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Sluggish Cognitive Tempo and Positive Valence Systems: Unique Relations with Greater Reward Valuation but Less Willingness to Work.

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Abstract

Background: Research has started conceptualizing sluggish cognitive tempo (SCT) within the Research Domain Criteria (RDoC), but no study has tested SCT symptomatology in relation to the positive valence systems.

Methods: Participants (N = 4,679; 18–29 years; M = 19.08, SD = 1.36; 69% female; 80.9% White) enrolled in six universities in the United States completed self-reported measures of positive valence systems, SCT, and psychopathology dimensions.

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Contributors

A.S. and J.F conceived of the study, conducted analyses, and drafted the manuscript. AL helped interpret findings and draft the manuscript. S.B., L.B., A.G., M.J., & M.K., provided feedback on the manuscript.

AUTHOR DECLARATION

We wish to confirm that there are no known conflicts of interest associated with this publication and there has been no significant financial support for this work that could have influenced its outcome.

We confirm that the manuscript has been read and approved by all named authors and that there are no other persons who satisfied the criteria for authorship but are not listed. We further confirm that the order of authors listed in the manuscript has been approved by all of us.

We confirm that we have given due consideration to the protection of intellectual property associated with this work and that there are no impediments to publication, including the timing of publication, with respect to intellectual property. In so doing we confirm that we have followed the regulations of our institutions concerning intellectual property.

Declarations of interest: none

Results: SCT symptoms were uniquely associated with greater reward valuation and expectancy of reward, but less willingness to work for reward. SCT symptoms were not uniquely related to initial and sustained response to reward. Conversely, depressive symptoms remained uniquely associated with greater reward valuation but less expectancy, willingness to work, initial, and sustained response to reward.

Limitations: The present study included a relatively homogenous sample of college-age students, solely relied on self-report measures of the positive valence systems, and analyses were conducted cross-sectionally.

Conclusions: Findings demonstrated that SCT has unique relations with various components of the positive valence system while controlling for commonly co-occurring psychopathology dimensions. Future research should continue investigating relations between SCT and positive valence systems to understand whether these domains may be targets for prevention and intervention.

Keywords

approach motivation; comorbidity; emerging adulthood; positive valence systems; Research Domain Criteria; sluggish cognitive tempo

Sluggish cognitive tempo (SCT), characterized by excessive daydreaming, inconsistent alertness, and underactive behavior, represents a collection of symptoms that are uniquely related to others forms of psychopathology and considerable functional impairment (Becker et al., 2016). Although there has been an increased consensus regarding a unified set of SCT symptoms (Becker et al., 2016), there remain questions regarding how to conceptualize SCT within larger classification systems of mental illness (Becker & Willcutt, 2019). Recently, the National Institute of Mental Health started an initiative, the Research Domain Criteria (RDoC) framework project, to identify general underlying psychobiological features of psychopathology across multiple levels of analysis. The RDoC framework consists of six domains that may be implicated in the etiology and co-occurrence of psychopathology (e.g., negative valence systems, positive valence systems, arousal/regulatory systems, cognitive systems, social processes, and sensorimotor systems). Although SCT symptoms have been conceptualized within certain RDoC systems (Becker & Willcutt, 2019), the positive valence systems have been largely overlooked. The present study addresses this limitation by testing relations between SCT and the positive valence systems in a large sample of college students.

Sluggish Cognitive Tempo

Although originally viewed as overlapping with attention-deficit/hyperactivity disorder inattentive (ADHD-IN) symptomatology, numerous studies demonstrate that SCT is unique from, yet highly related to, ADHD-IN across childhood, adolescent, and young adult samples (see Becker et al., 2016 for a review). Additionally, SCT is strongly associated with, but distinct from, internalizing symptomatology (Becker et al., 2018a). Within the internalizing domain, SCT appears to have the strongest association with, but remains unique from, depressive symptomatology (Becker et al., 2014; Kamradt, Momany, &

Nikolas, 2018). Despite the bulk of research being conducted with youth, SCT is common and associated with negative psychological, social, and academic impairment in young adults (Flannery, Becker, & Luebbe, 2016; Wood, Lewandowski, Lovett, & Antshel, 2017). Specifically, SCT symptoms are uniquely related to heightened risk for suicidal behavior (Becker, Holdaway, & Luebbe, 2018c), emotion dysregulation (Flannery et al., 2016; Jarrett et al., 2017), poor sleep quality (Becker, Luebbe, & Langberg, 2014b), social problems (Flannery et al., 2016), and poor academic functioning (Becker et al., 2014; Wood, Potts, Lewandowski, & Lovett, 2017). Collectively, there is convincing evidence that SCT in young adults undermines functioning across several domains, even when controlling for ADHD and related psychopathologies.

