
| I *looked forward* to spending time with others | .77 | .72 |
| I really *looked forward* to spending time on my hobbies | .63 | .62 |
| I *looked forward* to hearing feedback on my work | .68 | .58 |
| Action Selection | | |
| I cooked or went out for a special meal *even though* it took considerable time or effort[a] | .44 | .48 |
| I worked hard to earn praise from someone I respected, *even though* it required a lot more of my time | .54 | .52 |
| I made time to pursue my hobbies *even when* it was inconvenient | .55 | .58 |
| I went out with friends *even when* there were other things I could have been doing[a] | .37 | .50 |
| I focused on pursuing my long-term goals *even when* it was difficult | .57 | .58 |
| *Even when* I had limited free time, I carved out time to spend with loved ones | .72 | .66 |
| Initial Responsiveness | | |
| I *was excited* to discover that someone I met shared my interests | .49 | .39 |
| Laughing with friends *lifted my spirits* | .69 | .63 |
| When an upbeat song came on, I *got really into it* | .62 | .48 |
| I *felt pleased* when I reached a goal I set for myself | .67 | .58 |
| It *felt good* to have physical contact with someone I felt close to | .68 | .59 |
| I *felt delighted* when someone complimented me | .72 | .62 |
| I *savored* my first bite of food after feeling hungry | .59 | .56 |
| I *felt great* when someone listened carefully to a story I told | .66 | .67 |
| I *was delighted* to catch a breath of fresh air outdoors | .58 | .51 |
| Reward Satiation | | |
| My excitement about buying myself something new *lasted into the next day* | .49 | .42 |
| Receiving praise about my work made me feel pleased *for the rest of the day* | .70 | .49 |
| The inspiration I felt while watching a great movie *persisted after* the movie ended | .62 | .48 |
| Getting a hug from someone close to me made me happy *even after* we parted | .67 | .63 |
| I felt satisfied and relaxed *for a long time* after a good meal | .64 | .66 |
| A fun activity during the weekend sustained my good mood *throughout the new week* | .71 | .61 |

*Note*. The wording in the table represents the final wording that was used in Sample 2.
[a]Items were worded slightly differently in the two studies.

**Table 4.** Fit Indices for Positive Valence Systems Scale (PVSS) Factor Solutions.

| Model | Description | Scale | Sample | $\chi^2$ | *df* | RMSEA with 90% [CI] | SRMR | CFI |
|---|---|---|---|---|---|---|---|---|
| 1 | 1 General factor | PVSS-45 | Sample 1 | 4796.32 | 945 | .11 [.10, .11] | .08 | .63 |
| 2 | 1 General factor | PVSS-45 | Sample 2 | 4186.35 | 945 | .10 [.10, .10] | .08 | .61 |
| 3 | 1 General factor; 7 subfactors (higher order) | PVSS-45 | Sample 1 | 2986.60 | 938 | .08 [.08, .08] | .07 | .81 |
| 4 | 1 General factor; 7 subfactors (higher order) | PVSS-45 | Sample 2 | 2865.62 | 938 | .08 [.07, .08] | .07 | .77 |
| 5 | 1 General factor; 7 subfactors (higher order) | Highest loading items in Sample 1 | Sample 1 | 480.75 | 182 | .07 [.06, .08] | .05 | .94 |
| 6 | 1 General factor; 7 subfactors (higher order) | Highest loading items in Sample 1 | Sample 2 | 525.94 | 182 | .07 [.07, .08] | .06 | .90 |
| 7 | 1 General factor; 7 subfactors (higher order) | PVSS-21 | Sample 1 | 523.97 | 182 | .07 [.07, .08] | .05 | .93 |
| 8 | 1 General factor; 7 subfactors (higher order) | PVSS-21 | Sample 2 | 495.44 | 183 | .07 [.06, .08] | .06 | .91 |
| 9 | 1 General factor; 3 subfactors (higher order) | PVSS-45 | Sample 1 | 4336.95 | 942 | .10 [.10, .10] | .08 | .67 |
| 10 | 1 General factor; 3 subfactors (higher order) | PVSS-45 | Sample 2 | 3885.41 | 942 | .09 [.09, .10] | .08 | .65 |
| 11 | 1 General factor; 3 subfactors (higher order) | PVSS-21 | Sample 1 | 1364.04 | 186 | .13 [.13, .14] | .08 | .74 |
| 12 | 1 General factor; 3 subfactors (higher order) | PVSS-21 | Sample 2 | 1208.09 | 186 | .12 [.12, .13] | .08 | .70 |
| 13 | 1 General factor; 7 subfactors (higher order) | PVSS-21 | Sample 4 | 509.33 | 182 | .08 [.07, .09] | .05 | .91 |
| 14 | 1 General factor; 3 subfactors (higher order) | PVSS-21 | Sample 4 | 940.83 | 186 | .12 [.12, .13] | .07 | .79 |
| 15 | 1 General factor; 7 subfactors (bifactor) | PVSS-21 | Sample 4 | 471.49 | 168 | .08 [.07, .09] | .05 | .92 |

*Note.* *df* = degrees of freedom; RMSEA = root mean square error of approximation; CI = confidence intervals; SRMR = standardized root mean square residual; CFI = comparative fit index.

**Table 5.** Correlations of the Positive Valence Systems Scale (PVSS) With Convergent and Discriminant Measures.

| | PVSS-45 | | PVSS-21 | | |
|---|---|---|---|---|---|
| Scale | Sample 1 | Sample 2 | Sample 1 | Sample 2 | Sample 4 |
| Convergent measures | | | | | |
| Reward Processing | | | | | |
| Behavioral Activation Scale (BAS): Total | .67*** | .48*** | .66*** | .46*** | — |
| Behavioral Activation Scale (BAS): Reward Responsiveness | .65*** | .44*** | .65*** | .39*** | — |
| Sensitivity to Reward Questionnaire | .37*** | — | .34*** | — | — |
| Behavioral Activation Scale (BAS): Drive | .54*** | .37*** | .55*** | .38*** | — |
| GRAPES Generalized Reward Expectancy | .56*** | .37*** | .55*** | .39*** | — |
| Temporal Experience of Pleasure Scale (TEPS): Anticipatory | .73*** | .66*** | .72*** | .62*** | — |
| Temporal Experience of Pleasure Scale (TEPS): Consummatory | .64*** | .39*** | .66*** | .39*** | — |
| Snaith–Hamilton Pleasure Scale (SHAPS) | .72*** | — | .72*** | — | .69*** |
| Dimensional Anhedonia Rating Scale (DARS) | — | — | — | — | .56*** |
| Motivation and Pleasure Scale–Self-report (MAP-SR) | — | — | — | — | .76*** |
| Positive emotionality | | | | | |
| PANAS: State Positive Affect | .61*** | .60*** | .61*** | .61*** | — |
| Big Five Inventory (BFI): Extraversion | .52*** | .42*** | .52*** | .42*** | .45*** |
| Mood symptoms | | | | | |
| Patient Health Questionnaire (PHQ-9) | −.49*** | −.35*** | −.48*** | −.37*** | −.37*** |
| MASQ Anhedonic Depression | −.62*** | −.64*** | −.63*** | −.65*** | −.66*** |
| Hypomanic Personality Scale (HPS-20) | .28*** | — | .25*** | — | — |
| Personality Assessment Inventory (PAI): Mania Subscale | — | — | — | — | .21* |
| Contact with rewarding stimuli | | | | | |
| Reward Probability Index (RPI): Reward Probability | .71*** | — | .71*** | — | — |
| Reward Probability Index (RPI): Environmental Suppressors | −.47*** | — | −.49*** | — | — |
| Behavioral Activation for Depression Scale (BADS): Activation | — | — | — | — | .56*** |

