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How are irritability and anhedonia symptoms linked? A network approach

Sonia Sistiaga[1] | **Wan-Ling Tseng**[2] | **Lanting Zhang**[3] | **Mandy Rossignol**[1] | **Nellia Bellaert**[1]

[1]Cognitive Psychology and Neuropsychology Department, University of Mons, Mons, Belgium

[2]Yale Child Study Center, Yale School of Medicine, Yale University, New Haven, CT, USA

[3]Nuffield Department of Clinical Neuroscience, University of Oxford, Oxford, UK

Correspondence

Sonia Sistiaga, Cognitive Psychology and Neuropsychology Department, University of Mons, Mons, Belgium.

Email: sonia.sistiaga@umons.ac.be

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Abstract

Background: Anhedonia and irritability are two prevalent symptoms of major depressive disorder (MDD) that predict greater depression severity and poor outcomes, including suicidality. Although both symptoms have been proposed to result from paradoxical reward processing dysfunctions, the interactions between these symptoms remain unclear. Anhedonia is a multifaceted symptom reflecting impairments in multiple dimensions of reward processing (e.g., pleasure, desire, motivation, and effort) across distinct reward types (e.g., food, sensory experiences, social activities, hobbies) that may differentially interact with irritability. This study investigated the complex associations between anhedonia and irritability using network analysis.

Method: Participants ($N = 448$, Mage = 33.29, SD = 14.58) reported their symptoms of irritability on the Brief Irritability Test (Holtzman et al., 2015) and anhedonia (i.e., pleasure, desire, motivation, and effort dimensions across four reward types) on the Dimensional Anhedonia Rating Scale (Rizvi et al., 2015). A regularized Gaussian Graphical Model was built to estimate the network structure between items.

Results: Irritability was negatively related to willingness to expand effort to obtain food/drinks (estimate = −0.18), social activities (−0.13), and hobbies (−0.12) rewards. Irritability was positively associated with a desire for food/drinks (0.12).

Limitations: Only a small proportion (5.8%) of our sample was clinical and the study design was cross-sectional.

Conclusion: A specific link between irritability and the effort dimension of the hedonic response across three reward types was identified. Investigating effort expenditure deficits with experimental paradigms may help us understand the mechanisms underlying the comorbidity between irritability and anhedonia in the context of MDD.

KEYWORDS

anhedonia, depression, hedonic, irritability, network analysis, reward system

1 | INTRODUCTION

Depressive disorders, including major depressive disorder (MDD), are amongst the leading causes of disability worldwide (Ferrari et al., 2013), affecting 3.8% of the population including 5.0% of adults (WHO, 2023). Patients diagnosed with MDD present diverse symptom profiles (Fried & Nesse, 2015) associated with different genetic/demographic characteristics, and altered psychosocial functioning across individuals (Kendler et al., 2013; Lux & Kendler, 2010; Myung et al., 2012). To parse heterogeneity of depression, the Research Domain Criteria (RDoC) initiative proposed by the National Institute of Mental Health (Insel et al., 2010) encourages to shift the research focus from studying diagnostic categories toward a dimensional assessment of symptoms and functioning using multiple levels of analysis (e.g., physiological, behavioral, self-reported measures). Symptoms of irritability and anhedonia are particularly well suited to be examined through the RDoC framework since they are both thought to be characterized by dysfunctions in the Positive Valence System (Borsini et al., 2020; Brotman et al., 2017), a domain focused on motivation and reward-seeking behaviors (Insel et al., 2010).

