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Physical and Social Anhedonia in Female Adolescents: A Factor Analysis of Self-Report Measures

Xi Yang[1], **Melynda D. Casement**[1,*], **Kate Keenan**[2], **Alison E. Hipwell**[5], **Amanda E. Guyer**[3,4], **Erika E. Forbes**[5]

[1.]Department of Psychology, University of Oregon

[2.]Department of Psychiatry and Behavioral Neuroscience, University of Chicago

[3.]Center for Mind and Brian, University of California, Davis

[4.]Department of Human Ecology, University of California, Davis

[5.]Department of Psychiatry, University of Pittsburgh

Abstract

Anhedonia is a transdiagnostic symptom of psychopathology that includes diminished positive emotions and anticipation and enjoyment of rewards, with particular salience during adolescence. However, the construct validity of anhedonia dimensions is not well established, thus limiting operationalization and generalization of the construct. We applied exploratory and confirmatory factor analyses to identify latent dimensions of anhedonia across four commonly-used self-report measures covering different facets of anhedonic experience within a non-clinical sample of female adolescents across two waves of data collection ($N = 173$, $M_{age} = 19.25$; $N = 147$, $M_{age} = 20.23$). Factor analyses yielded a two-factor model with a physical anhedonia factor emphasizing enjoyment from physical sensations, and a social anhedonia factor focusing on emotional connections with other people. These results have implications for the measurement of anhedonia in women's emotional well-being and mental health research, including research designed to identify facets of anhedonia that predict the onset, severity, and persistence of psychopathology.

Keywords

anhedonia; adolescent; factor analysis; female; PGS

Anhedonia – diminished capacity to experience positive emotions (Kring & Germans, 2000) – is a common transdiagnostic symptom of depression, schizophrenia, substance use disorders, and suicidality (Auerbach et al., 2015; Bonanni et al., 2019; Ritsner, 2014; Shankman et al., 2014). Far from being an epiphenomenon of psychopathology, anhedonia precedes and predicts disorder onset (van Os et al., 1997; Wardenaar et al., 2012), severity (Davidson et al., 2010), prognosis (Crits-Christoph et al., 2018; Leventhal et al., 2014; Uher

*Corresponding author: Melynda Casement, casement@uoregon.edu, 1(541) 346-7051, University of Oregon, Department of Psychology, 1451 Onyx Street, Eugene, OR 97403.

et al., 2012; Wardle et al., 2017), treatment responses (McMakin et al., 2012) and recurrence (Garfield et al., 2014). As a key feature of serious and chronic forms of psychopathology, the construct of anhedonia is critical to understand and validate.

Although multiple facets of anhedonia exist, research linking anhedonia to psychopathology is often based on a limited scope of measurement. Two of the most extensively researched facets of anhedonic experience are physical and social anhedonia. Physical anhedonia has been measured with items such as “I would enjoy a cup of tea or coffee or my favorite drink” and “I would be able to enjoy a beautiful landscape or view” (Snaith et al., 1995), while social anhedonia has been measured with items such as “Just being with friends can make me feel really good” and “I have always enjoyed looking at photographs of friends” (Chapman et al., 1976). More recently, neurobiologically-based models of anhedonia have differentiated anticipatory pleasure from consummatory pleasure, where anticipatory anhedonia is defined as diminished excitement an individual experiences when they anticipate the receipt of a reward, and consummatory anhedonia as reduced enjoyment from receiving a reward (Der-Avakian & Markou, 2012; Shankman et al., 2014; Treadway & Zald, 2011). As described below, each of these facets of anhedonic experience may have differential predictive value and neurobiological mechanisms. However, it is difficult to evaluate the construct validity of anhedonia facets when measurement is limited to a single construct (e.g., physical anhedonia) or dimension (e.g., physical versus social, anticipatory versus consummatory).

Predictive and Construct Validity of Anhedonia Facets

A burgeoning field of anhedonia research provides preliminary evidence that different facets of anhedonia predict different forms of psychopathology and have different neurobiological mechanisms. Representing the largest portion of existing anhedonia research, physical anhedonia is a purported endophenotype of severe major depressive disorder (Shankman et al., 2010), while social anhedonia is a defining characteristic of individuals with schizotypal personality traits (Silvia & Kwapil, 2011) and schizophrenia-spectrum disorders (Kwapil, 1998; Weiser et al., 2007). The differentiation between self-reported physical and social anhedonia is also evidenced with their respective correlations of behavioral and neural measures. In behavioral studies, high levels of self-reported physical anhedonia have been linked with reduction in taste sensitivity (Berlin et al., 1998; Thomas et al., 2013) and enjoyment of positive auditory and visual stimuli (Fitzgibbons & Simons, 1992; Nusbaum et al., 2015). In neuroimaging studies, high physical anhedonia is correlated with hyperactivation in regions that monitor and modulate affective responses, and such hyperactivation may reflect self-evaluative processes (Amodio & Frith, 2006) and/or compensatory responses (Keedwell et al., 2005), which is associated with hypoactivation in reward related regions (Harvey et al., 2007, 2010). In contrast, behavioral studies have linked high social anhedonia with low response bias to social reward (Chevallier et al., 2016) and prosocial tendencies (Llerena et al., 2012; Setterfield et al., 2016). Not surprisingly, compared with low social anhedonia, high social anhedonia also has been linked to varied activity in neural networks for facial expression processing (Germine et al., 2011) and self-other social processing (Denny et al., 2012; Healey et al., 2014), which may contribute to and/or arise from reduced social approach motivation and/or pleasure from social interactions (Germine et al., 2011). Collectively, these data support the claim that physical and social anhedonia are unique aspects of anhedonic experience.