*(continued)*

**Table 5. (continued)**

| Scale | PVSS-45 | | PVSS-21 | | |
|---|---|---|---|---|---|
| | Sample 1 | Sample 2 | Sample 1 | Sample 2 | Sample 4 |
| Functioning | | | | | |
| Social Functioning Questionnaire (SFQ) | −.60*** | — | −.61*** | — | — |
| Behavioral Activation for Depression Scale (BADS): Work/ School Impairment | — | — | — | — | −.13 |
| Behavioral Activation for Depression Scale (BADS): Social Impairment | — | — | — | — | −.46*** |
| Discriminant measures | | | | | |
| Punishment sensitivity | | | | | |
| Behavioral Inhibition Scale (BIS) | −.15* | .01 | −.17* | −.05 | — |
| GRAPES Generalized Punishment Expectancy | −.23** | −.03 | −.23** | −.05 | — |
| Negative emotionality | | | | | |
| PANAS: State Negative Affect | −.37*** | −.16* | −.40*** | −.18** | — |
| Big Five Inventory (BFI): Neuroticism | −.40*** | −.24*** | −.42*** | −.27*** | −.31*** |
| Anxiety symptoms | | | | | |
| MASQ Anxious Arousal | −.26** | −.24*** | −.29*** | −.24*** | −.03 |
| Brief Fear of Negative Evaluation Scale–Straightforward Items (BFNE-S) | −.23** | −.09 | −.25** | −.13* | — |
| Positive personality traits | | | | | |
| Creative Behavior Inventory–Short form (CBI-SF) | .22** | — | .22** | — | — |
| Big Five Inventory (BFI): Agreeableness | .36*** | .46*** | .40*** | .45*** | .53*** |
| Big Five Inventory (BFI): Conscientiousness | .38*** | .37*** | .42*** | .36*** | .34*** |
| Social desirability | | | | | |
| Shortened Marlowe–Crowne Social Desirability Scale (MCSD) | .06 | — | .10 | — | — |

*Note*. PANAS-State = Positive and Negative Affect Schedule–State version (past few weeks); MASQ = Mood and Anxiety Symptom Questionnaire. The Sensitivity to Reward Questionnaire is a subscale of the Sensitivity to Punishment and Sensitivity to Reward Questionnaire.
*$p < .05$. **$p < .01$. ***$p < .001$.

of items per subfactor ranged from 3 (Outdoors) to 12 (Social Interactions) items. Model fit improved substantially, but the relatively low comparative fit index hinted that model fit would improve further with fewer items. We were also very interested in developing a shortened scale to enhance ease of administration. To capture the full range of reward types and allow for the analysis of reward-specific subscales, we included three items per subscale. We chose the highest loading items for each subscale in Sample 1 (the community sample), substituting three similarly loading items that demonstrated higher loadings in Sample 2 or that enabled additional PVS constructs to be represented (Table 6). The resulting scale, the PVSS-21 (see Supplemental Item 2, available online), includes seven reward-specific subscales (three items each) and provides coverage of all PVS constructs listed in Table 1 (three to four items each). The PVSS-21 therefore yields (a) a total score that includes representation of the PVS constructs and (b) seven reward-specific subscale scores. We did not include Action Selection because this construct was excluded from the updated PVS and its items did not load strongly on the subfactors. Further details about factor structure are provided in the following sections.

## *Method*

Participants and measures for Samples 1 and 2 are described in Study 1.

*Sample 3 Participants and Measures*. Given the close link between positive valence processes and depression, we evaluated the reliability and validity of the PVSS in a new sample of participants with and without major depression. This sample also allowed us to quantify the magnitude of differences in scores, as well as differences in response patterns, between individuals with and without MDD.

The sample included 76 adults recruited through electronic and print advertisements from the Philadelphia community. Participants completed the Anxiety and Related Disorders Interview Schedule (ADIS) for *Diagnostic and Statistical Manual of Mental Disorders–Fifth edition* (*DSM-5*; Brown & Barlow, 2014), widely considered the "gold standard" interview for depressive and anxiety disorders. Interviews were administered by doctoral, master's, or bachelor's-level diagnosticians who underwent extensive training and demonstrated high interrater agreement with the supervising licensed psychologist. Each interview was

**Table 6.** Confirmatory Factor Analysis Loadings for the Positive Valence Systems Scale, 21 Items (PVSS-21).

| Item | Sample 1 | Sample 2 | Sample 3 | Sample 4 | PVS construct |
|---|---|---|---|---|---|
| Food | $\alpha = .84$ | $\alpha = .76$ | $\alpha = .69$ | $\alpha = .77$ | |
| I *expected* to enjoy my meals | .87 | .78 | | .82 | Reward Expectancy |
| I *looked forward* to an upcoming meal | .81 | .78 | | .84 | Reward Anticipation |
| I *savored* my first bite of food after feeling hungry[a] | .74 | .67 | | .58 | Initial Responsiveness |
| Loading on general factor | .71 | .73 | | .72 | |
| Physical Touch | $\alpha = .89$ | $\alpha = .82$ | $\alpha = .82$ | $\alpha = .87$ | |
| It *felt good* to have physical contact with someone I felt close to | .86 | .78 | | .81 | Initial Responsiveness |
| I *expected* to enjoy being hugged by someone I love | .87 | .78 | | .86 | Reward Expectancy |
| Getting a hug from someone close to me made me happy *even after* we parted | .85 | .78 | | .82 | Reward Satiation |
| Loading on general factor | .73 | .73 | | .83 | |
| Outdoors | $\alpha = .86$ | $\alpha = .84$ | $\alpha = .82$ | $\alpha = .85$ | |
| I *was delighted* to catch a breath of fresh air outdoors | .87 | .90 | | .80 | Initial Responsiveness |
| I *expected* to enjoy a brief moment outdoors | .83 | .82 | | .84 | Reward Expectancy |
| I *went out of my way* to admire the beauty around me | .78 | .69 | | .77 | Effort Valuation |
| Loading on general factor | .66 | .56 | | .85 | |
| Positive Feedback | $\alpha = .78$ | $\alpha = .69$ | $\alpha = .71$ | $\alpha = .81$ | |
| I *looked forward* to hearing feedback on my work | .77 | .69 | | .72 | Reward Anticipation |
| I *worked hard* to earn positive feedback on my projects | .74 | .73 | | .82 | Effort Valuation |
| Receiving praise about my work made me feel pleased *for the rest of the day*[b] | .72 | .57 | | .78 | Reward Satiation |
| Loading on general factor | .89 | .85 | | .83 | |
| Hobbies | $\alpha = .81$ | $\alpha = .69$ | $\alpha = .86$ | $\alpha = .80$ | |
| I *actively pursued* activities I thought would be fun | .78 | .75 | | .74 | Effort Valuation |
| I *put energy* into activities I enjoy | .83 | .69 | | .77 | Effort Valuation |
| A fun activity during the weekend sustained my good mood *throughout the new week*[b] | .72 | .61 | | .77 | Reward Satiation |
| Loading on general factor | .90 | 1.00[c] | | .95 | |
| Social Interactions | $\alpha = .88$ | $\alpha = .84$ | $\alpha = .88$ | $\alpha = .88$ | |
| I *looked forward* to spending time with others | .90 | .85 | | .85 | Reward Anticipation |
| I *wanted* to participate in a fun activity with friends | .80 | .82 | | .84 | Reward Valuation |
| I *wanted* to spend time with people I know | .85 | .72 | | .84 | Reward Valuation |
| Loading on general factor | .83 | .79 | | .86 | |
| Goals | $\alpha = .71$ | $\alpha = .66$ | $\alpha = .70$ | $\alpha = .80$ | |
| I *wanted* to accomplish goals I set for myself | .67 | .68 | | .78 | Reward Valuation |
| I *felt pleased* when I reached a goal I set for myself | .74 | .68 | | .88 | Initial Responsiveness |
| I *expected* to master the tasks I undertook | .66 | .57 | | .65 | Reward Expectancy |
| Loading on general factor | .91 | .81 | | .79 | |
| Total | $\alpha = .94$ | $\alpha = .91$ | $\alpha = .93$ | $\alpha = .95$ | |

[a]Higher loading item in Sample 1 replaced with item that loaded more strongly in Sample 2. [b]Higher loading item in Sample 1 replaced with item that represented Reward Satiation construct. [c]The variance for this subfactor was constrained to 0 because it originally had a negative residual variance and a correlation of >1 with the general factor.

discussed by the assessment team and diagnostic decisions were reached by consensus.