Despite research supporting the construct validity of SCT, there remains a lack of consensus on the best way to conceptualize SCT (Becker & Willcutt, 2018). Previous research has suggested that SCT may represent a specifier for ADHD (Carlson & Mann, 2002) or may be a separate psychiatric disorder that frequently co-occurs with ADHD (Barkley, 2012). More recently, some have contended that SCT may function as a transdiagnostic construct implicated in the development, associated impairments, and comorbidity of psychopathologies (Becker et al., 2016). This transdiagnostic conceptualization fits within the RDoC as the purpose is to begin conceptualizing mental illnesses via a dimensional, rather than categorical, approach by identifying underlying features of mental illness that may cut across multiple disorders (Sanislow et al., 2010).

Positive Valence Systems

The goal of the RDoC framework is to catalogue how differential functioning across multiple levels of analysis (e.g., biological, observation, self-report) and across several domains of functioning contribute to the development of psychopathology (Sanislow et al., 2010). To date, the negative valence, cognitive, and arousal/regulatory systems have received attention with respect to SCT (Becker & Willcutt, 2019). How SCT may fit within the positive valence systems has been overlooked. This poses a significant limitation in the literature as it prevents a complete understanding of SCT within the RDoC framework, and reward functioning is a critical indicator of psychological adjustment (Olino, 2016). Specifically, positive emotions are theorized to accelerate the reduction of negative emotions, broaden cognition, build interpersonal resources, and promote resilience and well-being (Fredrickson & Joiner, 2018). Collectively, investigating SCT within the context of the positive valence systems will provide further information on an important, yet overlooked, domain of functioning.

Within the RDoC matrix, approach motivation (reward valuation, expectancy, willingness to work, action selection), initial response, sustained response, and reward learning are the proposed key components of the positive valence systems. These systems correspond to psychobiological aspects responsible for the initial value placed on, pursuit of, response to, maintenance of, and habitual learning of rewarding situations or experiences (Olino, 2016). *Reward valuation* describes the value an individual places on rewarding experiences, *expectancy* involves the anticipation of experiencing reward, and *willingness to work* describes an individual's effort and motivation to obtain rewards (Fussner, Mancini, &

Luebbe, 2017; Olino, 2016). Finally, *initial response* is similar to in-the-moment reward responsiveness, whereas *sustained response* involves the duration of rewarding experiences following the receipt of a reward (Olino, 2016). The positive valence systems map onto similar constructs in other theoretical models of personality, including the reward valuation, willingness to work, and general reward responsiveness domains of the Behavioral Activation System (i.e., the BIS/BAS; Carver & White, 1994). However, the positive valence system provides a comprehensive approach to testing reward functioning, by including reward expectation and disentangling initial from sustained responses to reward (Olino, 2016).

SCT and Positive Valence Systems

Indirect evidence suggests a potential link between SCT and positive valence systems. First, as mentioned above, numerous studies have documented considerable overlap of SCT with depressive and inattentive symptomatology across multiple samples (Becker et al., 2016). In turn, depressive, and less so inattentive symptoms, are strongly associated with deficits in several aspects of reward functioning (Fredrick, Mancini, & Luebbe, 2019b; Meinzer et al., 2012). Depressive symptomatology has long been characterized by deficits in reward functioning (Fredrick et al., 2019b). Specifically, research shows that depressive symptoms are linked with reduced anticipation of reward (Sherdell, Waugh, & Gotlib, 2012), willingness to obtain reward (Fussner et al. 2018), and sustained respond following a reward (Fussner, Luebbe, & Bell, 2015). Recent research also shows that individuals with depression place excessive valuation on reward which may have paradoxical effects for reward functioning (Gentzler et al., 2019). Finally, studies demonstrate that inattentive symptomatology is associated with diminished reward responsiveness (Meinzer et al., 2012; Mitchell & Nelson-Gray, 2006) and willingness to work for reward (Becker et al., 2018b). In sum, SCT symptomatology may be associated with disrupted reward functioning given the strong relations between depression, and less so inattention, with reward functioning. Of course, it is also possible that the link between SCT and potential deficits in reward functioning might disappear when controlling for inattentive and depressive symptomatology.

The unique relation between SCT and any aspect of the positive valence systems has only been tested twice. First, Becker et al. (2013) found parent-reported reward responsiveness, measured by the Sensitivity to Punishment and Sensitivity to Reward Questionnaire (SPSRQ-C), to be unrelated to SCT symptoms in a sample of school-aged children (Becker et al., 2013). This was then extended to a large, multisite sample of young adults, in which SCT was unrelated to reward responsiveness or willingness to work, but was uniquely related to greater fun seeking behavior as measured by the Behavioral Activation System (BIS/BAS; Carver & White, 1994) (Becker et al., 2018b). Fun-seeking, or openness to try new things and craving excitement (Carver & Whote, 1994), has been compared to the reward valuation domain in the positive valence systems (Olino, 2016). Becker and colleagues (2018b) suggested that greater fun-seeking behaviors (e.g., misusing substances) possibly result in SCT characteristics (e.g., sleepy, lethargic). Indeed, experimental research has found shortened sleep to contribute to increased SCT symptoms (Becker, Epstein et al., 2019). The conflicting findings across these two studies may be a result of age differences in

the sample and/or different measurements of positive valence systems. Further studies are needed that more comprehensively examine constructs within the positive valence systems. Likewise, differences in the measurement of SCT may explain divergent results given that the Becker et al. (2013) study used a handful of items included on a broadband rating scale of child behavior whereas Becker et al. (2018b) used an SCT-specific rating scale developed based on meta-analytic findings. Additional studies are needed, and the current study used the same measure and sampling frame as the Becker et al. (2018b) study to allow for more direct comparisons.