Anhedonia, originally defined as inability to experience pleasure (Ribot, 1986), is the second cardinal feature of depression (American Psychiatric Association, 2013) and affects approximately 70% of individuals with MDD (Cao et al., 2019; Shankman et al., 2014). Anhedonia predicts the severity and duration of depressive symptoms (Buckner et al., 2008; Pelizza & Ferrari, 2009), higher risk of suicide (Auerbach et al., 2014; Fawcett et al., 1990; Spijker et al., 2010), and poorer response to antidepressant treatments (McMakin et al., 2012). Irritability, an increased proneness to anger and frustration (Brotman et al., 2017), is not included in DSM-5 criteria for MDD in adults although research has shown that 40%–50% of adults with depressive disorder also exhibit irritability symptoms (Fava et al., 2010; Judd et al., 2013). In adults with MDD, the presence of irritability correlates with greater severity and duration of depressive episode, increased psychosocial impairment, reduced life satisfaction, and is more strongly associated with suicidality than overall depression (Jha et al., 2019). Longitudinal associations also exist between early irritability and adult depression (see Vidal-Ribas & Stringaris, 2021).

Anhedonia and irritability seem to co-occur in the symptomatology of adult MDD, as anhedonia was reported by 88.2% of irritable MDD patients in the US National Comorbidity Survey Replication (Fava et al., 2010). Reward processing dysfunction has been implicated in the development of both symptoms (Borsini et al., 2020; Brotman et al., 2017). Despite their common co-occurrence in the clinical presentation of depression, the reward dysfunctions respectively associated with each symptom appear to be paradoxical (Vidal-Ribas & Stringaris, 2021). While irritability is associated with *increased* responsivity to reward in youths and behavioral approach tendencies (Bebko et al., 2014; Brotman et al., 2017; Perlman et al., 2015), anhedonia is associated with *blunted* neural responsivity to reward and low reward approach (Borsini et al., 2020; Dillon et al., 2014; Keren et al., 2018; Treadway & Zald, 2011; Whitton et al., 2015). Although the distinction explained above focuses on consummatory pleasure, multiple reward-related processes precede and influence the pleasure experienced from receiving a reward. Indeed, anhedonia is a multifaceted symptom that can reflect deficits in the multiple stages of reward processing: interest/desire (i.e., wanting a reward), motivation (i.e., initial energy expenditure to obtain a reward), effort expenditure (i.e., sustained energy expenditure to obtain a reward), and consummatory pleasure (e.g., enjoyment of reward; Husain & Roiser, 2018; Rizvi et al., 2015; Robinson & Berridge, 2003; Rømer Thomsen et al., 2015; Treadway & Zald, 2011). Furthermore, anhedonia may be experienced generally or for specific reward types (e.g., sensory, social; Shankman et al., 2014). A common categorization distinguishes reward from sensory experiences (e.g., smell, touch) and pleasure from social interactions (Kringelbach & Berridge, 2010; Shankman et al., 2014). Other meaningful reward types for human behavior also include food (e.g., Matyjek et al., 2020), money (e.g., Delgado et al., 2006), and recreational activities (Berridge & Robinson, 1998; Rizvi et al., 2015; Snaith et al., 1995). While all reward experiences share common brain circuits and neurotransmitters (Kringelbach & Berridge, 2010), research on anhedonia suggest that reward impairments may be category-specific. For example, patients diagnosed with MDD showed lower neural responses when anticipating *social* rewards compared to controls, while there were no group differences when anticipating *monetary* rewards (Zhang et al., 2022). This idea supports the necessity of distinguishing multiple reward types when studying anhedonia. How these anhedonia-related deficits in reward processing relate to irritability is still unknown and warrants further research. Although irritability in youths was linked to increased consummatory pleasure in response to monetary rewards (i.e., more positive mood, enhanced neural activation in the middle frontal gyrus and anterior cingulate cortex; Bebko et al., 2014; Perlman et al., 2015), irritability in the context of adult MDD may not be associated with similar mechanisms, given that brain regions supporting reward processing continue to develop throughout childhood (Galván, 2010; Lukie et al., 2014). Indeed, a prior study has examined reward processing of irritability in young adults and found no link between irritability and neural responsivity to monetary rewards (Deveney, 2019). Understanding the association between irritability and the four dimensions of anhedonia (i.e., decreased interest, motivation, effort, and consummatory pleasure), across multiple reward types (i.e., food/drink, hobbies, social activities, and sensory experiences) at the self-reported level may lay the groundwork for much needed mechanistic studies investigating the pathophysiology of the comorbidity between irritability and anhedonia in the context of MDD.