Anticipatory and consummatory anhedonia are also differentially associated with varied forms of mental illness. For example, deficits in anticipatory anhedonia are most commonly associated with depression (Sherdell et al., 2012) and schizophrenia (Gard et al., 2007), whereas deficits in consummatory anhedonia are associated with substance use disorders (Destoop et al., 2019; Garfield et al., 2014) and a potentially more severe subtype of depression - melancholic depression (Fletcher et al., 2015). Self-report questionnaires (Gard et al., 2006; Diane Carol Gooding & Pflum, 2014) and behavioral and behavioral and neural tasks that use different classes of reward probes (Hooker et al., 2014; Pizzagalli et al., 2008) have been used to measure the anticipation of pleasant experiences and savoring of hedonic experiences of physical and social natures, and some convergence exists across the methods (Geaney et al., 2015; Szczepanik et al., 2019). At the neurobiological level, questionnaire measures of anticipatory and consummatory anhedonia are linked with different neural markers of incentive/reward salience and processing (Chen et al., 2018; Szczepanik et al., 2019; Yin et al., 2015). Behaviorally-measured anticipatory anhedonia (e.g., diminished wanting) and consummatory anhedonia (e.g., decreased liking) also have different neural substrates within the nucleus accumbens (Berridge et al., 2009) and frontal-striatal circuitry (Zhang et al., 2016). Although preliminary, these results from multiple measures provide initial evidence that anticipatory and consummatory anhedonia have discriminant predictive validity and unique neurobiological mechanisms.

Anhedonia during Adolescence

Adolescence and young adulthood are associated with a normative increase in reward-seeking and risk taking behavior (Steinberg, 2010), but also with vulnerability to mental health problems related to consummatory anhedonia (Bennik et al., 2014), and increased incidence of anhedonia-related disorders such as depression, schizophrenia, substance use disorders, and suicidality (Twenge et al., 2019). Changes in hedonic experience and reward-related neural systems (Corral-Frías et al., 2015; Davey et al., 2008; Wetter & Hankin, 2009) are proposed mechanisms for the onset of anhedonia-related mental disorders during adolescence and young adulthood, and different facets of hedonic experience may differentially predict the emergence of varied forms of psychopathology during adolescence. For example, the relative importance of social connection in girls versus boys may contribute to the higher incidence of depression in adolescent girls (Jenkins et al., 2002; Nilsen et al., 2013). Therefore, it may be particularly valuable to accurately characterize anhedonia factors during adolescence and young adulthood, and in females specifically.

Previous structural analyses of anhedonic experience in adolescents and young adults provide limited support for distinctions between different anhedonia facets. For example, a confirmatory factor analysis that included multiple measures of hedonic experience in college students (physical, social and consummatory) found support for a general hedonic capacity factor independent of a physical anhedonia measure (Leventhal et al., 2006). A more recent exploratory factor analysis on the broad positive valence system in college students found that multiple anhedonia questionnaires (physical, social, anticipatory, and consummatory) were differentially explained by a general factor along with specific factors of pleasure seeking and sociability (Olino et al., 2018). Furthermore, principal component analyses validating the psychometric properties of single anhedonia scales have failed to find consistent evidence for the distinction between anticipatory and consummatory facets (Gooding et al., 2016; Gooding & Pflum, 2014). These results highlight the need for additional validation of anhedonia factors.

In anhedonia research, when behavioral measures of anhedonia dissect individual behaviors to quantifiable components and neuroscience studies correlate neural anomaly with behaviors and self-reported data of anhedonia (Rizvi et al., 2016), both are attempts to capture the diffuse and transient emotional reactions to rewarding stimuli. While behavioral and neuroscientific data add incremental validity to the identification and understanding of anhedonia, self-report measures still possess tremendous value in clinical science. The armamentarium of self-report measures on anhedonia have been used to provide direct evidence of individuals' experience and characterize clinical phenotypes (Rizvi et al., 2016). Subjective feelings and beliefs about a person's functioning as well as personality prompt people to seek care, and the self-reported measures are screeners for as well as the foundations of clinical diagnoses and measures of treatment efficacy.

The Present Study

The aim of this study was to extend existing literature on latent constructs of anhedonia and further inform validity of these constructs. We used a data-driven approach to identify the major one or two latent variables of anhedonia across seven (sub)scales from four commonly used self-report anhedonia measures within a non-clinical sample of late-adolescent girls who participated in two waves of data collection from the longitudinal Pittsburgh Girls Study-Emotions Substudy (PGS-E; Keenan et al., 2008). Exploratory factor analysis was applied to data collected when girls were 19 years of age (Wave 8), and confirmatory factor analysis was applied to data collected when girls were 20 years of age (Wave 9). The use of EFA and CFA across two waves of data collection was intended to assess replicability of the latent constructs of anhedonia. Understanding anhedonic experience in general, and in adolescent girls in particular, could clarify the facets of anhedonia under the RDoC domains (e.g., the Positive and Negative Valence systems, Social Processes) and inform intervention strategies for adolescents with elevated risk of psychopathology. Given that anhedonia developed at late adolescence has high stability and predictive power of depression (Bennik et al., 2014) and female adolescents are more vulnerable to anhedonia and depression (Nolen-Hoeksema & Girgus, 1994; Wade et al., 2002; Zahn-Waxler et al., 2008), studies of anhedonia among adolescent and young adult women are particularly important for public health research and targeted intervention development.

Method

Participants

Data were derived from participants in waves 8 and 9 of the Pittsburgh Girls Study – Emotions sub-study (PGS-E; Keenan et al., 2008), which is part of the on-going Pittsburgh Girls Study (PGS). PGS participants were recruited when they were between the ages of five and eight based on enumeration of households and oversampling of low-income neighborhoods (Hipwell et al., 2002; Keenan et al., 2010). The PGS-E is a longitudinal substudy of risk for depression beginning at 9 years of age and continuing through early adulthood (*N* = 232; Keenan et al., 2008). PGS-E participants were girls from the youngest cohort of PGS whose scores on a depression measure fell in the upper quartile for the sample, plus a random selection of those scoring below that cut-point, matched on race (Keenan et al., 2008). A battery of anhedonia questionnaires was administered during waves 8 (*N* = 173) and 9 (*N* = 147) of the PGS-E, when participants were approximately 19 and 20 years of age, respectively. Most participants were Black American (69% in wave 8, 73% in wave 9), and the remaining participants were White (23~25%), multiracial (3~5%) or Asian (0~1%). Across wave 8 and wave 9, 131 individuals participated in both waves. PGS-E protocol (IRB: 011167) was approved and monitored by the University of Pittsburgh Institutional Review Board and performed in accordance with relevant guidelines and regulations.