Inclusion in the depressed group ($n = 34$) required a current diagnosis of MDD. Nondepressed control participants ($n = 42$) reported no past or present psychopathology. Individuals with current substance use disorders (excluding tobacco use disorder), active psychosis, or active suicidal intent were excluded from participating. The groups did not differ in age, $t(74) = 0.26$, $p = .800$, or in sex, race, or ethnicity (all $\chi^2 < 9.33$, all $p > .053$). Interviewers diagnosed participants with *DSM-5* MDD and rated anhedonia severity on a 0 to 8 scale in the ADIS depression module. Participants completed the PVSS-45, as well as the MASQ (described above), as part of a larger questionnaire battery.

## Results

*Preliminary Analyses (Samples 1 and 2).* Participants utilized the full response scale, with no evidence of floor or ceiling effects (see Supplemental Table 1, available online). Frequencies

ratings showed that the vast majority of participants perceived the rewards in the scale as available to them over the previous 2 weeks (S1: $M = 83\%$, $SD = 12\%$, 60% to 100%; S2: $M = 90\%$, $SD = 9\%$, 72% to 100%). Additionally, the U.S. grade level needed to comprehend the PVSS-21 is only 5.61 (between 5th and 6th grades) according to the Flesch Kincaid Grade-level index, indicating that it is easily comprehensible to the majority of readers.

*Factor Analyses (Samples 1 and 2).* To measure model fit, we ran CFAs in M*plus* using maximum likelihood estimation with oblique rotation. As we conceptualized the seven reward-specific subscales as contributing directly to the overall score, we utilized a high-order model in which items were indicators of reward-specific subfactors, and subfactors were indicators of the overall factor. The PVSS-21 showed evidence of good fit in both samples (Table 4, Models 7 and 8). For comparison, we show that a version of the PVSS including only the highest loading items in Sample 1 without substitutions showed essentially identical fit (Table 4, Models 5 and 6). In both samples, PVSS-21 items loaded strongly on the subfactors (S1: ≥.66; S2: ≥.57; Table 6) and formed reliable subscales (S1: $\alpha \geq .71$; S2: $\alpha \geq .66$). Subscales had high loadings on the overall factor, with loadings highest for Hobbies (.90-1.00),[4] Positive Feedback (.85-.89), and Goals (.81-.91) and lowest for Outdoors (.56-.66) in both samples. Reliability of the full scale was high ($\alpha = .91$-$.94$).

We also tested an alternative CFA model including only three reward-specific subfactors (social, physical, and recreational) using the PVSS-45 and the PVSS-21. These CFAs had fit indices below conventional standards (Table 4, Models 9-12) and had poorer fit than the models with seven reward-specific subfactors in both samples (all $\Delta\chi^2 > 712.65$, all $p < .001$). Finally, we tested a bifactor CFA model in which each item loaded directly on a general factor as well as on a specific subscale factor, with all factors constrained to be orthogonal (Reise, 2012). These models did not converge in either sample, likely because the strong relationships between the general factor and subfactors prevented them from being modeled as orthogonal.

*Internal Consistency (Sample 3).* Replicating results from Samples 1 and 2, the PVSS-21 ($\alpha = .93$) and its subscales ($\alpha = .69$-$.88$) were internally consistent in Sample 3 (Table 6).

*Retest Reliability (Sample 2).* An unselected subset of Sample 2 participants repeated the PVSS 2 weeks later. We chose 2 weeks because of the PVSS's 2-week time frame and our goal of testing reliability over a nonoverlapping period of time. The retest coefficient for the total score was high, $r(57) = .83$, $p < .001$. Retest coefficients for the seven subfactors ranged from .55 (Goals) to .91 (Social Interactions; see Supplemental Tables 3-9, bottom, available online).

*Convergent and Discriminant Validity (Samples 1 and 2).* Differences between the PVSS's correlations with convergent and discriminant constructs (Table 5) were examined using tests for dependent correlations, utilizing the absolute value of the correlation (Cohen & Cohen, 1983). In both samples, the PVSS-21 was more strongly associated with reward sensitivity than punishment sensitivity: its correlations were larger with the BAS (.46 to .66) than the BIS (−.17 to −.05), and with the GRAPES Generalized Reward Expectancy subscale (.39 to .55) than the Punishment Expectancy subscale (−.23 to −.05), all $t > 4.23$, all $p < .001$. The PVSS-21 was also more strongly related to positive affect (PANAS-PA; $r = .61$) than negative affect (PANAS-NA; −.40 to −.18) in both samples, both $t > 3.08$, both $p < .002$. In Sample 2, the PVSS-21 was more strongly correlated with BFI Extraversion ($r = .42$) than Neuroticism ($r = -.27$), $t(250) = 2.13$, $p = .034$. In Sample 1, however, the difference between correlations with BFI Extraversion ($r = .52$) and Neuroticism ($r = -.42$) was not significant, $t(163) = 1.48$, $p = .141$.

Evidence for the specificity of the PVSS-21 to positive emotionality vis-à-vis other positive personality traits was mixed. In Sample 1, The PVSS-21 was more highly correlated with BFI Extraversion ($r = .52$) than creativity (CBI-SF, $r = .22$), $t(163) = 3.43$, $p = .001$. It was not, however, more strongly related to Extraversion (.42 to .52) than to either Agreeableness (.40 to .45) or Conscientiousness (.36 to .42), all $t < 1.52$, all $p > .131$.

Finally, we examined correlations with symptom measures. As hypothesized, the PVSS-21 was more strongly correlated with MASQ Anhedonic Depression (−.65 to −.63) than Anxious Arousal (−.29 to −.24) in both samples, both $t > 5.13$, both $p < .001$. While the PVSS-21 was robustly related to depression (−.48 to −.37), the magnitude of these correlations suggests that it was not redundant with depression. The PVSS was only modestly related to social fears (BFNE-S; −.25 to −.13) and unrelated to social desirability (MCSD; S1 = .10).

*Discriminative Validity (Sample 3).* Individuals with MDD scored lower than controls on the PVSS-21, $t(60) = 4.64$, $p < .001$. Mean scores for depressed individuals were around "slightly true of me" ($M = 6.23$, $SD = 1.28$), whereas mean scores for nondepressed controls fell between "moderately true of me" and "very true of me" ($M = 7.45$, $SD = 0.96$). Differences between the two groups were large (Cohen's $d = -1.12$, 95% confidence interval [−1.55, −0.83]). Levene's test for equality of variances indicated greater dispersion of scores among depressed than nondepressed individuals, $F(1, 74) = 5.67$, $p = .020$.

### Incremental Validity

*Samples 1 and 2.* To test whether the PVSS-21 predicted important outcomes over and above existing measures

of positive valence constructs, we conducted hierarchical regression analyses predicting anhedonic depression (MASQ), overall depression (PHQ-9), hypomanic symptoms (HPS-20), and social/occupational impairment (SFQ). For Sample 1, we entered on the first step the set of reward processing measures most highly correlated with the PVSS (BAS total, TEPS: Anticipatory, TEPS: Consummatory, and SHAPS). For Sample 2, we entered all four reward processing measures administered to this sample (BAS total, TEPS: Anticipatory, TEPS: Consummatory, and GRAPES Generalized Reward Expectancy subscale). On the second step, we entered the PVSS-21. Results are shown in Table 7.