Network analysis is a suitable approach to study precise symptoms interactions and probe depression heterogeneity, as it allows for the visualization of correlations between specific items and symptom clusters. In network theory, MDD is conceptualized as a complex system emerging from causally connected, interacting, and reciprocally reinforcing symptoms (Borsboom & Cramer, 2013; Borsboom, 2017). In the network analysis studies of depression, anhedonia has been identified as one of the most central nodes (see Wichers et al., 2021 for a review), but irritability was rarely measured. To our knowledge, three network analysis studies have simultaneously included measures of irritability and anhedonia. Bai et al. (2021) found that irritability was the most central symptom among nursing students during the COVID-19 pandemic, and anhedonia was identified as a bridge symptom linking depressive and anxiety (including irritability) symptoms. Li et al. (2023) demonstrated that the inward irritability symptom “annoyed” had the second highest strength in the network in a sample of Chinese college students during COVID-19 pandemic, indicating that it was closely connected to others anxiety and depression (including anhedonia) symptoms. Garabiles et al. (2019) also showed that irritability was more strongly connected to anhedonia and fatigue than any other depressive or anxiety symptoms in a sample of migrant domestic workers, a population vulnerable to depression and anxiety disorders (Hall et al., 2019; Lindert et al., 2009).

While these studies highlight the strong links between anhedonia and irritability, they only measured anhedonia using a single item (e.g., “Little interest or pleasure in doing things” from the Patient Health Questionnaire [PHQ-9]; Kroenke et al., 2001), which neglects the complexity of anhedonia and does not differentiate between its reward processing sub-components. Using a multi-item scale developed specifically to probe the multiple dimensions of hedonic function (e.g., desire, motivation) and reward types (e.g., social vs. food rewards), such as the Dimensional Anhedonia Rating Scale (DARS; Rizvi et al., 2015), might provide a more nuanced understanding of the association between irritability and anhedonia. Therefore, the purpose of the present study was to leverage network analysis to identify the complex associations between irritability and the different dimensions of anhedonia (i.e., desire, motivation, effort, and pleasure) measured by a multi-domain scale (i.e., the DARS).

2 | METHOD

2.1 | Participants and procedure

All participants gave their consent before completing the survey and data anonymity was respected. The Ethics Committee at the first author's University approved the study before its implementation. Subjects were asked about their age, gender, race/ethnicity, education level, and employment status, before completing an online version of the questionnaires described below.

2.1.1 | Community-based sample

Participants were recruited through advertisements on social networks, wherein the recruitment materials explicitly conveyed that their participation in the study would contribute to improving the understanding of symptoms of anhedonia and irritability across multiple psychopathological disorders. A total of 520 participants completed the survey. Participants were selected based on the following exclusion criteria: non-French speaker, current major medical condition, psychiatric condition other than depression or anxiety, past or current substance/alcohol dependence, history of neurological problems, stroke, or head trauma. After exclusion, the community-based sample included 422 participants (ages 18–74 years, M_{age} = 32.59 years, SD = 14.38, 82.20% females). In total, 182 (43.13%) participants had Center for Epidemiological Studies of Depression (CESD; Radloff, 1977) scores that exceed the clinical cutoff (≥20) established by Vilagut et al. (2016).

2.1.2 | Clinical sample

The clinical sample, recruited from hospitals and clinics, included 26 patients (ages 18–78 years, M_{age} = 44.31 years, SD = 13.43, 84.60% females), 20 of whom were diagnosed with MDD and 6 were diagnosed with bipolar disorder (BD). BD-diagnosed patients were included because they are likely to present high levels of irritability and anhedonia symptoms (American Psychiatric Association, 2013). According to the RDoC framework, we combined community-based and clinical samples and analyzed irritability and anhedonia as dimensional symptoms to capture the full spectrum of symptom variations. The inclusion of the clinical group did not significantly change the network results (see Comparison Network Results). A summary of the socio-demographic characteristics of the final sample, constituted of 448 participants, is presented in Table 1.