Materials

PGS-E waves 8 and 9 included four widely used measures of anhedonia: the Chapman Revised Anhedonia Scale (Chapman et al., 1976), the Snaith-Hamilton Pleasure Scale (Snaith et al., 1995), the Brief Affective Neuroscience Personality Scale (Davis & Panksepp, 2011) and the Temporal Experience of Pleasure Scale (Gard et al., 2006). Collectively, these measures and their subscales index physical, social, anticipatory, and consummatory anhedonia traits. Each of the first-generation anhedonia measures (Rizvi et al., 2016) was designed to evaluate a different aspect of hedonic experience. The Chapman Revised Anhedonia Scale was initially developed to characterize social anhedonia (Chapman et al., 1976). The Snaith-Hamilton Pleasure Scale was derived as a simple and bias-free measure to capture a wide range of joyful events (Snaith et al., 1995). The Brief Affective Neuroscience Personality Scale was designed to investigate cross-species affective neurobiological systems and we selected the items on the Seeking, Care and Play systems (Davis & Panksepp, 2011). The Temporal Experience of Pleasure Scale was developed based on the accumulation of evidence differentiating consummatory from anticipatory pleasure especially from the neuroscience research (Gard et al., 2006). We sought to evaluate whether latent constructs of anhedonia could be identified across questionnaires that elucidate heterogeneous characteristics of hedonic experience. For the purpose of this study, all items were coded such that higher scores indicate higher levels of anhedonia.

The Chapman Revised Social Anhedonia Scale—The Chapman Revised Social Anhedonia Scale (RSAS) measures characteristics in the experience of nonphysical, interpersonal pleasure (Chapman et al., 1976). It is a 40-item *true (1) – false (0)* scale with adequate reliability and construct validity (Mishlove & Chapman, 1985). Sum scores were computed (ranging from 0 to 40) and a sum score above 16 was suggested as high anhedonia (Kwapil et al., 2002). Example items are “Although there are things that I enjoy doing by myself, I usually seem to have more fun when I do things with other people” and “I don’t really feel very close to my friends”. The internal consistency of the scale in two samples, computed using the Kuder-Richardson 20 test (Kuder & Richardson, 1937), were both .84, which is within the acceptable range.

The Snaith-Hamilton Pleasure Scale—The Snaith-Hamilton Pleasure Scale (SHAPS) assesses the experience and anticipation of a pleasurable experience related to hobbies, social interaction, eating, and physical sensation (Snaith et al., 1995). It is often considered the gold standard for assessing anhedonia in depression (Rizvi et al., 2016). It consists of 14 items on a scale of *definitely agree (1)* to *definitely disagree (4)* with sum scores ranging from 14 to 56[1]. Example items are "I would enjoy a warm bath or refreshing shower" and "I would find pleasure in small things, e.g., a bright sunny day, a telephone call from a friend". The SHAPS has been shown to have high reliability and validity (Nakonezny et al., 2015). In this study, the internal consistency of this scale was high (alpha range = .92 – .94).

The Brief Affective Neuroscience Personality Scale—The Brief Affective Neuroscience Personality Scale (BANPS), which is based on Affective Neuroscience Personality Scale (ANPS), measures behavioral traits that are putatively associated with six affective neurobiological systems (play, seeking, care, fear, rage, and grief) (Barrett et al., 2013; Davis & Panksepp, 2011). It consists of 39 items on a scale of *strongly disagree (1)* to *strongly agree (5)*. It has adequate reliability and construct validity (Barrett et al., 2013). In this study, the play (6 items) (e.g., "I like to kid around with other people"), the seeking (6 items) (e.g., "I enjoy finding new solutions to problems") and the care (4 items) (e.g., " I am the kind of person that likes to touch and hug people") subscales were examined as separate measures of hedonic experience and reverse scored. For each subscale, higher sum scores (ranging from 4 to 30) indicated higher anhedonia. In the present sample, the internal consistencies for the three subscales were Play (alpha range = .73 – .77), Seeking (alpha range = .66 – .68), and Care (alpha range = .58 – .55). Given the small number of items in the subscales, mean inter-item correlations were computed and all subscale values were in the optimal range (.2 – .4) (Briggs & Cheek, 1986): Play (.33 – .37), Seeking (.22 – .25), and Care (.25 – .24).

The Temporal Experience of Pleasure Scale (TEPS)—The Temporal Experience of Pleasure Scale (TEPS) assesses trait dispositions in anticipatory and consummatory physical hedonic experience (Gard et al., 2006). It is composed of 18 items on a scale of *very false for me (1)* to *very true for me (6)*. Eight items are from the consummatory subscale and 10 items are from the anticipatory subscale. Both subscales show average convergent and discriminant validity (Gard et al., 2006; Ho et al., 2015). In this study, the subscales were reverse scored and higher sum scores (ranging from 8 to 60) indicate higher anhedonia. In the present sample, the internal consistency was acceptable for the anticipatory pleasure factor (alpha range = .81 – .76) and consummatory factor (alpha range = .70 – .76).

Statistical Analyses

The factor structure of anhedonia was examined using exploratory factor analysis (EFA) of questionnaire data from PGS-E Wave 8, and confirmatory factor analysis (CFA) of questionnaire data from PGS-E Wave 9. EFA and CFA analyses were conducted among those with Wave 8 data and those with Wave 9 data separately to maximize the sample

Footnote 1.: We adopted the 4-point Likert scale scoring method instead of the simpler method originally proposed (Snaith et al., 1995) to enhance the granularity of the scale. A similar two-factor model was found when the scale was dichotomized.

size for each type of analysis (Wave 8 $N = 173$; Wave 9 $N = 147$). Analyses utilized sum scores from the Play, Seeking and Care subscales of the BANPS (BANPS_Play, BANPS_Seek, BANPS_Care), RSAS total score, SHAPS total score, and sum scores from the anticipatory and consummatory subscales of the TEPS (TEPS_Anti, TEPS_Cons). Reasons for conducting the analyses on a subscale level instead of an item level were two-fold: 1) The correlation matrix on the item level was unfactorable as the majority of the inter-indicator correlations were below .30 (Hair et al., 2014) which may arise from the relatively weak associations between the 40 dichotomous RSAS items and the remaining 48 measure items that use Likert scales, and 2) it is common practice to conduct factor analyses across different measures on a scale level rather than on an item level (e.g., Leventhal et al., 2006; Olino et al., 2018).