The PVSS-21 significantly predicted lower anhedonic depression (both $\beta < -.29$, both $p < .003$) and lower overall depression (both $\beta < -.31$, both $p < .004$) even after controlling for these additional reward measures in Samples 1 and 2. Similarly, the PVSS-21 predicted lower social/occupational impairment over and above these measures ($\beta = -.36$, $p = .001$).[5] By contrast, the PVSS-21 no longer predicted hypomanic symptoms when accounting for these measures ($\beta = -.04$, $p = .755$).

*Sample 3*. We tested associations of the PVSS-21 with self-reported and clinician-rated anhedonic symptoms. The PVSS-21 predicted lower MASQ Anhedonic Depression ($\beta = -.70$, $p < .001$), even after controlling for MDD status ($\beta = -.41$, $p < .001$, $\Delta R^2 = .13$). The PVSS-21 also predicted lower clinician-rated anhedonia severity ($\beta = -.57$, $p < .001$). It continued to predict lower anhedonia severity after controlling for MDD status ($\beta = -.17$, $p = .001$, $\Delta R^2 = .02$), although much less strongly, likely because of the close relationship between anhedonia and MDD status ($r_{pb} = .92$, $p < .001$). Even within the MDD group, individuals with higher PVSS-21 scores had lower anhedonic depression ($\beta = -.69$, $p < .001$) and lower clinician-rated anhedonia severity ($\beta = -.45$, $p = .008$).

*Subscales*. Intercorrelations among the PVSS-21 subscales ranged from .23 to .72 in Samples 1 to 3 (mean intercorrelations = .46 to .53; see Supplemental Table 2, available online), suggesting that the subscales have substantial shared variance, yet are still differentiable.

*Samples 1 and 2*. Correlations of PVSS-21 subscales with convergent and discriminant measures support the validity of the subscales (see Supplemental Tables 3-9, available online). Incremental validity analyses paralleling those for the overall score (Table 7) show that the individual subscales often predicted outcomes beyond the multiple full scales that were included in the analyses as covariates. Several subscales were especially consistent predictors of outcomes (Outdoors, Hobbies, Social Interactions, and Goals), with Hobbies emerging as the most consistent and robust predictor.

To directly compare the subscales, we conducted hierarchical regression analyses with the subscales entered simultaneously as predictors so that they controlled for one another. Anhedonic depression (MASQ) and overall depression (PHQ-9) served as outcomes. In Sample 1, Hobbies ($\beta = -.37$, $p < .001$) and Social Interactions ($\beta = -.28$, $p = .003$) were unique negative predictors of anhedonic depression, whereas Hobbies ($\beta = -.28$, $p < .001$), Goals ($\beta = -.27$, $p < .001$), and Social Interactions ($\beta = -.26$, $p < .001$) were unique negative predictors of overall depression. In Sample 2, Hobbies ($\beta = -.50$, $p < .001$), Goals ($\beta = -.18$, $p = .004$), and Physical Touch ($\beta = -.12$, $p = .044$) were unique negative predictors of anhedonic depression, while only Hobbies ($\beta = -.43$, $p < .001$) remained a negative predictor of overall depression. Surprisingly, in Sample 1 Food positively predicted anhedonic depression ($\beta = .21$, $p = .004$) and overall depression ($\beta = .18$, $p = .001$) in these analyses and the earlier incremental validity analyses.

*Sample 3*. We ran a mixed-model analysis of variance with MDD status as a between-subjects factor and the PVSS-21 subscales as within-subject factors. We found main effects of MDD status and subscales (both $F > 4.01$, both $p < .002$) as well as an interaction indicating that the magnitude of the group difference varied by subscale, $F(1, 4.98) = 3.26$, $p = .007$. The largest differences between depressed and nondepressed individuals were evident for the Hobbies ($d = -1.23$) and Social Interactions ($d = -1.13$) subscales (see Supplemental Figure 3, available online).

## Discussion

In Study 2, we developed a brief version of the PVSS that has a total score representing a strong overall factor and seven subscales representing reward-specific subfactors. The PVSS-21 items were administered to a selected community sample, an unselected student sample, and a clinical sample of individuals with and without MDD. The PVSS-21 exhibited strong factorial validity, internal consistency, retest reliability, and convergent and discriminant validity. The PVSS-21 also predicted anhedonic depression, overall depression, and functional impairment over and above existing reward processing measures. Finally, the PVSS-21 showed promise as a clinical measure, discriminating depressed from nondepressed individuals and predicting anhedonia severity even among depressed individuals. Adding to the promise of the overall score, the PVSS-21 subscales also evidenced convergent, discriminant, and incremental validity. The informativeness of the subscales was suggested by their different patterns of associations with clinical outcomes, with Hobbies (and to a lesser extent, Social Interactions, Goals, and Outdoors) showing particular sensitivity to reward deficits in depression.

**Table 7.** Incremental Validity for Positive Valence Systems Scale, 21 Items (PVSS-21): Total Score and Subscales.

| | Anhedonic depression (MASQ) | | Overall depression (PHQ-9) | | Hypomanic symptoms (HPS-20) | | Social/occupational impairment (SFQ) | |
|---|---|---|---|---|---|---|---|---|
| | β | $\Delta R^2$ | β | $\Delta R^2$ | β | $\Delta R^2$ | β | $\Delta R^2$ |
| Sample 1[a] | | | | | | | | |
| Total | −.30** | .03 | −.34** | .04 | −.04 | <.01 | −.36** | .04 |
| Food | .17* | .02 | .19* | .02 | .05 | <.01 | .14 | .01 |
| Physical Touch | −.11 | .01 | −.15 | .02 | −.06 | <.01 | −.25** | .04 |
| Outdoors | −.25** | .03 | −.22* | .02 | −.04 | <.01 | −.17 | .01 |
| Positive Feedback | −.06 | <.01 | −.01 | <.01 | .05 | <.01 | −.01 | <.01 |
| Hobbies | −.36*** | .06 | −.35*** | .06 | .05 | <.01 | −.33*** | .05 |
| Social Interactions | −.28*** | .04 | −.37*** | .08 | −.10 | .01 | −.35*** | .07 |
| Goals | −.15 | .01 | −.21* | .02 | −.04 | <.01 | −.17* | .02 |
| Sample 2[b] | | | | | | | | |
| Total | −.49*** | .13 | −.32*** | .05 | | | | |
| Food | −.16* | .02 | −.20** | .03 | | | | |
| Physical Touch | −.21** | .02 | −.05 | <.01 | | | | |
| Outdoors | −.22*** | .04 | −.16* | .02 | | | | |
| Positive Feedback | −.20** | .03 | −.16* | .02 | | | | |
| Hobbies | −.50*** | .16 | −.35*** | .08 | | | | |
| Social Interactions | −.27*** | .06 | −.12 | .01 | | | | |
| Goals | −.28*** | .06 | −.15* | .02 | | | | |

| | Anhedonic depression (MASQ) | | Overall depression (PHQ-9) | | Hypomanic symptoms (PAI-MAN) | | Social impairment (BADS) | |
|---|---|---|---|---|---|---|---|---|
| | β | $\Delta R^2$ | β | $\Delta R^2$ | β | $\Delta R^2$ | β | $\Delta R^2$ |
| Sample 4[c] | | | | | | | | |
| Total | −.14 | .01 | −.05 | <.01 | .32* | .04 | −.06 | <.01 |
| Food | .02 | <.01 | .02 | <.01 | .17 | .02 | .06 | <.01 |
| Physical Touch | .01 | <.01 | .11 | .01 | <.01 | <.01 | <.01 | <.01 |
| Outdoors | −.15* | .01 | −.10 | .01 | .26* | .04 | −.09 | .01 |
| Positive Feedback | −.02 | <.01 | .06 | <.01 | .29** | .06 | .15 | .02 |
| Hobbies | −.33*** | .05 | −.28* | .03 | .26* | .03 | −.17 | .01 |
| Social Interactions | .03 | <.01 | .05 | <.01 | .05 | <.01 | −.08 | <.01 |
| Goals | −.08 | .01 | −.15 | .02 | .02 | <.01 | −.14 | .01 |
| Sample 4[d] | | | | | | | | |
| Total | −.43*** | .09 | −.20 | .02 | .33** | .05 | −.23* | .02 |
| Food | −.06 | <.01 | −.02 | <.01 | .19 | .02 | .02 | <.01 |
| Physical Touch | −.20* | .03 | −.01 | <.01 | .06 | <.01 | −.12 | .01 |
| Outdoors | −.26** | .05 | −.15 | .02 | .28** | .05 | −.15 | .02 |
| Positive Feedback | −.20** | .03 | −.03 | <.01 | .30** | .07 | .04 | <.01 |
| Hobbies | −.55*** | .18 | −.36*** | .08 | .27* | .04 | −.30** | .06 |
| Social Interactions | −.18* | .02 | −.06 | <.01 | .10 | .01 | −.19* | .02 |
| Goals | −.21** | .03 | −.20* | .03 | .05 | <.01 | −.21* | .03 |