2.2 | Questionnaires

2.2.1 | Dimensional anhedonia rating scale (DARS)

The 17-item DARS (Rizvi et al., 2015) assesses the dimensions of interest, motivation, effort, and consummatory pleasure across four major reward types: hobbies, food/drinks, social activities, and sensory experiences. Participants provide examples of their own favorite activities and are asked to rate how each item apply to them “right now” on a

TABLE 1 Demographic and clinical characteristics of the final sample ($N = 448$).

	N/Mean (SD)	%
Age, Mean (SD)	33.29 (14.58)	
Gender		
Male	76	16.96
Female	369	82.37
Other	3	0.67
Education		
Primary school	20	4.46
High school	93	20.76
Bachelor	182	40.63
Master	140	31.25
Ph.D	9	2.01
Missing data	4	0.89
Race/ethnicity		
Asian	7	1.56
Hispanic or Latino	11	2.46
Middle Eastern	4	0.89
African	23	5.13
White or Caucasian	398	88.84
Missing data	4	0.89
Professional status		
Student	162	32.16
Workers	241	53.79
Unemployed	5	1.12
Retired	19	4.24
Missing data	21	4.69

5-point Likert scale ranging from 0 (*not at all*) to 4 (*very much*). The subscale scores are the sum of all the items within a reward type, and the total score is the sum of the score obtained for each subscale. A high score on the DARS corresponds to high interest, motivation, effort, and pleasure (i.e., a low level of anhedonia). We used a French version of the DARS. The translation/validation procedures and factorial analyses are detailed in Supplementary Results S1. The total/subscale scores were used in the descriptive analysis, and item scores were used in the network analysis.

2.2.2 | Brief irritability test (BITe)

The BITe (Holtzman et al., 2015) is a 5-item self-report questionnaire, rated on a 6-point Likert scale ranging from 1 (*never*) to 5 (*always*), designed to assess irritability over the past 2 weeks. The total score is calculated by summing the score of each item. A high score on the BITe corresponds to a high level of irritability. We used the French-validated version of the BITe (Bellaert et al., 2022). In the current sample, BITe demonstrated excellent internal consistency (α = 0.87) and a single-factor structure (CFI = 0.98, TLI = 0.95, RMSEA = 0.05, SRMR = 0.03, all factor loadings ≥ 0.70). The total score was used in the descriptive and in the network analyses, as the BITe was found to be a unidimensional scale (Holtzman et al., 2015; Toohey & DiGiuseppe, 2017).

2.3 | Data analysis

2.3.1 | Descriptive analysis

Means and standard deviations of the DARS total and subscale scores and the BITe total score were computed, and bivariate, zero-order correlations between them were examined.

2.3.2 | Network construction

Analyses were performed using RStudio (version 4.2.2) and the *bootnet* package (version 1.5). The network was constructed with 17-DARS items and BITe total score (i.e., "nodes"). In the network model used (i.e., pairwise Markov random field), the connections between the nodes (i.e., "edges") represent the direct partial correlation coefficients between two nodes while accounting for all the other nodes in the network, which limits the apparition of spurious edges and ensures that two variables are connected only if they are conditionally dependent (Epskamp et al., 2022; Lauritzen, 1996). To account for the non-normality of the data, we applied a non-paranormal transformation (H. Liu et al., n.d.) using the *huge* package (version 1.3.5; Zhao et al., 2012) and used a rank-order transformation (Spearman correlations). A regularized Gaussian graphical model with Graphical least absolute shrinkage and selection operator (LASSO) regularization was built to estimate the network structure between items using the *ggmModSelect* function from the *bootnet* package (version 1.5). For better visualization, we used the colorblind theme in *qgraph* (Epskamp et al., 2012) with blue edges indicating a positive partial correlation and red edges indicating a negative partial correlation between variables. Thicker edges indicate stronger associations between variables (Epskamp et al., 2012). Age and gender were added as covariates to control for the effect of these variables, considering the large age range (18–79 years old) and the unbalanced gender ratio (82.18% of women). Consistent with the study objective, we focused our interpretation on the links between irritability and anhedonia.