Exploratory Factor Analysis—We followed recent guidelines for conducting the EFA (Watkins, 2018). Data were evaluated to be appropriate for EFA because: 18 out of 21 (the total number of 7 × 7 bivariate correlations) inter-indicator correlations exceeded .30 and none of the correlations were lower than .23 (Hair et al., 2014); the dataset had high sampling adequacy [Kaiser-Meyer-Olkin Statistics (KMO) = .84; Kaiser, 1974] with the *REdaS* package (*v0.9.3*; Maier, 2015); and Bartlett's test of sphericity (Bartlett, 1954) suggested that the correlation matrix was factorable, $\chi^2(21) = 366.15$, $p < .001$.

We selected common factor analysis over principal component analysis because our goal was to identify the latent constructs of anhedonia (Fabrigar et al., 1999) rather than reduce the data (Brown, 2015). We conducted parallel analysis (Horn, 1965) and used a scree plot (Cattell, 1966) with the *psych* package (*v1.8.12*; Revelle, 2019) to determine the number of factors to extract. We first used the iterated principal axis estimation [PA; also known as ordinary least squares (OLS), principal factors or MINRES; Watkins, 2018] as it has no distributional assumptions (Cudeck, 2000) and increases the possibility of recovering all major common factors (Briggs & MacCallum, 2003). We then replicated the result with maximum likelihood (ML) estimation.

We also assumed that the factors extracted across the anhedonia measures would be reasonably correlated, so we adopted a promax rotation (Hendrickson & White, 1964). The criterion for determining factor adequacy considering the number of indicators in this study was that each factor has at least three salient indicators with factor loading greater than or equal to .30 (Brown, 2015).

To contrast with a general factor model, we considered a unidimensional model with PA estimation. Model fit comparisons were based on the following standard indicators (Hu & Bentler, 1999; Symonds & Moussalli, 2011): the standardized root mean square residual (SRMR; Joreskog, 1984), the root mean square error of approximation (RMSEA; Steiger, 1990), the comparable fit index (CFI; Bentler, 1990), the Tucker-Lewis index (TLI; Tucker & Lewis, 1973), the Akaike Information Criterion (AIC; Akaike, 1987), the Bayesian Information Criterion (BIC; Schwarz, 1978) and/or the sample size-adjusted BIC (BIC_{adjust}; Sclove, 1987) estimated using the *psych* (*v1.8.12*; Revelle, 2019) and *lavaan* package (*v0.6.5*; Rosseel, 2002). Chi-square tests are provided for completeness. Acceptable values are as follows (Hu & Bentler, 1999; Symonds & Moussalli, 2011): SRMR <= .08, RMSEA

<= .06 (*p* > .05 meaning not rejecting the null hypothesis that RMSEA <= .05) (RMSEA < .10 slightly worse fit; MacCallum et al., 1996), CFI, TLI >= .95 (CFI >= .90 slightly worse fit) and in general, lower AIC, BIC and BIC_{adjust} suggest better model fit; χ^2 *p* > .05 suggests no significant difference between the patterns observed in the raw data and the specified model.

Confirmatory Factor Analysis—We conducted the CFA referencing the work of Brown (2015). Based on the exploratory factor analysis outputs from Wave 8 data, we used ML estimation with two different models on Wave 9 data: Model 1) Factor A measured by indicators of TEPS_Anti, TEPS_Cons, SHAPS, and BANPS_Seek; and Factor B measured by indicators of BANPS_Care, RSAS, and BANPS_Play; Model 2) In addition to allowing Factor A to be measured by indicators of TEPS_Anti and TEPS_Cons and Factor B by indicators of BANPS_Care and RSAS, BANPS_Play, BANPS_Seek and SHAPS were allowed to load on both factors. All analyses were conducted in R (version: 1.2.1206). The full reproducible code and sensitivity analyses excluding potential influential cases are included in the Supplementary Materials.

Results

Descriptive statistics are presented in Table 1 (N_8 = 173, M_{age8} = 19.25, SD_8 = .45; N_9 = 147, M_{age9} = 20.23, SD_9 = .43). Data were normally distributed (Curran et al., 1996) and the anhedonia levels were similar to data reported in other non-clinical samples (Barrett et al., 2013; Gard et al., 2007; Kwapil et al., 2002; Langvik & Borgen Austad, 2019). Bivariate correlation matrixes for Waves 8 and 9 data are presented in the Supplementary Materials (Table 1 and 2). To check sample representativeness, the racial distribution was compared with the chi-square test of independence between the full PGS-E sample (*N* = 232) and the sample in the present study from data collected at Wave 8 (*N* = 173), χ^2 = 1.09, *df* = 2, *p* = 0.578 and Wave 9 (*N* = 147), χ^2 = 2.79, *df* = 2, *p* = 0.248[2]. We also compared the number of years of public assistance receipt from age 5 to age 16 (Romens et al., 2015), a proxy of the family financial status, using Welch two-sample t-tests between the full PGS-E sample and the sample at Wave 8, *t* = −0.04, *df* = 376.49, *p* = 0.968, 95% [−0.72, 0.69], and Wave 9, *t* = −0.52, *df* = 306.92, *p* = 0.606, 95% [−0.96, 0.56][3]. These analyses indicated that Wave 8 and Wave 9 participants' racial distribution and receipt of public assistance were not substantively different from that of the full PGS-E sample, suggesting that the present study included a representative sample of participants from the larger study.

Exploratory Factor Analysis

The parallel analysis and scree plot produced for the factorable correlational matrix both suggested that two factors should be extracted. The two-factor solution was examined for adequacy: Factor A was saliently loaded by the anticipatory and consummatory subscales

Footnote 2.: The racial distribution comparisons between the current study participants and the PGS-E participants who did not complete Waves 8 and 9 showed that fewer Black participants chose to not participate compared to white and mixed race participants: Wave 8, χ^2 = 7.27, *df* = 2, *p* = .026; Wave 9, χ^2 = 11.69, *df* = 2, *p* = .003.