Present Study

The present study overcomes previous limitations in the literature by testing the relation between SCT and multiple domains of the positive valence system in a large sample of young adults. A sample of young adults is important given research documenting heightened rates of SCT symptoms in college students (Flannery et al., 2016; Jarrett et al., 2017). Depressive, inattentive, and hyperactive-impulsive symptoms were included as covariates to identify unique relations between SCT symptoms and the positive valence systems. Like Becker and colleagues (2018b), we measured drive (i.e., willingness to work), but we also assessed reward valuation, expectancy, and separated initial from sustained response to test multiple components of the positive valence system. Although a complete test of the positive valence systems would include additional units of analyses (e.g., behavioral, genetic), the focus of the present study was to extend previous research to help understand the relation between SCT and the positive valence system at the self-reported symptom level.

The present study had two major aims. First, the study examined bivariate relations between SCT symptoms and various aspects of the positive valence systems. It was expected that SCT would be significantly correlated with greater reward valuation, and less expectancy, willingness to work, initial response, and sustained response. This hypothesis was supported by research finding significant bivariate relations between SCT symptoms and greater fun seeking, lower willingness to work, and reduced reward responsiveness (Becker et al., 2018b). Due to the lack of research on SCT and reward expectancy directly, this hypothesis was guided by previous research showing depressive symptomatology to be related with reduced anticipation of rewards (Sherdell, Waugh, & Gotlib, 2012). Second, the study tested whether SCT symptoms are uniquely associated with various aspects of the positive valence system while controlling for other psychopathology symptoms. Following research showing that SCT symptoms are uniquely related to greater fun-seeking behaviors and unrelated to willingness to work and initial response (Becker et al., 2018b), it was hypothesized that SCT symptoms would be uniquely related to greater reward valuation, but not uniquely related to willingness to work and initial response to reward. There were no specific hypotheses made for whether SCT symptoms would be uniquely associated with reward expectancy and sustained response as these facets have yet to be tested in previous research.

Method

Participants

Participants included 4,679 undergraduates enrolled in six universities in the United States. Five of the six universities are large, public universities located in various regions, with the sixth university being a private institution in the Midwest. Participants' ages ranged from 18 to 29 years (M = 19.08, SD = 1.36). Of participants, 69.8% identified as female, 30% as male, and 0.2% as other. The majority of participants identified as White (80.9%), others identified as either Black/African American (7.1%), Asian (6.2%), Biracial/Multiracial (4.8%), American Indian/Alaska Native (0.5%), or Native Hawaiian/Other Pacific Islander (0.2%). Further, 10% of participants identified as Hispanic or Latino. More than half of participants were in their first year of college (58.3%), with others in their second (21.8%), third (12.5%), and fourth or later (7.1%) year of college. Around 65% of participants reported a family income greater than $50,000. Finally, participants reported lifetime diagnoses of a depressive disorder (12.6%, n = 588) and attention deficit disorder (ADD) or ADHD (9.1%, n = 424).

Procedure

This study was approved by the local Institutional Review Board (IRB) at each university. Five of the sites administered an online Qualtrics survey, while students at the sixth university provided informed consent in-person and then completed the same online Qualtrics survey on their own. Participants across all universities were granted course credit for participation. Debriefing information was provided at the end of the survey.

Measures

SCT symptoms.—The Adult Concentration Inventory (ACI; Becker et al., 2018a) is an adult self-report measure of SCT that includes 10 items that distinguish SCT from ADHD-IN and internalizing symptoms. These symptoms (e.g. "I am slow at doing things;" "My mind feels like it is in a fog") were rated on a four-point scale (0 = *not at all*, 1 = *sometimes*, 2 = *often*, 3 = *very often*) in reference to the past six months. The ACI has been used with college students and has demonstrated strong internal consistency and discriminative validity in relation to other psychopathologies (Becker et al., 2018a; Fredrick et al., 2019a). In the present study, internal consistency was good (α = .88).

ADHD symptoms.—The 18 item Barkley Adult ADHD Rating Scale-IV (BAARS-IV, Barkley, 2011) was used to evaluate ADHD symptoms. Participants responded to items in reference to how often each statement best describes their behavior over the past six months using a four-point scale (0 = *not at all*, 3 = *very often*). The BAARS-IV includes two 9-item subscales: inattentive (IN) (e.g., "I have difficulty organizing tasks and activities;" α = .88) and hyperactive/impulsive-type (HI) (e.g., "I fidget with hands or feet or squirm in seat;" α = .81). These subscales have demonstrated adequate internal consistency and test-retest reliability and have been used widely with adults (Barkley, 2011).