2.3.3 | Indices of bridge centrality

To identify edges bridging anhedonia and irritability, the bridge centrality of the nodes was computed using the *networktools* package (version 1.5.0) based on four indices: bridge strength, bridge closeness, bridge betweenness, and bridge expected influence (Jones et al., 2021). Bridge centrality analysis require the a-priori definition of *communities*, which are theoretically driven groups of nodes, typically corresponding to a psychiatric disorder. In our case, we defined two communities as two symptoms: 1) anhedonia (i.e., 17 items of the DARS) and 2) irritability (i.e., the total score of the BITe), because we were interested in identifying edges bridging anhedonia and irritability.

Bridge strength measures the node's absolute value of the summed edge weights (i.e., the sum of the partial correlations) connected to nodes from other communities. Bridge closeness measures the average distance between one node and all nodes outside of its own community. The distance is defined as the inverse of the edge weights such that edges with higher weights indicate nodes that are closer together and have a greater risk of activating other nodes. Bridge betweenness measures the number of times a node is on the shortest path between two other nodes from two distinct communities. Bridge expected influence, similar to bridge strength, measured the node's sum of connectivity with nodes from other communities, but without taking the absolute value of the edge weights.

According to Jones et al., 2021, we identified significant bridge nodes by selecting the nodes with a bridge strength score in the top 80th percentile.

2.3.4 | Accuracy and stability checks

Bootstrapping methods were used to assess the stability and robustness of the edge-weights and bridge centrality indices, using the *bootnet3* package (version 1.5). The accuracy of edge-weights was estimated by drawing non-parametric 95% bootstrapped confidence intervals (CI) with 2,500 iterations around them. To assess the stability of bridge centrality indices, a correlation-stability coefficient (CSC) was computed by taking progressively smaller subsets of data (case-dropping) and calculating the correlations between the bridge centrality indices of the subset data and the original full sample. The CSC measures the stability of bridge centrality and CSC(cor = 0.7) represents the proportion of the sample that can be removed while maintaining a correlation greater than or equal to 0.70 with the original centrality score, with a 95% confidence interval. CSC should not be less than 0.25, and a coefficient above 0.50 indicates relatively stable networks (Epskamp et al., 2018). The anonymized data set and code used for the analyses can be downloaded on the Open Science Framework: https://osf.io/nvmu4/.

2.3.5 | Comparison network analysis

We performed a Network Comparison Test (NCT; van Borkulo et al., 2022) to test if the network structure was different whether the clinical sample ($n = 26$) were included or not. The NCT was run with 2000 iterations and the individual bridge edges between BITe and DARS were tested.

3 | RESULTS

3.1 | Descriptive results

Means, SDs, and bivariate correlations of the DARS subscales, total scores and BITe scores are presented in Table 2. BITe total score was significantly correlated with DARS total score ($r = -0.21$, $p < .001$), with social activities ($r = -0.23$, $p < .001$) and hobbies ($r = -0.20$, $p < .001$) subscales. BITe total score was not correlated with food/drinks ($r = -0.05$, $p = 0.25$) and sensory experiences ($r = -0.09$, $p = 0.07$) subscales.

3.2 | Network structure

The network (see Figure 1) revealed four clusters: each consisting of the four DARS reward types (i.e., hobbies, food/drinks, social activities, sensory experiences).

Four edges bridged BITe total score to DARS items. Three negative partial correlations were found, linking irritability to DARS items measuring the effort dimension of anhedonia. BITe was negatively associated with the item 1 for food/drinks rewards ("*I would make an effort to get/make these food/drinks*"; partial direct correlation [PDC] = −0.18), with the item 4 for social activities rewards ("*I would actively participate in my favorite social*

TABLE 2 Mean, standard deviations, and bivariate correlations between the DARS total score and subscores and the BITe total score.