Footnote 3.: The family financial status comparisons between the current study participants and the PGS-E participants who did not complete Waves 8 and 9 showed no significant difference: Wave 8, *t* = −0.098, *df* = 91.28, *p* = .922, 95% [−1.22, 1.10]; Wave 9, *t* = −1.09, *df* = 180.85, *p* = .276, 95% [−1.51, .43].

from the TEPS, the SHAPS, and the seek subscale from the BANPS; Factor B was saliently loaded by RSAS, the care and play subscales from the BANPS (see Figure 1). The SHAPS, the seek and play subscales from the BANPS also cross-loaded on a second factor. Following rotation, Factor A accounted for 26% of the total variance and 53% of the common variance; Factor B accounted for 23% of the total variance and 47% of the common variance. Altogether, the two-factor solution explained 48% of the total variance with the two factors correlated at .68. The result of PA estimation and ML estimation were convergent.

To contrast with a unidimensional construct model, we examined a one-factor solution for adequacy (see Figure 1). Following rotation, the single factor accounted for 40% of the total variance. The result of PA estimation and ML estimation were convergent. Model fit comparison indexes suggest the two-factor model fit the data more sufficiently (see Table 2). Compared to the one-factor model, the two-factor model fit is superior based on RMSEA, BIC and CFI.

Confirmatory Factor Analysis

The wave 9 correlational matrix indicated that the data were appropriate for factor analysis, $\chi^2(21) = 330.92$, $p < .001$, KMO = .79. Based on the EFA results, the first CFA examined Model 1, a two-factor congeneric solution. Model 1's general fit was not acceptable based on the majority of the goodness-of-fit indicators (see Table 3 and Supplemental Figure 4).

We then examined Model 2, a non-congeneric solution with indicators (the SHAPS, the seeking and play subscales from the BANPS) allowed to cross-load on both factors. Model 2's acceptable fit was supported by all the global model fit indicators and Model 2 fit the data significantly better than Model 1, $\chi^2(3) = 24.98$ $p < .001$. In this non-orthogonal two-factor model, Factor A was strongly loaded by the anticipatory and consummatory subscales from the TEPS, and Factor B was saliently loaded by RSAS and the care subscale from the BANPS. The SHAPS, the seeking and play subscales from the BANPS loaded significantly on both factors as non-congeneric indicators. Based on the magnitude of the loadings, the SHAPS loaded more strongly on Factor A than Factor B. The play subscale from the BANPS loaded slightly more strongly on Factor B, whereas the seek subscale from the BANPS loaded nearly equally on both factors. With all indicators significantly loaded on the factors, Model 2's acceptability and utility was further supported with low localized strain (i.e., low modification indices) and proper parameter estimates (i.e., low residual correlations; see Table 2 and Figure 2 as well as Table 3, 4 and 5 in Supplemental Material). Potential influential cases were examined and subsequent supplementary sensitivity analyses supported Model 2 (See Supplemental Material).

Discussion

Exploratory and confirmatory factor analyses across four measures of anhedonia completed one year apart resulted in a model of two correlated latent anhedonia variables in this non-clinical sample of female adolescents. Combining the results from Wave 8 and Wave 9, the two factors were interpreted based on the content and intended use of the salient and congeneric indicators/(sub)scales. The first latent factor represents Physical Anhedonia (factor PA) because the salient indicators (the Anticipatory and Consummatory subscales from the Temporal Experience of Pleasure Scale) are used to measure hedonic and physical experience without the presence of other individuals. The core of the PA latent variable is the ability to derive pleasure from neutral and positive objects (mostly depending on the senses; e.g., freshly cut grass, a cup of coffee or tea) and experience (e.g., amusement park, a warm bath). The second latent factor represents Social Anhedonia (factor SA) because the salient indicators (the Chapman Revised Social Anhedonia Scale and the Care subscale from the Brief Affective Neuroscience Personality Scale), focuses on the nonphysical and interpersonal pleasure derived from feeling emotionally connected to other people. The essence of the SA factor is to enjoy being emotionally close with others and engage in behaviors because of such a connection (e.g., thinking friends are important, caring for them and enjoying activities with other people).

The significant cross-loadings in the better-fitted Model 2 from the CFA are consistent with a two-factor structure of anhedonia. Although most of the items in the SHAPS index physical enjoyment, four of the 14 items index social interactions. Similarly, the Seeking subscale from the BANPS includes items that assess curiosity about objects (e.g., puzzles) and relationships. In contrast, the Play subscale from the BANPS assesses pleasure from social interactions as well as a general fun-loving tendency. Due to the presence of items covering both physical and social pleasure and possibly other general domains of positive emotionality, cross-loadings of the three subscales of the BANPS are reasonable and interpretable. Although it was not an explicit and original goal to examine the developmental stability of anhedonia constructs in this longitudinal study because measures were only 1 year apart, we found large effect size correlations (*r*s = .491~.785) among the anhedonia measures collected in waves 8 and 9 (see Supplementary Materials, Table 6). This is consistent with the high temporal stability of anhedonia found in adolescents (Bennik et al., 2014; Nelis et al., 2019; Sussman & Leventhal, 2014). The high cross-wave correlations in this study may also suggest relative temporal stability of the recovered anhedonia factors in this population.

The composition of questionnaires used in this study, only one of which (i.e., TEPS) specifically assessed anticipatory and consummatory anhedonia, precluded the identification of factors in the temporal domain of anhedonic experience. Due to the preponderance of scales that assess physical and social anhedonia in the field and in this study, additional measures may be required to adequately evaluate evidence for anticipatory and consummatory constructs of anhedonia in future research. However, even with the inclusion of additional questionnaires designed to capture the temporal experience of anhedonia, we speculate that challenges in identifying temporal domain factors will still exist. Recent factor analysis of the Temporal Experience of Pleasure Scale provided weak support for the original two-factor structure, with low divergent validity in the anticipatory and consummatory anhedonia subscales (Ho et al., 2015). Principal component analyses of the Anticipatory and Consummatory Interpersonal Pleasure Scale as well as its adolescent version consistently revealed factors based on categories of social interactions instead of factors aligning with anticipatory and consummatory dimensions of hedonic experience (Gooding et al., 2016; Gooding & Pflum, 2014). A principal component analysis with the Anticipatory and Consummatory subscales of the TEPS along with a Subjective Happiness

Scale (Lyubomirsky & Lepper, 1999) also resulted in a single dimension (Leventhal et al., 2006).