Depressive symptoms.—The 7-item *depression* subscale of the Depression Anxiety Stress Scales-21 (DASS-21; Antony, Bieling, Cox, Enns, & Swinson, 1998; Lovibond &

Lovibond, 1995) was used to assess depressive symptoms. Participants responded to each item (e.g., "I was unable to become enthusiastic about anything;" α = .90) in reference to the past week using a four-point scale (0 = *did not apply to me at all*, 3 = *applied to me very much or most of the time*). The DASS-21 demonstrates high reliability and is widely accepted as valid for use with college-aged participants (Antony et al., 1998).

Reward valuation.—The 7-item Valuing Happiness Scale (VHS; Mauss, Tamir, Anderson, & Savino, 2011) assessed the extent to which individuals value happiness. Items (e.g. "To have a meaningful life, I need to feel happy most of the time;" α = .75) are rated on a scale from 1 (*strongly disagree*) to 7 (*strongly agree)*. The VHS has documented adequate internal consistency (Mauss et al., 2011) and convergent validity with measures assessing individuals' valuation of positive emotions (Ford, Shallcross, Maus, Floerke, & Gruber, 2014).

Expectancy.—The *anticipating* subscale of the Savoring Beliefs Inventory (SBI; Bryant, 2003) and the *anticipation* subscale of the Temporal Experience of Pleasure Scale (TEPS; Gard, Gard, Kring, & John, 2006) were each used to evaluate reward expectancy. Both subscales were designed to assess individuals' reported ability and tendency to experience pleasure while anticipating future positive experiences (Bryant, 2003; Gard et al., 2006), and were highly correlated in the present study ($r = .70$, $p < .001$). The SBI anticipatory subscale includes 8 items (e.g., "I feel a joy of anticipation when I think about upcoming good things;" α = .83) rated on a 7-point scale (1= *strongly disagree*, 7 = *strongly agree*), while the TEPS-anticipation subscale includes 9 items (e.g., "I look forward to a lot of things in my life;" α = .85) rated on a 6-point scale (1 = *very false for me*, 6 = *very true for me*). A composite was calculated by first standardizing and then averaging the SBI-anticipation and TEPS-anticipation items. The anticipation subscales of both the SBI and TEPS have documented convergent validity with measures of extraversion and reward seeking (Bryant, 2003; Gard et al., 2006).

Willingness to work.—The 4-item *drive* subscale of the Behavioral Inhibition System/ Behavioral Activation System (BIS/BAS) Scales was used to assess willingness to work towards pleasurable and rewarding stimuli (Carver & White, 1994). The extent to which individuals attempt to obtain reward (e.g., "I go out of my way to get things I want;" α = . 78) is rated on a four-point scale (1= *strongly disagree*, 4 = *strongly agree*). The BAS scales have demonstrated adequate internal consistency, convergent, and discriminative validity (Carver & White, 1994; Johnson, Turner, & Iwata, 2003).

Initial response.—The *savoring the moment* subscale of the SBI (Bryant, 2003) and the Dispositional Positive Emotion Scale (DPES; Shiota, Keltner, & John, 2006) were used to assess participants' self-reported initial response to rewarding experiences. The savoring the moment subscale includes 8 items regarding beliefs about savoring positive experiences (e.g., "It's easy for me to enjoy myself when I want to;" α = .78). The DPES includes 38 items measured on a 7 point-scale (1 = *strongly disagree*, 7 = *strongly agree*). Participants report on their tendency to experience a variety of positive emotions (e.g., "I am an intensely cheerful person;" α = .96). The two subscales were highly correlated ($r = .83$, $p < .001$) and

a composite was calculated by averaging the standardized SBI-savoring the moment score and DEPS-total score. The SBI-savoring the moment and DPES have documented strong internal consistency and each are related to indicators of positive affectivity (Bryant, 2003: Hurley & Kwon, 2013; Shiota et al., 2006).

Sustained response.—The 9-item *positive rumination* scale of the Response to Positive Affect Scale (RPA; Feldman, Joormann, & Johnson, 2008) was used to assess individuals' reported responses that enhance and maintain positive experiences. Research provides support for using a composite of self- and emotion-focused rumination subscales (Nelis et al., 2016). Items (e.g., "Think about how happy you feel;" $\alpha = .89$) are rated on a four-point scale (1 = *almost never*, 4 = *almost always)*. This subscale has demonstrated adequate internal consistency and discriminative validity (Feldman et al., 2008).

Analytic Approach

Data quality check.—We used an instructional manipulation check (IMC; Oppenheimer, Meyvis, & Davidenko, 2009), trap questions (e.g., "Please click on the response „sometimes'"), and a question measuring the participants' reported effort in order to ensure quality responses. The IMC asked the participant to select a specific answer, which they were required to answer correctly, in order to proceed with the survey. We designated a threshold of 50% accuracy or higher for the trap questions and an effort rating of 5 or higher on a 0 to 10 scale (0 = *not much effort*, 10 = *my best effort)*.[1] Of a total of 4955 participants, 4679 (94%) met designated criteria.