	Scores		Correlations
	Mean	SD	BITe
DARS			
Total	49.25	9.26	−0.21***
Social Activities	10.91	3.50	−0.23***
Hobbies	11.89	2.94	−0.20***
Food/Drinks	11.00	2.99	−0.05
Sensory Experiences	15.44	3.96	−0.09
BITe	16.14	5.19	

Note: DARS = Dimensional Anhedonia Rating Scale; BITe = Brief Irritability Test.
***$p < 0.001$.

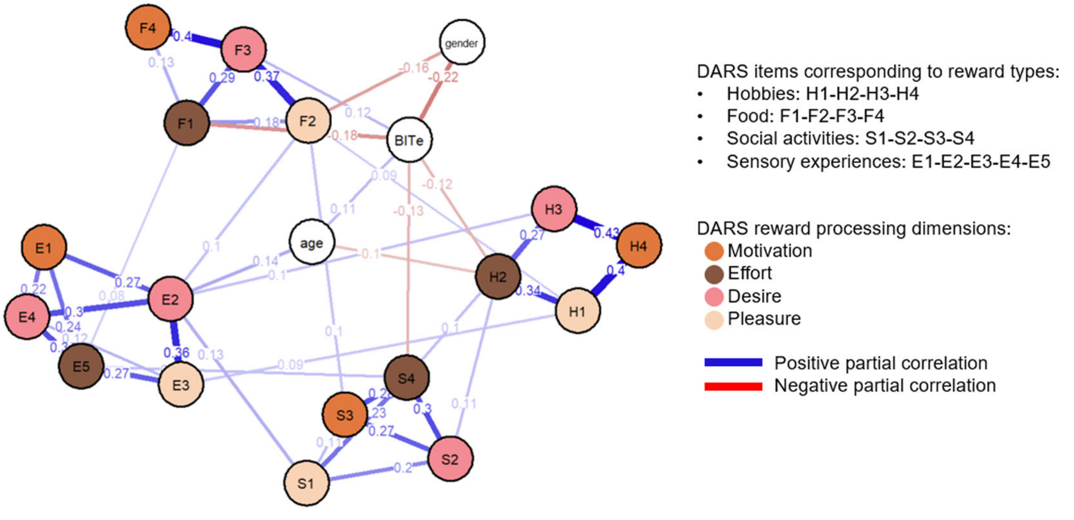

FIGURE 1 Network of DARS and BITe items ($N = 448$). DARS = Dimensional Anhedonia Rating Scale; BITe = Brief Irritability Test.

activities"; PDC = −0.13) and with the item 2 for hobbies rewards type ("*I would spend time doing my favorite activities*"; PDC = −0.12). Lastly, a positive partial correlation was found between the BITe and DARS item 3 assessing desire for food/drinks rewards ("*I want to have my favorite foods/drinks*") (PDC = 0.12).

3.3 | Bridge centrality indices

The bridge strength, bridge closeness, bridge betweenness, and bridge expected influence indices are presented in Supplementary Figure S1. Nodes with the highest bridge strength were BITe, DARS food item 1, DARS social item 4, DARS hobbies item 2, and DARS food item 3. Nodes with the highest negative bridge expected influence were the BITe, DARS food item 1, DARS social item 4, and DARS hobbies item 2. DARS food item 3 had the highest positive bridge expected influence. All the other nodes had a bridge strength and bridge expected influence of 0. Nodes with the highest bridge betweenness were DARS food items 3 and 2, and DARS experience item 2. Nodes with the highest bridge closeness were the DARS food items (1, 2, 3, 4). The most important bridge nodes (i.e., with bridge strength in the top 80th percentile) were the BITe and three DARS items measuring the effort dimension of anhedonia (i.e., food item 1, social item 4, and hobbies item 2).

3.4 | Accuracy and stability checks

The bootstrapping of the bridge centrality indices by case-dropping is shown in Supplementary Figure S2. The coefficient CS indicated that bridge betweenness (CS[cor = 0.7] = 0.00) and bridge closeness (CS[cor = 0.7] = 0.21) was not stable in the subset cases. They were therefore not interpreted further. Bridge strength (CS[cor = 0.7] = 0.62) and bridge expected influence (CS[cor = 0.7] = 0.51) reached the threshold of 0.50 defined by Epskamp et al. (2018) to be considered stable. The estimated accuracy of all edge-weights is shown in Supplementary Figure S3. The relatively narrow CIs indicate acceptable accuracy.