One additional challenge in distinguishing the anticipatory-consummatory dimension of anhedonia via personality/trait measures may arise from the time index of self-report measures compared behavioral and neural measures. Self-report measures generally index relevant life experiences based on episodic memory of the events (e.g., vacations) or semantic knowledge (e.g., I am a party person) (Robinson & Clore, 2002; Strauss & Gold, 2012). In contrast, behavioral and fMRI tasks are designed to index momentary anticipatory and consummatory pleasure. Therefore, in-the-moment experience sampling and specific behavioral and fMRI tasks may be more sensitive to anticipatory and consummatory facets of anhedonia than self-report measures. In addition, some evidence suggests that adolescents may not clearly distinguish anticipatory from consummatory pleasure via self-report (Watson et al., 2019). Self-report measures may not adequately differentiate anticipatory versus consummatory anhedonic experience (Berridge & Robinson, 2003).

Comparisons of the Present Model with the Past Models

The present model converges with the results of an EFA involving four of the same indicators (RSAS, SHAPS, the two subscales from TEPS) in an undergraduate sample (Olino et al., 2018). In Olino and colleagues' preferred five-factor models, the four indicators that were also included in our study significantly loaded on a General Extraversion/Positive Emotionality factor, which is consistent with the moderate association between the PA and the SA factor in the present analysis. Additionally, subscales from the Temporal Experience of Pleasure Scale loaded significantly on a Pleasure Seeking factor akin to the PA factor, and the Chapman Revised Social Anhedonia Scale mainly loaded on a Sociability factor which is similar to the SA factor. The SHAPS loaded on a Positive Emotion factor.

Similarities also exist between the present model derived from factor analyses and a recent thematic analysis of interviews with adolescents suffering from anhedonia (Watson et al., 2019). In the study by Watson et al., four main themes were revealed: 1) The experience of losing pleasure with a flattening of emotion; 2) the struggles with motivation and engagement; 3) the loss of a sense of connection; and 4) uncertainty with the sense of self and purpose. The PA factor in the present model appears related to themes 1 and 2, while the SA factor resembles a sub-theme under theme 3 “Feeling disconnected from others”. Since no items in the anhedonia questionnaires clearly measure a sense of self or purpose, theme 4 is not covered by the present model. These convergences suggest that despite the use of different methodologies, the present model may also be applicable to understanding aspects of anhedonia within other diverse samples including late-adolescent girls with anhedonia.

Discrepancies exist between our two-factor model and another model that consisted of a general hedonic factor (Leventhal et al., 2006). This general hedonic factor was significantly loaded by the Snaith-Hamilton Pleasure Scale but not the Revised Chapman Physical Anhedonia Scale (Chapman et al., 1976). In contrast, the present PA factor was defined mostly with physical anhedonia sub-scales. Such discrepancy in the count and content of latent variables between the two studies may arise from methodological differences.

For example, Leventhal et al. used confirmatory factor analysis to load three anhedonia measures and a picture rating task onto a single factor, based on a theoretical model in which questionnaires and laboratory-based measures of anhedonia are expected to converge and be distinguishable from depression and anxiety factors. In contrast, we relied on exploratory factor analyses to extract two factors out of the four anhedonia questionnaires prior to confirmatory factor analysis. As the present study included more distinct anhedonia measures and allowed for more model flexibility, the two-factor model may better capture and explain the latent variables of self-reported anhedonic experience.

While it would be ideal to incorporate other behavioral measures of anhedonia, we chose to focus on a single assessment modality in these analyses because behavioral and fMRI measures of hedonic processing were only collected in a sub-sample of study participants, which would reduce the sample size for analysis and potentially limit the reliability of the results. In addition, the modality of measurement (e.g., questionnaires, behavior) often accounts for much of the shared variance between measures (Brown, 2015).

Strengths and Limitations

Strengths of the present study include the use of factor analyses to examine the latent variables of anhedonia among a wide range of commonly used measures. The intentional inclusion of various measures tapping into opposing domains of anhedonia enabled comparisons among the components and provided initial understanding of the latent constructs of non-clinical female adolescents' self-reported anhedonia experience. The findings extend research on anhedonia constructs and portray the clustering features of the hedonic experiences among late-adolescent girls. In contrast with the previous studies on primarily White samples of high socioeconomic status (Leventhal et al., 2006; Olino et al., 2018; Watson et al., 2019), in this study, the high proportion of adolescent female participants from low socioeconomic households and/or of Black American ethnicity also helps reduce the diversity gap in the literature. Since the physical and social anhedonia factors found in this sample converge with the general literature, and scores on the anhedonia measures in this sample are similar to population norms, this study provides new evidence that low-income/Black American late adolescent girls' self-reported anhedonia has a clear social and physical category distinction. The absence of psychometric validation studies on some of the scales (e.g., RSAS) in adolescent and racially-diverse samples may limit scale generalizability. Future research should investigate differences in the construct of anhedonia across sex and age. One might speculate that females may gravitate towards physical anhedonia due to more somatic complaints (Zheng et al., 2019) which are further exacerbated by aging (Haug et al., 2004). Other anhedonia construct dimensions also need consideration. For example, reward motivation (anticipatory anhedonia; e.g., Treadway et al., 2009).

Limitations of this study include the application of confirmatory factor analysis and exploratory factor analyses in a two-wave design intended to assess replicability. Across waves 8 (N = 173) and 9 (N = 147), 131 individuals participated in both waves. CFA model fit success may result from chance associations in the samples due to sampling error; analyses using completely independent samples could have *increased* the generalizability of the results (Brown, 2015). However, the use of overlapping samples is common in factor analyses (Flom et al., 2018; Foster & Mohler-Kuo, 2018; Olver et al., 2018), especially in multi-wave studies (Castillo-Mayén et al., 2020; McKay et al., 2001; Summers et al., 2019). We believe the current CFA model results are likely to replicate because of the theoretical and empirical support for social and non-social anhedonia factors in other studies examining partially overlapping constructs (Chapman et al., 1976; Langvik & Borgen Austad, 2019). In addition, although large sample sizes are desirable, our sample sizes (with a relatively wide range of communality and a variables-to-factors ratio of 3.5) are within the recommended minimum necessary sample sizes of 90 to 160 to achieve a good level of agreement between the sample and population two-factor solutions (Mundfrom et al., 2005).