Primary Analyses.—A planned missingness design was applied to the present study to limit participant burden because data in the present study were part of a larger battery of measures. A three-form design was used. All participants completed data on a set of measures (typically called an X block). In the current study, SCT, depression, ADHD, and BAS-drive items were administered in the X block. Then, participants were randomized into one of three groups, each receiving approximately two-thirds of remaining positive valence systems measures distributed in a manner such that each variable ended up with approximately 33% missing data (see Little & Rhemtulla, 2013). Little's MCAR test (Little, 1988) suggested that data were missing in a pattern consistent with missing completely at random given the non-significant result, $\chi^2(46) = 51.57$, $p = .27$. To account for missing data, multiple imputation with 40 imputations was used (Graham, 2009) with participant demographics, psychopathology symptoms, and positive valence systems used in the algorithm to generate the imputations.

Bivariate correlations were conducted to test relations between SCT and commonly co-occurring psychopathologies with domains of the positive valence system. Because there were only nine participants who identified as "other" when asked about sex, these individuals were not included in preliminary bivariate analyses. In order to not exclude these individuals from the sample, two dummy-coded vectors were created for primary analyses, with female as the reference group. Because multiple imputation was applied to handle

[1]All primary analyses described below were conducted with the full sample as well as a sample that had 100% accuracy on all trap questions. Coefficients remained nearly identical to those presented in text, with no changes in significance.

missing values, unstandardized regression coefficients are presented in Table 2. Squared semi-partial correlations were calculated as a measure of effect size. Five separate multiple regression analyses were conducted, with each facet of the positive valence system as the outcome measure. A Bonferroni adjustment (.05/5 = .01) was applied given the number of regressions conducted. Age, sex, and race were entered as covariates, in addition to self-reported depressive, ADHD-IN, ADHD-HI, and SCT symptomatology. Race was coded as a dichotomous variable (0 = ethnic/racial minority; 1 = White).

Results

Are SCT symptoms bivariately related to aspects of the Positive Valence Systems?

All study variables were normally-distributed. Table 1 displays correlations among all primary study variables. Age, sex, and race were significantly correlated with aspects of the positive valence systems and were therefore included as covariates in subsequent analyses. Regarding aim 1, SCT symptoms were significantly, bivariately correlated with greater reward valuation, though with less willingness to work, expectancy, initial response, and sustained response. Note that effect sizes for these bivariate correlations were small in magnitude. Similarly, ADHD-IN and depressive symptoms were significantly correlated with greater reward valuation, though with less willingness to work, expectancy, initial response, and sustained response. For ADHD-IN, with the exception of initial response which had a moderate effect size, all other effects were small. For depression, effect sizes were small to moderate, with the effect for initial response being large. Finally, the majority of the positive valence systems were significantly interrelated and had small effect sizes, with the exception of large relation of reward expectancy to initial reward.

Are SCT symptoms uniquely related to aspects of the positive valence systems?

Reward valuation.—Depressive symptoms were uniquely associated with greater reward valuation (sr^2 = .19, p < .001). SCT symptoms were also uniquely associated with greater reward valuation (sr^2 = .09, p < .001), whereas inattentive symptoms were unrelated to reward valuation.

Expectancy.—Depressive (sr^2 = −.20, p < .001) and inattentive (sr^2 = −.08, p < .001) symptoms were related to lower expectancy. Conversely, and differing from bivariate results, SCT symptoms (sr^2 = .07, p < .001) were uniquely related to *greater* reward expectancy.

Willingness to work.—Depressive (sr^2 = −.14, p < .001), inattentive (sr^2 = −.06, p < .001), and SCT (sr^2 = −.04, p = .01) symptoms were each uniquely associated with less willingness to work for rewarding experiences.

Initial response.—Depressive (sr^2 = −.37, p < .001) and inattentive (sr^2 = −.08, p < .001) symptoms were associated with lower initial response to reward. SCT symptoms were not uniquely related to unrelated to initial response to reward (sr^2 = .01, p = .59)

Sustained response.—Depressive (sr^2 = −.10, p < .001) and inattentive (sr^2 = −.06, p < .001) symptoms were uniquely associated with lower sustained response. Conversely, SCT

(sr^2 = .01, p = .51) symptoms were not uniquely related to higher sustained response to reward.

Discussion

Previous research has investigated ways of conceptualizing SCT within certain systems in the RDoC framework (Becker & Willcutt, 2019); however, no study has examined whether SCT is uniquely related with components of the positive valence system. In a large, multi-site sample of young adults, our results showed that SCT symptoms, while controlling for demographics and commonly co-occurring psychopathologies, were uniquely related with greater self-reported reward valuation and expectancy, but less willingness to work for reward. Although SCT was associated bivariately with lowered self-reported initial and sustained response to reward, it was unrelated to these constructs in multivariate analyses. These findings provide evidence of unique relations between SCT symptoms and various domains of reward functioning.