*Note*. MASQ = Mood and Anxiety Symptom Questionnaire; PHQ-9 = Patient Health Questionnaire; HPS-20 = Hypomanic Personality Scale–Short form; SFQ = Social Functioning Questionnaire; PAI-MAN = Personality Assessment Inventory–Mania subscale; BADS = Behavioral Activation for Depression Scale; BAS = Behavioral Activation Scale; TEPS = Temporal Experience of Pleasure Scale; SHAPS = Snaith–Hamilton Pleasure Scale; GRAPES = Generalized Reward and Punishment Expectancy Scale; DARS = Dimensional Anhedonia Rating Scale; MAP-SR = Motivation and Pleasure Scale–Self-report.

[a]Aside from the PVSS-21, measures entered included the BAS total, TEPS: Anticipatory, TEPS: Consummatory, and the SHAPS. [b]Aside from the PVSS-21, measures entered included the BAS total, TEPS: Anticipatory, TEPS: Consummatory, and the GRAPES Reward subscale. [c]Aside from the PVSS-21, measures entered included the SHAPS, DARS, and the MAP-SR. [d]Aside from the PVSS-21, measures entered included the SHAPS and DARS. Given the high correlation between the PVSS-21 and the MAP-SR, the MAP-SR was excluded from these analyses.

*$p < .05$. **$p < .01$. ***$p < .001$.

There were several exceptions to the robust findings described above. First, while the PVSS-21 was more strongly related to positive than negative affect in Samples 1 and 2, it was more strongly related to extraversion than neuroticism only in Sample 2. Interestingly, extraversion and neuroticism were themselves highly correlated in Sample 1 ($r = -.53$). These results highlight that the PVSS-21, like most clinical measures, has significant associations with adverse outcomes like neuroticism even though it is typically more strongly related to convergent constructs.

Additionally, we found mixed results for specificity to positive emotionality versus other positive personality traits. The PVSS-21 was more strongly related to extraversion than creativity, but was not more strongly related to extraversion than agreeableness or conscientiousness. Finally, the PVSS-21 did not predict responses to hypomanic symptoms on the HPS-20 over and above existing reward measures. This may be due to low levels of hypomanic symptoms in our sample and consequent range restriction ($M = 6.4$, $SD = 4.63$; scores can range from 0 to 20). Alternatively, this may be due to the HPS-20's focus on personality traits congruent with hypomania instead of state-like symptoms of clinically significant hypomania. A final possibility is that the PVSS may be more sensitive to reward processing disruptions in depression than hypomania.

## Study 3: Validation of the PVSS-21 as a Stand-Alone Measure

As the PVSS-21 items were administered as part of the PVSS-45 in Study 2, in Study 3 we tested the PVSS-21 as a stand-alone measure. To further diversify the types of samples in which the PVSS was tested, we recruited an unselected community sample. Study 3 gave us the opportunity to evaluate the PVSS-21 in relation to newer reward processing measures, and to clarify ambiguous results from Studies 1 and 2 by retesting the relationships of interest in an independent sample.

### Method

*Participants.* Sample 4 included 266 participants recruited from MTurk. All participants completed the PVSS-21 and a measure of general depression (PHQ-9); 140 participants also completed convergent and discriminant measures. The same quality control procedures applied to MTurk participants in Sample 1 were applied to Sample 4, resulting in the exclusion of 50 participants with invalid data. Sample 4 had a relatively higher percentage of males (58.6%) but a similar racial and ethnic profile as Sample 1 (Table 2). More participants reported minimal ($n = 145$) than mild ($n = 67$) or moderate ($n = 54$) depression symptoms on the PHQ-9.

#### Measures for Validity Testing

*Convergent measures*. *Reward processing.* To test the PVSS-21's relationship to newer measures of PVS constructs, we included the MAP-SR ($\alpha = .93$) and the DARS ($\alpha = .92$), both described in the Introduction and summarized in Table 1. Due to the strong relationship between the PVSS and the SHAPS in Sample 1 and the SHAPS' strong performance in incremental validity analyses, we also included this measure ($\alpha = .90$).

*Positive emotionality.* Due to ambiguous results in Study 2 regarding the stronger relationship of the PVSS-21 to extraversion versus neuroticism, we readministered BFI Extraversion ($\alpha = .92$) and Neuroticism ($\alpha = .91$).

*Mood symptoms*. As in the previous studies, we assessed overall depression (PHQ-9; $\alpha = .90$) and anhedonic depression (MASQ Anhedonic Depression; $\alpha = .96$). To further probe the relationship of the PVSS-21 with hypomanic symptoms, we included a different measure of hypomanic symptoms: the Personality Assessment Inventory–Mania subscale (PAI-MAN; Morey, 2007). Individuals rated the extent to which core characteristics of hypomania, including elevated activity level, grandiosity, and irritability, described them ($\alpha = .90$).

*Contact with rewarding stimuli*. We included the Behavioral Activation for Depression Scale (BADS; Kanter, Mulick, Busch, Berlin, & Martell, 2007) Activation subscale ($\alpha = .87$) to measure the extent to which participants engaged in activities consistent with their goals over the previous week.

*Social/occupational impairment*. In Study 2, we assessed overall social/occupational impairment with the SFQ. In Study 3, we separated these components by including a measure of occupational and educational impairment (BADS Work/School Impairment subscale, $\alpha = .88$) and a measure of social impairment (BADS Social Impairment subscale, $\alpha = .89$).

*Discriminant measures.* As in the previous studies, we assessed anxiety symptoms characterized by hyperarousal using the MASQ Anxious Arousal subscale ($\alpha = .96$). We also assessed BFI Agreeableness ($\alpha = .85$) and Conscientiousness ($\alpha = .87$) to reexamine the PVSS-21's ability to discriminate reward responding from other positive personality traits.

### Results

#### Factor Analysis

*Higher order CFA*. A higher order CFA in M*plus* with the same parameters as in Study 2 showed evidence of good fit (Table 4, Model 13) comparable to the fit demonstrated in Study 2. PVSS-21 items loaded strongly on the subfactors ($\geq .58$; Table 6) and formed reliable subscales ($\alpha = .77$-$.88$) which, in turn, loaded highly on the overall factor. As in Study 2, Hobbies loaded very highly on the overall factor

**Table 8.** Bifactor Confirmatory Factor Analysis Loadings for the Positive Valence Systems Scale, 21 Items (PVSS-21) in Sample 4.