Although the adoption of a scale-level analysis over an item-level analysis was based on matrix factorability and common practices, psychometric inconsistency across questionnaires (e.g., dichotomized versus ordinal scales, varied proportions of negatively-worded items, predominance of consummatory versus anticipatory items) and some within-item heterogeneity (e.g., items covering both physical and social components) limited the capacity to analyze the data on a more fine-tuned item level. Relatedly, the use of seven subscales for analysis precludes the capacity to identify more than two factors. While it would be ideal to do item-level analyses across anhedonia measures, we were not able to find any precedent of published item-level research for this construct. Merits exist in both scale-level and item-level factor analyses. Psychometric properties of existing scales/subscales can be used to corroborate previous research, and the themes of scales/subscales are usually theory-based. However, single measure item-level factor analysis has been found to produce improved model fit and resolve secondary loadings compared to scale-level analysis (McGrath, 2014). Although we were able to interpret the significant cross-loadings, and the relatively high number of non-congeneric indicators may be due to a relatively liberal indicator loading threshold of .3 (Brown, 2015), the low internal consistency and heterogenous content of some of the scales (e.g., BANPS subscales) provide further support for the heterogeneity of anhedonia constructs. Factor analysis with content-homogeneous scales, or item-level analysis of self-report questionnaires with consistent measurement levels, may produce clearer factor solutions.

Directions for Future Research

In this study, we sought to evaluate whether latent constructs of anhedonia could be identified across questionnaires that assess different characteristics of hedonic experience. These widely-used self-report measures represent an important level of measurement for the systematic identification and characterization of the RDoC domains (e.g., the Positive and Negative Valence systems, Social Processes). Furthermore, self-reported anhedonia may be the most feasible platform for informing diagnostics and therapeutics given that anhedonia is perhaps one of the most impairing and enduring aspects of depressive orders. The present model helps characterize the construct of anhedonia by delineating two latent variables for anhedonic experience (physical and social) across self-reported anhedonia questionnaires. The confirmation of separate latent variables of anhedonia highlights the need for researchers to clearly define and characterize each facet of anhedonia rather than relying on a small number of items to measure anhedonia as a homogenous construct. While the medium-sized correlation between the PA and SA factors in this study indicates some shared variance in the two types of anhedonic experience, the uniqueness of the interactive experiences with other people versus non-social sensory experiences is informative. Interestingly, although the ability to derive pleasure from solitary activities has been linked with life satisfaction (Leary et al., 2003) and good mental health (Larson & Lee, 1996), social anhedonia may contribute to psychopathology, and schizophrenia-spectrum disorders in particular (Silvia & Kwapil, 2011). In addition to the differential predictive validity of physical and social anhedonia in models of psychopathology, future research could identify potential interactions between the two types of anhedonia: the compounding effect from suffering high anhedonia of both types, and the potential protective effects of hedonic experience of one type of anhedonia in absence of the other.

Future research could also establish whether there are differential therapeutic benefits to interventions that target physical versus social anhedonia. There is growing evidence that interventions targeting positive affective functioning (Craske et al., 2016; Dunn et al., 2019; McMakin et al., 2011; Taylor et al., 2017) and biobehavioral interventions (e.g., ketamine; Lally et al., 2014; deep brain stimulation; Schlaepfer et al., 2008) decrease anhedonia. Existing interventions could be improved by targeting specific subtypes of anhedonic experience. For example, there is preliminary evidence that in individuals with social anhedonia, working memory training improves monetary- and affect-related hedonic processing (Li et al., 2016). Finally, future work could determine whether physical and social anhedonia correlate with other behavioral and neural measures of hedonic experience (e.g., reward processing, effort to obtain rewards, social connection) to confirm the independence and overlapping components of the two factors.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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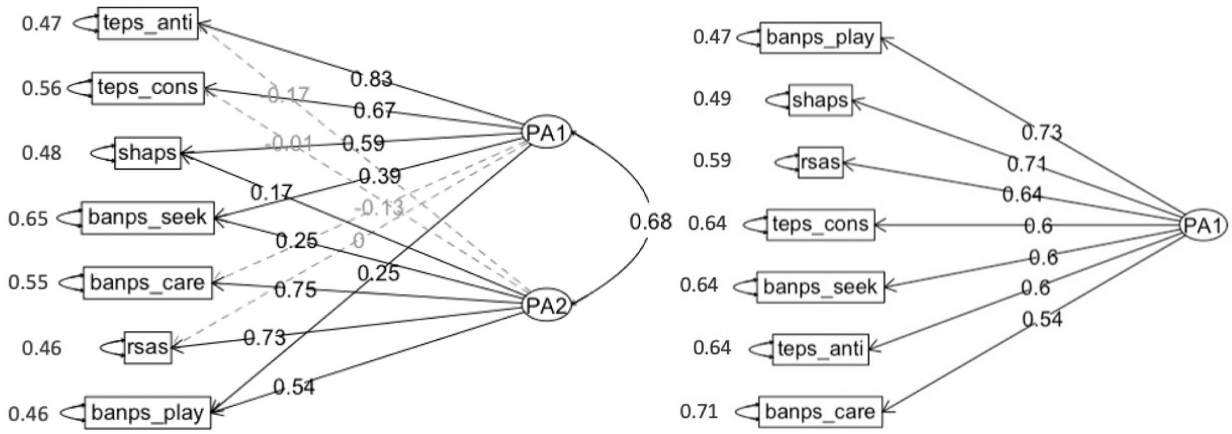

Figure 1.

EFA factor loadings of Wave 8 data (*N* = 173). On the left: PA1: Factor A from principal axis analysis; PA2: Factor B from principal axis analysis. RSAS: the Chapman Revised Social Anhedonia Scale; SHAPS: the Snaith-Hamilton Pleasure Scale; BANPS_Play, BANPS_Seek and BANPS_Care are the Play, Seek and Care subscales of the Brief Affective Neuroscience Personality Scale. TEPS_Anti and TEPS_Cons: the anticipatory and consummatory subscales of the Temporal Experience of Pleasure Scale. The grey dashed line indicates negative loadings from indicators. On the right, one factor was extracted and the indicators were sorted according to the loading size. No analytic constraints (e.g., fixed loadings) were applied.