3.5 | Comparison network results

Results showed that the network structure ($M = 0.13$, $p = 0.99$), the global strength ($S = 0.26$, $p = 0.61$), and the edge-edge comparisons (all $ps \geq 0.39$) suggested the lack of evidence of a group difference between the network including the clinical sample ($N = 448$) and the network not including the clinical sample ($n = 422$). Given the small number of participants in the clinical sample, NCT results should be interpreted carefully.

4 | DISCUSSION

This study leveraged network analysis to identify the specific associations between irritability and the different dimensions of anhedonia (i.e., desire, motivation, effort, and pleasure) across four reward types (i.e., social activities, non-social hobbies, food/drinks, sensory experiences), at the self-reported level. The network was composed of four clusters corresponding to the four reward types (i.e., social activities, non-social hobbies, food/drinks, sensory experiences). Four bridge connections linked irritability and anhedonia symptoms. The three most prominent bridges revealed that irritability symptoms were correlated with reports of less willingness to expand effort for food/drink, social activities, and non-social hobbies. The fourth bridge showed a link between irritability and a higher desire for food/drinks. Understanding the specific links between irritability and anhedonia may inform the development of mechanistic studies investigating the pathophysiology of the comorbidity between irritability and anhedonia. This could guide interventions for individuals experiencing clinical levels of irritability and anhedonia.

The strongest bridge connection linked higher irritability to less willingness to prepare food/drinks. Paradoxically, irritability was associated to greater desire to have food/drinks. Some studies have suggested the use of eating as a coping mechanism to deal with irritability and have described emotional eating as a response to negatively valanced emotions (van Strien et al., 2007), and as a behavior adopted to relieve irritability (Nishitani et al., 2009). Conversely, hunger has also been identified as a potential cause for irritability (Toohey & DiGiuseppe, 2017; Toohey, 2020). This may explain the positive association found between irritability and desire for food/drinks. However, our results also suggest that highly irritable individuals would rather not exert effort to make food/drinks. Given irritability's prevalence in depression (Fava et al., 2010; Judd et al., 2013; Perlis et al., 2005, 2009), and fatigue being a MDD diagnostic criterion (American Psychiatric Association, 2022), diminished energy might reduce motivation to make food in individuals with depression. Indeed, depressive symptoms was linked to unhealthy dietary habits and a preference for junk/fast food (Gregório et al., 2017; Selvaraj et al., 2022). The association between irritability and decrease motivation but increase desire for food/drinks rewards suggests that these two hedonic dimensions may be dissociated for the same reward type, suggesting the importance of considering the multiple dimensions of hedonic response when studying reward deficits in MDD.

Higher irritability was also associated to less willingness to participate in social activities. Irritability, characterized by low frustration tolerance and temper outbursts (Brotman et al., 2017), increases the likelihood of social difficulties (Evans et al., 2015; Waschbusch et al., 2020), which might in turn reduce enjoyment or engagement in social activities. Indeed, difficulties in interpersonal relationships predict higher levels of anhedonia and depression (Flynn & Rudolph, 2011; Vrshek-Schallhorn et al., 2015). A recent 6-year longitudinal study has shown that the association between irritability and later anhedonia was mediated by intermediate chronic interpersonal stress in adolescents (Losiewicz et al., 2023), suggesting that irritable adolescents are more likely to experience chronic stress in social situations, which may later lead to increases in anhedonia. Furthermore, irritable adolescents may experience self-regulation difficulties during peer evaluations. Specifically, those with high versus low irritability displayed distinct activation patterns in socioemotional brain regions (e.g., amygdala, dorsal anterior cingulate cortex) while anticipating and receiving predictably negative social feedback in an ecological peer interaction paradigm (Yan et al., 2023). In addition, high irritability was associated with hostile interpretations of ambiguous faces following frustration (Deveney et al., 2020). These difficulties may influence how irritable individuals anticipate and perceive peer interactions and lead to higher chronic interpersonal stress. This highlights the importance of using social reward paradigm to investigate the mechanisms linking irritability to anhedonia, given that irritability often occur with interactional partners and in social contexts.