Bivariate relations of SCT and positive valence systems

The first goal of the study was to examine bivariate relations of SCT with the positive valence systems. Additionally, commonly co-occurring psychopathology symptoms were tested in relation to the positive valence systems. A similar pattern of results emerged; specifically, SCT, inattentive, and depressive symptoms were each associated with greater reward valuation but less willingness to work, lowered expectancy, less initial response, and less sustained response to reward. To our knowledge, this is just the second study to examine SCT in relation to multiple aspects of adult reward functioning. Becker and colleague's (2018b) study of SCT and reward functioning found that SCT was bivariately related to greater fun-seeking behavior, less willingness to work, and reduced reward responsiveness. Findings from the present study provide additional domains of reward functioning that may be disrupted for individuals with SCT symptoms; specifically, less reward expectancy and sustained response to reward.

Notably, the magnitude of effect sizes for depressive symptoms and positive valence systems were generally stronger compared to inattentive and SCT symptoms. These findings are consistent with a large body of research demonstrating disruptions in reward functioning as a hallmark feature of depressive symptomatology (Fredrick et al., 2019b; Fussner et al., 2018). Additionally, findings for inattentive symptoms are consistent with research demonstrating relations with less willingness to work and reward responsiveness (Becker et al., 2018b; Meinzer et al., 2012), though past research has found non-significant bivariate relations with reward valuation (Becker et al., 2018b). These findings provide novel evidence that inattentive symptoms are also bivariately correlated with less reward expectancy and sustained response. Overall, bivariate results suggest that SCT shares common deficits in reward functioning with both inattentive and depressive symptomatology.

Is SCT uniquely related to aspects of the positive valence systems?

Before interpreting SCT and psychopathology results from the regression analyses, it is important to note demographic factors that were uniquely associated with positive valence

systems. Although not a focus of the present study, participants identifying as White reported less reward valuation and willingness to work, but greater reward expectancy and initial response. Moreover, male participants, compared to participants identifying as female or other, reported greater reward valuation, willingness to work, and less reward expectancy and initial response. These findings are consistent with past evidence demonstrating cultural (Leu, Wang, & Koo, 2011) and sex (Gard et al., 2006) differences in the experience, expression, and regulation of positive emotions.

Findings from correlational analyses demonstrated associations with positive valence systems across depressive, inattentive, and SCT symptomatology. Due to the considerable overlap of these psychopathologies (Becker et al., 2016), it is possible that significant correlations among SCT and positive valence systems are attributable to the overlap with these psychopathologies. Therefore, it is important to identify unique contributions to each of the positive valence system facets. Indeed, SCT symptoms were not uniquely associated with initial or sustained response to reward experiences when controlling for demographics and co-occurring symptomatology, consistent with previous research (Becker et al., 2018b). However, SCT *was* uniquely related with greater reward valuation and expectancy, as well as less willingness to work for reward, though it should be noted that the magnitude of these effects were small.

This pattern of results raises the question of why SCT is uniquely related to some, but not all aspects of the positive valence system. Two related patterns emerged that may provide insight. First, the aspects related to SCT require relatively more cognitive input (compared to affective or behavioral) compared to other aspects of the positive valence systems, and second, these aspects all fall under the general domain of approach motivation (Olino et al., 2016). SCT symptoms were uniquely related with greater valuation and expectancy, suggesting potential overlap with attentional/cognitive components of the positive valence system. Findings for reward expectancy suggest that the unique feature of SCT, perhaps mind-wandering and daydreaming, is associated with greater reward expectancy. Possibly, individuals with SCT symptoms have a tendency to daydream and become lost in an upcoming positive experience. However, caution should be made when interpreting the finding for expectancy given that the direction of effect flipped from bivariate to multivariate analyses and effect sizes were relatively small. In addition, the magnitude of these effect sizes for SCT and positive valence systems were small, suggesting the importance of additional studies before conclusions about theoretical and clinical significance can be made.

Second, SCT symptoms were uniquely associated with positive valence systems that are theorized to capture approach motivation (i.e., valuation, expectancy, and willingness to work; Olino, 2016). Although SCT symptoms are associated with greater valuation and expectancy of reward, these symptoms are also related with *less* willingness to work. Before interpreting this finding, it is important to note that the previous study using the same measurement of willingness to work did not find a significant relation (Becker et al., 2018b) and effect sizes for this finding were small in the present study. A potential alternative interpretation of these findings, given the small effect sizes, is that SCT and positive valence systems are independent. Nevertheless, it is possible that the slow/lethargic components of SCT (Becker et al., 2016) undermine the motivation to obtain rewards. Or, individuals with

SCT symptoms experience paradoxical effects of regularly thinking and expecting rewards but lowered desire to seek rewards.