| Item | General factor | Specific factor |
|---|---|---|
| Food | $\omega = .80$ | $\omega_{hs} = .35$ |
| I *expected* to enjoy my meals | .57 | .59 |
| I *looked forward* to an upcoming meal | .59 | .62 |
| I *savored* my first bite of food after feeling hungry | .51 | .28 |
| Physical Touch | $\omega = .88$ | $\omega_{hs} = .27$ |
| It *felt good* to have physical contact with someone I felt close to | .70 | .37 |
| I *expected* to enjoy being hugged by someone I love | .68 | .65 |
| Getting a hug from someone close to me made me happy *even after* we parted | .71 | .37 |
| Outdoors | $\omega = .85$ | $\omega_{hs} = .23$ |
| I *was delighted* to catch a breath of fresh air outdoors | .66 | .51 |
| I *expected* to enjoy a brief moment outdoors | .72 | .41 |
| I *went out of my way* to admire the beauty around me | .68 | .35 |
| Positive Feedback | $\omega = .82$ | $\omega_{hs} = .24$ |
| I *looked forward* to hearing feedback on my work | .63 | .31 |
| I *worked hard* to earn positive feedback on my projects | .63 | .51 |
| Receiving praise about my work made me feel pleased *for the rest of the day* | .68 | .43 |
| Hobbies | $\omega = .83$ | $\omega_{hs} = .11$ |
| I *actively pursued* activities I thought would be fun | .70 | .17 |
| I *put energy* into activities I enjoy | .72 | .55 |
| A fun activity during the weekend sustained my good mood *throughout the new week* | .75 | .11 |
| Social Interactions | $\omega = .88$ | $\omega_{hs} = .23$ |
| I *looked forward* to spending time with others | .73 | .47 |
| I *wanted* to participate in a fun activity with friends | .73 | .44 |
| I *wanted* to spend time with people I know | .71 | .39 |
| Goals | $\omega = .82$ | $\omega_{hs} = .30$ |
| I *wanted* to accomplish goals I set for myself | .58 | .60 |
| I *felt pleased* when I reached a goal I set for myself | .69 | .51 |
| I *expected* to master the tasks I undertook | .58 | .28 |
| | $\omega_h = .94$ | |

*Note.* $\omega$ = coefficient omega; $\omega_{hs}$ = coefficient omega hierarchical subscale; $\omega_h$ = coefficient omega hierarchical.

(.95). Unlike Study 2, in which Outdoors had the lowest loading, Food had the lowest loading in Study 3 (.72). Reliability for the full scale was high ($\alpha = .96$). Once again, the CFA model including seven subfactors evidenced better fit than a model including only three reward-specific subfactors ($\Delta\chi^2 = 431.50$, $p < .001$), which had fit indices that fell below conventional standards (Table 4, Model 14).

*Bifactor CFA.* Next, we tested a bifactor CFA model in which items loaded on both a general factor and reward-specific subfactors, with all factors constrained to be orthogonal. Contrary to the results in Samples 1 and 2, this bifactor model did converge in Sample 4 (Table 4, Model 15) and demonstrated essentially identical fit as the higher order model (Model 13). Factor loadings (Table 8) showed that almost all items loaded more strongly on the general than the specific factors. Coefficient omega ($\omega$), a reliability estimate that reflects variance from both the total and subscale scores, was high for each subscale (.82-.88; Rodriguez, Reise, & Haviland, 2016b). Omega hierarchical ($\omega_h$), which estimates the proportion of variance attributed to the general factor, was also high (.94). Omega hierarchical subscale coefficients, estimating the proportion of variance attributed to subscale scores after controlling for the variance due to the general factor, were low and ranged from .11 (Hobbies) to .35 (Food). These coefficients reflected the previously described finding that Hobbies had the strongest relationship, and Food the weakest relationship, to the overall scale score in this sample. These results indicate that, in this sample, most subscale variance can be attributed to the general factor, with modest additions from the reward-specific subfactors.

*Convergent and Discriminant Validity.* As in Study 2, the PVSS-21 was more strongly related to MASQ Anhedonic Depression ($r = -.66$; Table 5) than Anxious Arousal, $r = -.03$; $t(137) = 7.91$, $p < .001$, and was related to, but not redundant with, overall depression on the PHQ-9 ($r = -.37$). The PVSS-21's correlation with BFI Extraversion ($r = .45$) was marginally higher than its correlation with

Neuroticism, $r = -.31$; $t(137) = 1.83$, $p = .069$, but no higher than its correlation with Agreeableness ($r = .53$) or Conscientiousness ($r = .34$), both $t < 1.13$, both $p > .259$.

*Incremental Validity.* We examined associations of the PVSS-21 with anhedonic depression (MASQ), overall depression (PHQ-9), hypomanic symptoms (PAI-MAN), and functional impairment (BADS) after accounting for the reward measures included in this study (SHAPS, DARS, and MAP-SR; Table 7). Due to the high correlation between the PVSS-21 and MAP-SR in this sample ($r = .76$), the PVSS-21 did not significantly predict anhedonic depression or overall depression when all three reward measures were included as covariates. With the MAP-SR excluded, the PVSS-21 was the strongest predictor of anhedonic depression ($\beta = -.43$, $p < .001$), predicting over and above the SHAPS ($\beta = -.19$, $p = .037$) and DARS ($\beta = -.18$, $p = .019$). With the MAP-SR excluded, the PVSS-21 also marginally predicted overall depression above and beyond the remaining measures ($\beta = -.20$, $p = .080$), with an effect size equal to the DARS ($\beta = -.20$, $p = .048$) and greater than the SHAPS ($\beta = -.10$, $p = .367$).

Only the PVSS-21 significantly predicted higher hypomanic symptoms ($\beta = .32$, $p = .020$) after accounting for the three other reward processing measures. However, neither the PVSS-21 nor any other reward measure significantly predicted lower work/school impairment with the other measures in the model, all $\beta < -.22$, all $p > .087$. Although the PVSS-21 significantly predicted lower social impairment ($\beta = -.23$, $p = .036$) over and above the SHAPS ($\beta = -.20$, $p = .068$) and DARS ($\beta = -.18$, $p = .048$), it no longer predicted social impairment when the MAP-SR was also in the model.

*Subscales.* Intercorrelations among the PVSS-21 subscales ranged from .44 to .71, with a mean of .59 (see Supplemental Table 2, available online). As in Study 2, correlations with convergent and discriminant measures (see Supplemental Tables 3-9, available online) supported the validity of the subscales. Incremental validity analyses (Table 7) showed that several individual subscales predicted anhedonic depression, social impairment, and hypomanic symptoms beyond the SHAPS and DARS, and to some extent beyond the MAP-SR as well. Similar to Study 2, subscales that were especially consistent predictors of outcomes included Hobbies, Outdoors, and Goals, with Hobbies serving as the most consistent and robust predictor.

We also directly compared the subscales by entering them as predictors of anhedonic depression (MASQ) and overall depression (PHQ-9) simultaneously so that they controlled for one another. As in Study 2, Hobbies remained a strong, unique predictor of lower anhedonic depression ($\beta = -.63$, $p < .001$) and overall depression ($\beta = -.39$, $p = .002$). Contrary to Study 2, Social Interaction was not a unique predictor of either outcome (both $\beta < -.05$, $p > .709$), whereas Outdoors uniquely predicted lower anhedonic depression ($\beta = -.19$, $p = .026$).

## Discussion

In Study 3, we tested the PVSS-21 as a stand-alone measure in an independent sample. As in Study 2, the higher order factor structure demonstrated good fit and both the full scale and its subscales were internally consistent. Further replicating Study 2, Hobbies loaded especially highly on the overall factor and remained a significant predictor of both anhedonic depression and overall depression when controlling for the other subscales. Goals and Outdoors were also robust predictors of clinical outcomes.

Although the bifactor model did not converge in Study 2, it did converge in Study 3, and the higher order and bifactor models demonstrated nearly identical fit. The bifactor model confirmed prior evidence of the PVSS's strong general factor by showing that items loaded more highly on the general factor than on the subfactors. As can be expected when items load strongly on a general factor, the reliability coefficients for the subscales were low when controlling for the general factor (Rodriguez et al., 2016b); such coefficients tend to be low because they represent the variance remaining after accounting for the general factor and are therefore residualized variables (Rodriguez, Reise, & Haviland, 2016a). By contrast, subscale reliabilities were high when both the general and specific factors were considered together. Last, the model clarified that much of each subscale's variance can be attributed to the general factor, although specific variance contributes to the score as well.