Finally, higher irritability was related to less willingness to spend time doing non-social hobbies. This result could underscore the impact of negative emotions associated with irritability on engagement in pleasurable activities. Indeed, past research shows that experiencing negative emotions can prevent us from engaging in pleasurable activities, which could be explained by the subjective feelings of difficulty evoked by the conflict between spontaneous facial expressions elicited by negative mood and those elicited by imagery of a pleasurable activity (Shen et al., 2020). Understanding these dynamics may allow us to shed light on the intricate interplay between negative emotions, irritability, and the pursuit of pleasurable hobbies.

Overall, the network revealed a specific link between higher irritability and less effort expenditure across three reward types (i.e., food/drinks, social activities, non-social hobbies). Individuals with depression and anhedonia show reduced willingness to expand (physical or cognitive) effort to obtain rewards, which could be due to reduced valuation of rewards (see Horne et al., 2021 for a review). However, whether deficits in effort expenditure and reward valuation also underlie irritability in youths with clinical irritability (e.g., those diagnosed with Disruptive Mood Dysregulation Disorder) or in adults with MDD is still unknown and understudied. Current models suggest that irritable youths may present difficulties in encoding the expected value of a reward, which could impair the ability to respond appropriately to reward contingencies, increasing the likelihood of frustration and negative affect (Brotman et al., 2017; Leibenluft & Stoddard, 2013; White et al., 2016).

According to our findings, individuals experiencing high irritability may show impairment of the same reward processing dimension (i.e., effort expenditure) across reward types (i.e., food/drinks, social activities, and hobbies) as well as impairments of different reward processing dimensions for the same reward type (i.e., decreased effort expenditure but increased desire for food/drinks). This highlights that future research may benefit from combining multiple dimensions of reward processing and distinct reward types when investigating the specific reward processing deficits associated with irritability and anhedonia. Most studies have investigated the pleasure response to monetary rewards (e.g., Deveney, 2019; Knutson et al., 2000; Pizzagalli et al., 2009), although recent studies have incorporated anticipatory and consummatory responses to a combination of monetary, social, and food rewards to study anhedonia (e.g., Banica et al., 2022; Frey et al., 2023; Wang et al., 2020). Furthermore, research may also benefit from using paradigms simultaneously measuring how the motivational, anticipatory, and consummatory stages of reward processing influence each other, such as the Effort Doors Task (Bowyer et al., 2021, 2022).

5 | LIMITATIONS

This study has some limitations. First, our sample only included a small proportion of patients with clinical diagnoses, although 43.13% of our community-based sample scored above the recommended CESD clinical cut-off (Vilagut et al., 2016) for depressive symptomatology. Our results need to be replicated in larger clinical samples before drawing conclusions about the interactions between irritability and anhedonia in MDD. Second, our sample was predominantly female. Although we controlled for gender in our analysis, future work with more representative samples of both males and females is necessary. Third, our results are cross-sectional, and causality cannot be inferred from the network analysis. Therefore, future research with experimental and longitudinal designs are needed to clarify the causal associations between irritability and anhedonia over time.

6 | CONCLUSION

Our study provides an initial examination of the complex associations between irritability and the different dimensions of anhedonia (i.e., desire, motivation, effort, and pleasure) across multiple reward types, through self-report. Our results revealed specific associations between irritability and less willingness to exert effort across three reward types. Future studies should use experimental paradigms coupled with fMRI or EEG to examine the role of reward processing in the links between irritability and anhedonia, especially in social contexts, in adults diagnosed with MDD.

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DATA AVAILABILITY STATEMENT

The data that support the findings of this study are openly available in OSF at https://osf.io/nvmu4/.

ORCID

Sonia Sistiaga http://orcid.org/0009-0005-2513-1482

PEER REVIEW

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SUPPORTING INFORMATION

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