Findings from the present study also demonstrate unique disruptions in the positive valence systems for depressive and inattentive symptoms. Depressive symptoms remained uniquely associated with all aspects of the positive valence system (i.e., greater reward valuation and lower scores on all other positive valence system constructs). This finding is consistent with numerous studies identifying relations between depressive symptomatology and less anticipation of reward, disrupted motivation to seek reward, and reduced initial and sustained response to reward across diverse populations (Fredrick et al., 2019b, Fussner et al. 2018; Whitton, Treadway, & Pizzagalli, 2015). Emerging research documents associations between overvaluation of reward and depressive symptomatology (Gentzler et al., 2019), suggesting that excessive valuation of happiness may have unintended effects. Finally, inattentive symptoms were uniquely associated with less self-reported reward valuation, expectancy, willingness to work, and initial and sustained response to reward, although the strength of these effect sizes were noticeably smaller compared to those for depressive symptoms. Previous research shows that inattentive symptoms are uniquely associated with reduced reward responsiveness (Meinzer et al., 2012; Mitchell & Nelson-Gray, 2006) and willingness to work for reward (Becker et al., 2018b).

In sum, our findings indicate that SCT symptoms have similar bivariate patterns of relations with reward functioning compared to co-occurring psychopathologies, but also show unique relations over and above these other symptoms. Specifically, SCT symptoms were uniquely related with the reward valuation, expectancy, and willingness to work domains, each of which involve self-reported behaviors associated with achieving reward. Conversely, SCT symptoms were not uniquely related to self-reported responses to and following reward attainment.

Limitations and Future Directions

Results should be interpreted in light of study limitations. First, analyses were conducted cross-sectionally, limiting inferences regarding causality. Future research should investigate whether SCT is prospectively associated with components of the positive valence system while controlling for psychopathologies. Similarly, the strength of the effect sizes for SCT and positive valence systems were small, and prospective designs will help clarify whether these relations remain or are attributable to co-occurring psychopathologies (e.g., depression), as well as clarify possible directionality of associations. In addition, the primary purpose of the RDoC initiative was to identify aberrant systems using multiple units of analysis that influence the development of psychopathologies (Sanislow, 2010). Although findings from the present study provide initial evidence for associations between SCT and the positive valence system, research should align with the RDoC framework by testing whether specific disruptions in the positive valence system prospectively predict or exacerbate SCT and co-occurring psychopathology while using multiple units of analysis (e.g., biological, neural circuitry).

Second, although participants were sampled from six different universities across the U.S., the sample was relatively homogenous. Given the findings that participants identifying with

non-White racial identities reported less reward expectancy and initial response, future research should consider testing these relations across varying racial/ethnic groups. This is important due to notable differences in the socialization of positive emotions across individuals from different cultural backgrounds (Leu et al., 2011). Additionally, future research would benefit from testing these relations in younger samples as SCT symptoms tend to increase following childhood (Leopold et al., 2016) and reward functioning undergoes changes across adolescence (Fredrick et al., 2019b). Finally, the self-report measures used for assessing the positive valence systems was guided by RDoC suggestions and theoretical alignment with positive valence system domains (National Institute of Mental Health, 2012; Olino, 2016). However, it is notable that there is a lack of research examining which measures best tap into the constructs of interest when studying the positive valence system. Future research should consider investigating factor analytic work to identify which self-report measures are effective in assessing positive valence systems and use those to study relations with SCT. Moreover, the sole reliance of self-report measures limits our complete understanding of reward functioning, and future work should test these relations using multiple units of analysis such as behavioral tasks (e.g., Iowa Gambling Task) and neurobehavioral research (see Olino, 2016, for a review).

Conclusion

The present study is the first to demonstrate that SCT symptomatology is uniquely associated with various components of the positive valence system over and above commonly co-occurring psychopathologies. Specifically, SCT symptoms were uniquely related to greater reward valuation and expectancy, but with less willingness to work for rewards. Conversely, SCT symptoms were not uniquely related with initial or sustained responses to rewards. These findings provide evidence for unique relations between SCT symptoms and specific positive valence systems at the self-reported level.

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Highlights

- Large sample of young adults recruited from multiple universities completed self-report measure of SCT, psychopathology symptoms, and various measures of positive valence systems.
- SCT symptoms were uniquely related to greater reward valuation and expectancy, but with less willingness to work for reward.
- SCT symptoms were not uniquely related to initial or sustained response to reward.
- Depressive symptoms remained uniquely associated with greater reward valuation but less expectancy, willingness to work, initial, and sustained response to reward.
- Findings provide evidence for unique relations between SCT symptoms and positive valence systems at the self-reported level.

Table 1.

Correlations, means, and standard deviations for study variables.