Overall, as in Study 2, the PVSS-21 was more strongly related to anhedonic depression than anxious arousal and was associated, but not redundant, with general depression. The PVSS-21 shared a marginally stronger association with extraversion than neuroticism. The pattern was similar to Study 2, wherein correlations appeared higher with extraversion than neuroticism in Samples 1 and 2, but the difference reached significance only in Sample 2. As in Sample 1, extraversion and neuroticism were highly correlated in the present sample ($r = -.55$), raising questions about the differentiability of these constructs as assessed by the BFI. Finally, as in Study 2, the PVSS-21 was not more strongly related to extraversion than to agreeableness or conscientiousness, suggesting that the PVS constructs captured by the scale are meaningfully related to other positive personality constructs.

The PVSS-21 significantly predicted anhedonic depression and social impairment, and marginally predicted overall depression, even when accounting for the DARS and SHAPS. The PVSS-21 was a particularly robust predictor of anhedonic depression relative to these scales. However, its prediction of these outcomes fell to nonsignificance

when accounting for the MAP-SR. Importantly, the PVSS-21 significantly predicted hypomanic symptoms when accounting for the MAP-SR as well as the DARS and SHAPS, underscoring its value beyond existing reward processing measures and supporting its relevance to hypomania as well as depression. None of the reward measures predicted work/school impairment when accounting for the other measures, perhaps reflecting unique occupational characteristics of MTurk workers, who were engaging in a work task by completing the survey.

## General Discussion

We developed the PVSS to provide a comprehensive self-report measure of the RDoC PVS domain. The PVSS assesses the constructs in this domain in relation to a diverse array of primary and secondary rewards in social, physical, and recreational categories. We first developed a 45-item scale that measured each PVS construct in relation to all reward categories, selecting items that loaded highly on the strong overall factor. Results across two samples supported the reliability and validity of the PVSS-45, but revealed that its one-factor model did not adequately represent the scale's heterogeneous content. Based on these results, we developed a 21-item scale, further selecting items to represent the reward-specific subfactors that emerged in the community and student samples. The PVSS-21 includes seven reward-specific subscales (Food, Physical Touch, Outdoors, Positive Feedback, Hobbies, Social Interactions, and Goals) in addition to the overall score. Each subscale is represented by three items, and the total scale includes at least three items for each construct retained across the 2011 and 2018 versions of this RDoC domain. The higher order factor structure of the PVSS-21 demonstrated good fit in three distinct samples, and extensive tests in these samples provided strong support for its validity. While the reported analyses focus on the PVSS-21 due to its stronger factorial validity and shorter length, the PVSS-45 may be useful to researchers who are interested in administering items that reference only a subset of PVS domains.

Participants found the PVSS to be clear, relevant, and easy to complete. The rewards assessed were rated as generally available to participants over the previous 2 weeks. Retest reliability was high over a 2-week interval, and both the overall scale and the subscales demonstrated high internal consistency. The PVSS-21 was more strongly related to reward sensitivity than punishment sensitivity, to positive affect than negative affect, and to anhedonic depression than anxious arousal. It was unrelated to social desirability, minimally related to social fears, and associated—but not redundant—with overall depression severity. Importantly, the PVSS-21 robustly discriminated persons with and without MDD and was strongly related to clinician-rated and self-reported anhedonia, even when controlling for depression status. The PVSS-21 exhibited strong incremental validity as well, in many cases predicting symptom and functional outcomes over and above other available reward processing measures.

Our findings demonstrate that the PVSS-21 is best conceptualized as a scale measuring individual differences in responding to rewards, with an overall factor that comprises differences in responding to specific reward types that are closely related (as represented by a higher order factor model). This is in contrast to a scale in which the subscales account for substantial additional variance over and above the general factor (as represented by a bifactor model; Chen, West, & Sousa, 2006; Reise, 2012). All three studies provided evidence for a strong overall factor, and Study 3 further showed that the reward-specific subscales include more variance from the general factor than the specific factors. These findings support the use of the overall score as a global measure of reward responding. At the same time, given evidence for the reliability and validity of the subscales, these scores can be used by researchers or clinicians who wish to examine the types of rewards that contribute most to prediction of outcomes.

Despite its strengths, the PVSS-21 has several other limitations. First, its correlations with hypomanic personality traits were small to moderate. After controlling for other reward measures, the PVSS-21 no longer predicted hypomanic traits in Sample 1, although it was the only measure to continue predicting hypomanic traits after controlling for other reward measures in Sample 4. Second, while the PVSS-21 consistently demonstrated larger correlations with extraversion than neuroticism, this difference did not always reach statistical significance, perhaps owing to the strong relationship between extraversion and neuroticism. Additionally, while the PVSS-21 was more strongly related to extraversion than creativity, it was not more strongly related to extraversion than to other positive personality traits such as agreeableness and conscientiousness. Third, one reward measure, the MAP-SR, outperformed the PVSS-21 in several incremental validity analyses in Sample 4. Importantly, however, the MAP-SR has its own limitations, including its lack of differentiation of reward types and PVS constructs, its restriction to social and recreational rewards, its aggregation of responses over the past week and upcoming weeks, and its limited psychometric data at present.

### *Utility of the PVSS*

Given rising interest in reward processing abnormalities as a clinical feature and potential risk factor for a range of mental disorders, the PVSS may be useful to a growing number of researchers. The PVSS is especially timely as RDoC becomes a more influential model for understanding psychopathology in general and reward processing in particular. While the RDoC matrix includes "self-report" as a

unit of analysis, some PVS constructs are not assessed by any self-report measure, and most measures map poorly onto current construct definitions. By contrast, the PVSS-21 provides excellent content coverage of the RDoC PVS domain. It includes three to four items for each PVS construct, as well as three items per reward type. Thus, although the subscales are organized by reward types rather than PVS constructs based on results of factor analyses, the total scale provides balanced representation of PVS constructs and reward types, with responses to each PVS domain contributing to the total score.

A further advantage of the PVSS is its assessment of responses to positive stimuli without reference to feelings of depression, making it appropriate for transdiagnostic research. The PVSS is therefore an answer to calls to develop self-report measures that map directly onto RDoC dimensions and can be used for transdiagnostic investigations of psychopathology. The PVSS's prediction of clinically relevant anhedonia, and the large impact of anhedonia on functioning and treatment, suggests that the scale may also be useful in clinical settings. For example, PVSS scores could be utilized to recommend reward-focused treatment for depression (Craske, Meuret, Ritz, Treanor, & Dour, 2016).

The utility of the PVSS is enhanced by its assessment of responses across a wide range of reward types. While other PVS measures include assessment of multiple rewards, we are unaware of any other scale in which reward types were derived analytically rather than through a priori groupings. For example, the DARS asks individuals to rate items that have already been grouped into "pastimes/hobbies," "foods or drinks," "social activities," and "sensory experiences." Similarly, the MAP-SR asks individuals to rate pleasure from "being with other people," pleasure from "hobbies, recreation, or from work," and so on. The DARS, unlike the MAP-SR, includes subscales derived from these item groups. The DARS and the PVSS-21 are the only PVS measures that allow for measurement of responses by reward type, and the PVSS-21 is the only measure that assesses a wide range of reward types grouped using empirically-based methods.

The PVSS-21 reward-specific subscales have a number of potential uses. First, they can help investigate which reward experiences are most strongly associated with mental health outcomes. In our studies, Hobbies, Outdoors, and Goals emerged as particularly strong predictors of outcomes, with Hobbies being the most robust and consistent predictor. These results suggest that research into reward responding in depression, as well as treatments targeting these processes, may wish to focus on responding to leisure and goal-oriented activities. Second, the subscales can used to quantify the magnitude of the disturbance in clinical populations by reward type. Our analyses showed that depressed individuals had particularly low ratings relative to healthy individuals on Hobbies and Social Interactions, a finding with some prior support (Olino, Silk, Osterritter, & Forbes, 2015; Rizvi et al., 2015). Third, clinicians could use the subscales to identify the extent to which responses to particular types of rewards are impaired for particular patients, thereby informing treatment planning.