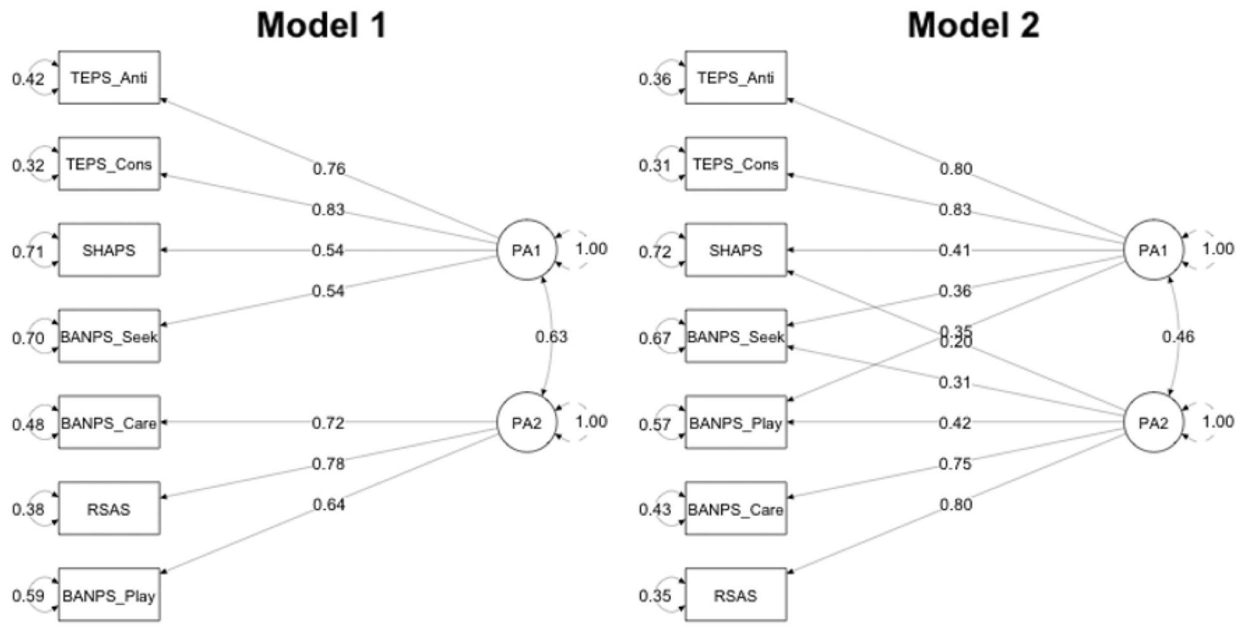

Figure 2.

CFA Model 1 and Model 2 factor loadings of Wave 9 data (*N* = 147). PA1: Factor A from principal axis analysis; PA2: Factor B from principal axis analysis. RSAS: The Chapman Revised Social Anhedonia Scale; SHAPS: the Snaith-Hamilton Pleasure Scale; BANPS_Play, BANPS_Seek and BANPS_Care are the Play, Seeking and Care subscales of the Brief Affective Neuroscience Personality Scale. TEPS_Anti and TEPS_Cons: the anticipatory and consummatory subscales of the Temporal Experience of Pleasure Scale.

Table 1.

Descriptive Statistics from the Anhedonia Questionnaires in Wave 8 (n = 173) and 9 (n = 147)

Scale	Sum Score Ranges	M_8 (SD_8)	$Skew_8$	$Kurtosis_8$	M_9 (SD_9)	$Skew_9$	$Kurtosis_9$
RSAS	0 ~ 40	12.34 (6.63)	−.39	−.23	12.37 (6.69)	−.34	−.60
SHAPS	14 ~ 56	22.90 (6.56)	−.37	−.69	22.31 (7.57)	−1.36	3.47
BANPS_Play	6 ~ 30	12.12 (4.17)	−.37	−.37	11.59 (4.04)	−.51	−.41
BANPS_Seek	6 ~ 30	14.76 (3.89)	.48	−.49	14.41 (3.94)	.12	−.13
BANPS_Care	4 ~ 20	10.55 (3.24)	.06	−.46	10.13 (3.24)	.01	−.78
TEPS_Anti	10 ~ 60	22.19 (8.12)	−.97	1.14	22.01 (7.63)	−1.11	1.73
TEPS_Cons	8 ~ 48	22.30 (7.64)	−.34	−.21	21.64 (8.28)	−.71	.74

Note: RSAS: the Chapman Revised Social Anhedonia Scale; SHAPS: the Snaith-Hamilton Pleasure Scale; BANPS_Play, BANPS_Seek and BANPS_Care are the play, seek and care subscales of the Brief Affective Neuroscience Personality Scale. TEPS_Anti and TEPS_Cons: the anticipatory and consummatory subscales of the Temporal Experience of Pleasure Scale.

Table 2.

Goodness-of-Fit Indicators of the CFA Models of Wave 8 Data (N = 173)

Models	SRMR	RMSEA [90% CI]	CFI	TLI	BIC	χ^2 (*df*) *p*
One-factor	.07	.12 [.08, 16]	.90	.86	−24.98	47.16 (14) $p < .001$
Two-factor	.04	.08 [.02, 13]	.98	.93	−24.11	17.11(8) $p = .029$

Note. Acceptable values are as follows (Hu & Bentler, 1999; Symonds & Moussalli, 2011): SRMR <= .08, RMSEA <= .06 ($p > .05$ meaning not rejecting the null hypothesis that RMSEA < = .05), CFI, TLI >= .95, χ^2 $p > .05$ suggests no significant difference between the patterns observed in the raw data and the specified model, in general, lower BIC suggest better model fit.

Table 3.

Goodness-of-Fit Indicators of the CFA Models of Wave 9 Data (N = 147)

Model	SRMR	RMSEA [90% CI]	CFI	TLI	AIC	BIC_{adjust}	χ^2 (*df*) *p*
(1) A congeneric two-factor model	.08	.12 [07, .16] $p = .01$	.92	.87	6172.64	6170.03	38.32 (13) $p < 0.001$
(2) A non-congeneric two-factor model	.03	.05 [0, .11] $p = .47$	.99	.98	6153.65	6150.52	13.34 (10) $p = .21$

Note. Acceptable values are as follows (Hu & Bentler, 1999; Symonds & Moussalli, 2011): SRMR <= .08, RMSEA <= .06 ($p > .05$ meaning not rejecting the null hypothesis that RMSEA < = .05), CFI, TLI >= .95. In general, lower AIC and BIC_{adjust} suggest better model fit.