	1	2	3	4	5	6	7	8	9	10	11	12
1. Age	-											
2. Sex	−.10**	-										
3. Race	−.10**	.02	-									
4. SCT	−.00	.10**	−.01	-								
5. ADHD-I	.05**	−.02	−.02	.71**	-							
6. ADHD-H/I	.02	.00	.04**	.46**	.54**	-						
7. Depression	.05**	.00	−.04**	.50**	.53**	.31**	-					
8. Reward valuation	−.00	.10**	−.07**	.24**	.18**	.16**	.28**	-				
9. Willingness to work	−.00	−.05**	−.05**	−.09**	−.08**	.12**	−.17**	.03	-			
10. Expectancy	−.09**	.22**	11**	−.07**	−.16**	−.03	−.24**	.06	15**	-		
11. Initial Response	−.07**	.12**	.06**	−.25**	−.31**	−.12**	−.49**	−.11**	19**	.56**	-	
12. Sustained Response	−.01	.03	.02	−.08**	.11**	−.01	−.15**	.03	.13**	.28**	.28**	-
Mean	19.08	--	--	1.20	1.68	1.69	.54	4.40	2.80	4.93	5.10	2.58
SD	1.36	--	--	.59	.54	.50	.61	1.02	.58	.90	1.02	.62

Note. For sex, male = 0, female = 1. For race, 0 = non-White, 1 = White. Age is calculated in years. SCT = sluggish cognitive tempo; ADHD = attention deficit/hyperactivity disorder; I = inattention; H/I = hyperactive/impulsive. Means and SDs are presented from the original data set. Correlations reflect pooled estimates across imputed datafiles.

* $p < .05$,

** $p < .01$.

Table 2

SCT symptoms and the Positive Valence Systems

	b	SE	t	sr^2
DV= Reward Valuation	$F(8, 3107) = 49.60$, $p < .001$, $R^2 = .11$			
Age	−.01	.02	−0.44	−.01
Sex D1	.20	.05	4.31**	.09
Sex D2	.07	.36	.19	.00
Race	−.16	.05	−3.13*	−.06
Depression	.38	.04	8.86**	.19
ADHD-H/I	.15	.04	3.46*	.06
ADHD-I	−.13	.05	−2.55	−.04
SCT	.23	.05	4.99**	.09
DV = Expectancy	$F(8, 4645) = 94.4$, $p < .001$, $R^2 = .14$			
Age	−.03	.01	−3.00*	−.04
Sex D1	−.41	.03	−13.07**	−.20
Sex D2	.00	.29	.01	.00
Race	.19	.03	5.51**	.08
Depression	−.36	.04	−9.94**	−.20
ADHD-H/I	.12	.04	3.5**	.06
ADHD-I	−.22	.04	−5.83**	−.08
SCT	.15	.03	4.53**	.07
DV = Willingness to Work	$F(8, 4657) = 47.63$, $p < .001$, $R^2 = .08$			
Age	−.00	.00	−0.39	−.01
Sex D1	.06	.02	3.17*	.05
Sex D2	.08	.19	.42	.01
Race	−.10	.02	−4.80**	−.07
Depression	−.16	.02	−10.12**	−.14
ADHD-H/I	.29	.02	14.65**	.21
ADHD-I	−.10	.02	−3.94**	−.06
SCT	−.06	.02	−2.68*	−.04
DV = Initial Response	$F(8, 4650) = 199.56$, $p < .001$, $R^2 = .26$			
Age	−.02	.01	−2.28	−.03
Sex D1	−.23	.03	−8.24**	−.11
Sex D2	.20	.28	.71	.10
Race	.08	.03	2.64**	.03
Depression	−.70	.02	−29.43**	−.37
ADHD-H/I	.16	.03	5.44**	.07
ADHD-I	−.21	.04	−6.07**	−.08

	b	SE	t	sr^2
SCT	.02	.03	0.54	.01
DV = Sustained Response	$F(8, 3094) = 31.81$, p < .001, $R^2 = .07$			
Age	.00	.01	.38	.01
Sex D1	−.03	.03	−1.23	−.02
Sex D2	.31	.26	1.20	.02
Race	.01	.03	.30	.01
Depression	−.13	.02	−5.99**	−.10
ADHD-H/I	.10	.03	3.70**	.06
ADHD-I	−.12	.03	−3.60**	−.06
SCT	.02	.03	.66	.01

Note. For sex D1, female/other = 0, male = 1. For sex D2, female/male = 0, other = 1. For race, 0 = non-White, 1 = White. Age is calculated in years. SCT = sluggish cognitive tempo; ADHD = attention deficit/hyperactivity disorder; I = inattention; H/I = hyperactive/impulsive. A bonferroni correction was used based on the total number of regressions used. *p = (.05/5) = .01. Overall model statistics are presented from the original data set which included a planned missingness design. The following are the range of F values across the 40 imputed data sets (p < .0xx for all models across all imputations): Reward valuation: $F(8, 4676) = 47.53 – 87.96$; Reward expectancy: $F(8, 4676) = 75.33 – 96.11$; Willingness to work: $F(8, 4676) = 47.66 – 48.13$; Initial response: $F(8, 4676) = 200.32 – 207.47$; Sustained response: $F(8, 4676) = 57.33 – 70.71$.

*p < .01.

**p < .001.