### *Implications for the RDoC Positive Valence Systems Domain*

The present findings have two main implications for the organization of the RDoC PVS domain. First, they add to a growing body of work demonstrating that the PVS constructs are not differentiable by self-report. The PVS constructs are listed separately in the RDoC matrix based on evidence suggesting that they map onto differentiable neural units (Liu et al., 2011). However, as noted in the Introduction, few neurobiological studies have directly compared the PVS constructs or examined the associations between them. By contrast, several questionnaire studies using multiple measures of reward processing and/or positive emotionality have found positive valence dimensions to be highly correlated (Naragon-Gainey & Watson, 2014; Naragon-Gainey, Watson, & Markon, 2009; Stanton & Watson, 2015; Watson, Stasik, Ellickson-Larew, & Stanton, 2015) or to have strong relationships with an overarching factor (Olino et al., 2018). Questionnaires that directly assess PVS constructs have yielded similar findings: the ACIPS and DARS provide weak differentiation of the constructs they assess (Gooding & Pflum, 2014; Rizvi et al., 2015). Although the TEPS distinguishes anticipatory from consummatory pleasure, this differentiation was achieved by purposely retaining items with low intercorrelations after finding that the two constructs were strongly related (Gard et al., 2006). The close relationships between positive valence constructs in past studies and in the present research highlight the need for further investigation into the structure of the PVS, as well as of other RDoC domains. The available data, however, suggest that participants do not readily distinguish PVS constructs via self-report, even when, as in the present study, they are encouraged to attend to these differences.

Second, our results indicate that although self-reported responses to rewards are characterized by a strong overall factor, they vary based on reward type. This suggests that, at least at the self-report level, the RDoC PVS domain may be better organized by reward type than by reward construct. Not only are reward types not reflected in the current RDoC matrix, but they have not traditionally been incorporated into behavioral paradigms that are used to assess PVS constructs. These paradigms mainly test individuals' responses to small monetary rewards, which may have limited ecological validity and may also miss the types of rewards (e.g., hobbies, social interactions) that most strongly distinguish clinical from nonclinical populations. Fortunately, new work is beginning to examine different

types of rewards (Dutra, Cunningham, Kober, & Gruber, 2015; Olino et al., 2015), and further investigation—facilitated by measures like the PVSS that explicitly assess responses to a wide range of appetitive stimuli—could help inform the development of potent, nonmonetary behavioral paradigms.

Importantly, while current evidence suggests that RDoC PVS constructs are not differentiable at the self-report level, this does not imply that the constructs themselves are invalid. Instead, these results underscore the need for psychometric studies that test differentiability of PVS constructs at multiple levels of analysis (e.g., neural, behavioral). At the same time, growing evidence that the PVS constructs are poorly differentiated by self-report invites more fundamental questions about how the RDoC framework should be evaluated and what evidence would suggest the need for changes to its structure or content. A useful analogy may be offered by another classification of psychopathology, the *DSM*. Like *DSM-5*, RDoC is a product of expert consensus guided by available theory and research on (putatively) distinct constructs. Scales are routinely developed to assess *DSM* disorder constructs, and research evaluating the construct validity and factor structure of these scales has sharpened understanding of the constructs themselves (Clark & Watson, 1995), leading to improved classification (cf. Yufik & Simms, 2010). In a similar vein, developing scales that carefully operationalize RDoC dimensions, and rigorously evaluating their construct validity, can help advance understanding of the dimensions and suggest improvements to the RDoC framework. This is especially the case if multiple measures, assessing the dimensions at different units of analysis, reveal consistent discrepancies between the framework and the data.

### *Limitations*

This research had several limitations. First, we based definitions of the PVS constructs (and therefore item wording) on the RDoC matrix, seeking additional guidance from the research literature and from experts in the field. However, there is not yet consensus on precise operational definitions of the RDoC constructs, meaning that some judgment was required when writing items. Of note, although we based item wording on the 2011 RDoC PVS matrix, construct definitions were very similar to those in the 2018 matrix and items did not require revisions to fit the newer definitions. Second, the PVSS-21's reward-specific subfactors were found to include substantial portions of variance belonging to a strong general factor. This finding may diminish the value of the PVSS-21 subscales, as they do not account for substantial additional variance over and above the general factor. Nevertheless, evidence for the validity of a higher order factor model, coupled with the high reliability of the subscales when all sources of variance were considered, suggests that the subscales can still be used to understand how responses to particular rewards contribute to individual differences in reward processing. Third, each PVSS-21 subscale includes only three items. We selected high-loading items that together provided an adequate level of reliability; consequently, the correlations among items were high.

Fourth, we did not test the PVSS in relation to behavioral measures of reward processing, given feasibility concerns, limited research supporting their validity, and their measurement of only one PVS construct and reward type. Future research aimed at evaluating behavioral measures and examining their relationships to the PVSS would be of value. Fifth, the subsample for estimating the retest coefficient was relatively small, although even at this sample size the 95% confidence interval was favorable (.73-.90). Sixth, given our focus on depression, we selected samples based on depression scores and restricted symptom measures to depression, anxiety, and—to a lesser extent—hypomania. Future studies should examine measures of clinically significant mania as well as other disorders involving abnormal responses to positive stimuli. Relatedly, future research should clarify the extent to which individuals with conditions involving cognitive impairment (e.g., schizophrenia; Schultze-Lutter, 2009) have difficulty imagining how they would have felt had they experienced the rewards in the PVSS over the prior 2 weeks. Finally, while there is extensive research examining anhedonia as a decrease in positive valence processes, anhedonia is also listed as a behavior under the "loss" construct of the RDoC negative valence systems domain (NIMH, 2011a). This discrepancy highlights the complex, multifaceted nature of anhedonia and the gaps that remain in our understanding of it.

Despite these limitations, the PVSS is the first measure of an RDoC domain with strong evidence of reliability and validity across diverse samples. It offers a powerful tool for probing the nature and correlates of positive valence processes, with the potential to advance understanding of depression and other conditions in which these processes are disrupted.

## Authors' Note

Portions of this work were included in a paper presented at the Association for Behavioral and Cognitive Therapies Annual Convention in October 2016.

## Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

## Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: This

work was supported by a Psychology Department research grant and the Virginia A. Roswell Student Dissertation Award, both awarded to Gabriela Kattan Khazanov. Further support was provided by R01 MH094425 awarded to Ayelet Meron Ruscio.

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## Supplemental Material

Supplemental material for this article is available online.

## Notes

1. Two items that performed poorly in the first pilot study were excluded from the second pilot study, so the second pilot study included a total of 72 items.
2. We retained the Action Selection items in the PVSS-45 to facilitate measurement of all possible constructs considered to be important to reward responding in this longer scale (Ridderinkhof, Van Den Wildenberg, Segalowitz, & Carter, 2004).
3. The 2011 PVS domain lists Reward Expectancy and Anticipation under one broad construct, but we measured them separately because of their theoretical differences and because they have been investigated as separate constructs (Gard et al., 2006; Greenberg et al., 2015). The 2018 PVS domain lists these as separate constructs.
4. In Sample 2, the variance of Hobbies was constrained to 0 to enable model identification as this subscale originally had a negative residual variance and a correlation greater than 1 with the general factor.
5. Measures of functional impairment and hypomanic symptoms were only administered to Sample 1. In Sample 1, the SHAPS also continued to predict lower anhedonic depression ($\beta = -.43$), overall depression ($\beta = -.48$), and social/occupational impairment ($\beta = -.43$) when controlling for the other reward processing measures, and the BAS continued to predict lower anhedonic depression ($\beta = -.27$). In Sample 2, the GRAPES Reward subscale continued to predict lower anhedonic depression ($\beta = -.31$) and overall depression ($\beta = -.28$) when controlling for the other reward processing measures.

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